

# WATCHING THE SKY NEW REALIZATIONS, NEW MEANINGS, AND SURPRIZING ASPECTS IN UNIVERSITY LEVEL ASTRONOMY

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*Abstract:* Learning astronomy is challenging at all levels due to the highly specialized form of communication used to share knowledge. When taking astronomy courses at different levels at university, learners are exposed to a variety of representations that are intended to help them learn about the structure and complexity of the Universe. However, not much is known about the reflective awareness that these representations evoke. Using a simulation video that provides a vivid virtual journey through our Milky Way galaxy, the nature of this awareness is captured and categorised for an array of learners (benchmark by results obtained for experts). The results illustrate how the number and nature of new things grounded in *dimensionality, scale, time and perspective* reflective awareness can too easily be taken for granted by both teachers and learners.

*Keywords:* Astronomy Education Research, Perspective, Awareness, Representations

## Introduction

Learning astronomy can be difficult for learners at all levels due to the highly specialized form of communication used to share knowledge in the disciplinary discourse of astronomy. The learners' can be anyone interested in learning astronomy, from amateurs to astronomy and physics graduate students. When taking astronomy courses at different levels at university, learners are exposed to a variety of *representations* with the aim of helping them learn about the Universe. Many of these representations have been created in two-dimensional form (2D) and experts (teachers who are professional astronomers or physicists) involved in this case study wanted the learners in their classes, to come to understand, or better understand, some of the more fundamental processes and underlying structures of the Universe from those representations.

Teachers often take for granted that learners experience, and develop, a three dimensional (3D) representation of the Universe in their minds, i.e., this is an aspect that is often *appresent* to the learners. For example, when teachers introduce nebulae using 2D pictorial representations and 3D verbal representations a visual appresentation aspect is introduced. Such appresentation aspects are further enhanced when time, as the fourth dimension, is introduced.

Simulation videos are often used to dynamically introduce learners to the structure and complexity of the Universe in 3D. However, little is known about the learning possibilities that such a collection of representations (representation affordance), may present to reflective learners (cf. Schön, 1991).

Our case study was designed to initiate an investigation into the nature of this awareness. Our starting point has been to use a highly regarded and widely used simulation video that sets out to illustrate some of the fundamental structural components of our Universe by taking viewers on a virtual reality journey through and out of our Milky Way Galaxy. Results in terms of evoked awareness for groups of undergraduates and experts' are described and discussed.

### **Research setting**

There is a growing international interest in viewing learning, in areas such as physics and astronomy, from a disciplinary discourse perspective. Such a perspective suggests that challenges to learning may be related to difficulties embedded in the handling of the highly specialized forms of communication used to share knowledge within a discipline (for epistemic examples, see Driver & Ericksson, 1983; Säljö, 2000; and diSessa & Sherin, 2000). Our study is hence built around a disciplinary discourse modelling of how both teachers and learners work with this communication (Airey & Linder, 2009) using a particular example of a simulation video that is widely used to dynamically introduce learners to the structure and complexity of the Universe in 3D (*Flight to the Virgo Cluster* which can be found at <http://www.ifa.hawaii.edu/~tully/outreach/movie.html>). This video introduces a viewer to the Milky Way in colour and three-dimensional orientation across millions of light years of simulated travel across the Milky Way. The research agenda sought to capture the reflective awareness of fundamental structural components of our Universe that was afforded to viewers as they engaged with the first million light years of the video journey.

### **Research question**

What is the nature of awareness afforded by the disciplinary representations encountered in a computer simulation of travelling through the Milky Way Galaxy?

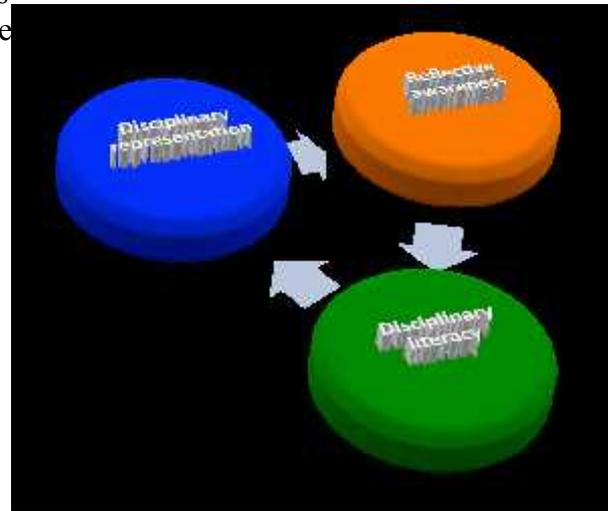
### **Theoretical framework**

The research framing draws on the Airey & Linder (2009) modelling of disciplinary discourse in relation to semiotic representations and on Schön's (e.g., 1991) development of John Dewey's formulation of reflection in a learning situation.

Airey & Linder (2009, p. 28), using a multimodal lens (cf. Kress et al., 2001), defined disciplinary discourse as "the complex of representations, tools and activities of a discipline". They use their modeling of disciplinary discourse and the related learning possibilities of different disciplinary representations to develop a "generative metaphor" (Schön & Argyris, 1978) of *discursive fluency*: "By discursive fluency we mean a process through which handling a mode of disciplinary discourse with respect to a given disciplinary way of knowing in a given context becomes unproblematic, almost second-nature. Thus, in our characterization, if a person is said to be discursively fluent in a particular mode, then they come to understand the ways in which the discipline generally uses that mode when representing a particular way of knowing" (Airey & Linder, 2009, p. 33).

For a learner to become discursively fluent in introductory parts of the disciplinary discourse of astronomy, we argue that the concepts needed are those we illustrate in Figure 1:

- **Disciplinary representation:** the collection of disciplinary representations that makes up the 'disciplinary discourse' that enables disciplinary knowledge sharing.
- **Disciplinary literacy:** the ability to appropriately participate in the communicative practices of a discipline (Airey, 2011a; 2011b).
- **Reflective awareness:** the learning affordances that engagement with a collection of representations facilitates. The notion of reflection here is drawn from the work of Schön (for example, 1983) in that it is related to our learning experience and the noticing of new things and the noticing of things in new ways.



Recent reviews of astronomy education research show that almost all of the work done in this field has taken place at a pre-university level and that very little has been grounded in a disciplinary discourse perspective (Lelliott, 2010; Bailey, 2011). The work reported on in this paper goes towards addressing both shortcomings. It attempts to provide further understanding of the astronomy learning experience.

## Method

From a pilot study, conducted on a small group of nine physics learners and one astrophysicist expert, we obtained reflective descriptions showing how learners and experts differed in how they chose to describe what they noticed when viewing the Flight to the Virgo Cluster simulation. The learners' descriptions lead to fewer and characteristically less sophisticated categories (e.g. description of the Milky Way, relative distances between stars, nebulae and galaxies) whereas the experts' descriptions, besides being characteristically more sophisticated (e.g. shape and colour of nebulae, the 3D representation of the video versus elapsed time, stars and exoplanets, gravity and the shape of the galaxy), were also larger in number.

A survey was undertaken and made accessible on the web through the online survey: *Awareness of the Universe* at [www.hkr.se/AER](http://www.hkr.se/AER) (Username: galaxy, no Password). The data obtained for the case study reported on at the time of the ESERA 2011 conference was collected from some 34 participants from universities in both Sweden and the USA: 23 learners from across the Swedish university spectrum (Introductory astronomy, Astrobiology, Second year undergraduate physics learners, and Ph.D. students), and 11 experts from both Swedish and US university settings.

The participants were shown video clips extracted from the Flight to the Virgo Cluster simulation and were asked to reflect on what they had seen by answering the following questions:

*Watch this clip and answer the questions below! Please answer the questions in order of appearance, using numbers. If you have not noticed something new, feel free to say so.*

*1) Please write what comes to mind when you watch this clip, like things you noticed, sudden new realizations or connections, surprising or confusing things.*

*2) What, if any, "I wonder..." questions did this clip raise for you?*

The video clips were obtained by clipping a piece of the video into seven short logically holistic sections, lasting on average 15 seconds, and stopping the video at these points to allow for the participants to write down aspects of their reflective awareness which were related to each video clip (just watched).

After the seven clips were viewed and the accompanying questions answered, five follow up questions were asked so as to ascertain, for example, whether they knew where the journey started/ended and things what particularly caught their attention in the movie as a whole.

These written reflective descriptions were coded and sorted into constructed categories, using a constant comparison approach (Strauss and Corbin, 1998; Gibbs, 2002). In other words, the categories were not pre-defined, but rather emerged from the data.

## **Results and discussion**

The analysis of the on-line survey showed that learners' reflective descriptions were markedly different from those of the experts. In terms of the nature of awareness associated with the array of representations that made up the clips of video used for the study, shape, colour and 3-dimensionality were the most prominent in the constituting of conceptualizations in the reflective descriptions. In particular, the representations embedded in 3D generated a clear dimension of "noticing things in new ways", which collectively we characterized as "progressive layers of discernment". When comparing and contrasting learners and experts the profile of awareness categories differed as follows:

**Learners:** Orion, constellation, perspective, 3D, scale, gas blobs, nebulae, galaxy, colours, speed, structure, the Milky Way, etc.

**Experts:** Orion, constellation, perspective, 3D, scale, emission nebulae, reflection nebulae, absorption nebulae, stellar nurseries, time, speed, the Milky Way, other galaxies, distribution of stars, stars, star formation, stellar evolution, exoplanets, gravity, star clusters, excitation and de-excitation, HI and HII regions, parallax, etc.

These results are summarized in graphical form in **Figure 2** in terms of learner academic level and the average number of awareness categories that were identified in the video answers provided by the participants.

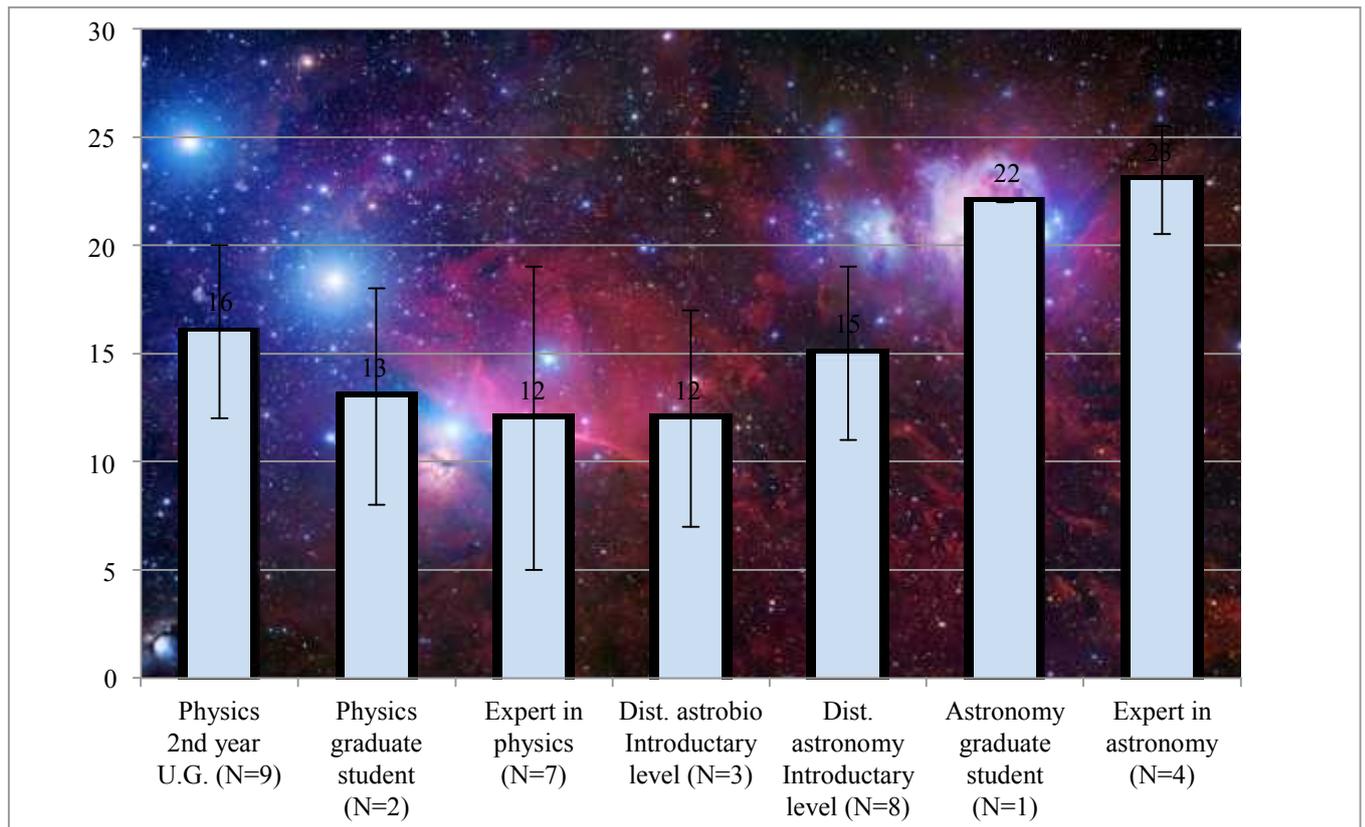


Figure 2 The preliminary results from the study, where the different groups of learners' are plotted on the horizontal axis in academic progression order/subject versus the number of used categories on the vertical axis. The heights of the bars are the average number of categories that we have identified for each group with N=x participants. The error bars are the standard deviations, or, if the number of participants in a group is too low it is the actual spread.

There were also clearly discernable differences between learners from the astrobiology course and learners from the astronomy course. The astrobiology-course learners awareness was grounded much more in esoteric descriptive items such as exoplanets, search for extra terrestrial life, space travel, and shining fog. On the other hand, the astronomy-course learners profile was very similar to that of their general physics counterparts in terms of the number of awareness categories that they used in their descriptions. However, the actual categories did not overlap nearly as well. The physics learners tended to use categories common to a more general physics realm, such as gravity, force, emission lines from different elements (H and He), and the colours of nebulae emanating from different elements and different atomic levels and transitions.

Perhaps the most intriguing result is that across all categories of learners the following categories of awareness were common:

- The experience of 3D -- new *2D-3D awareness*  
Many learners have not experienced the universe as a 3D space; they rather see the Universe in 2D terms, but the simulation gave them insight into the real structure of the universe.
- New *perspective awareness*  
The learners are surprised by the experience of the awareness of new perspectives. For example, noticing how the individual stars in the Orion constellation are at quite different distances from Earth, or seeing a structural view of Orion close up and then passing through.

- The enormous distances between stars and other structures in the galaxy -- the New *scale awareness*

The learners' answers revealed the difficulties that they had had in appreciating the enormous distances between structures and components of the universe, such as stars, nebulae, star clusters and galaxies.

- New *Time awareness*

This is an awareness that many learners struggle with in the sense that they do not realise that the Universe they see from Earth does not necessarily look anything like the Universe seen from other places. Because of the limitations that the speed of light introduces to the visual appearance of moving objects, the "actual Universe" is different from what one is able to see from Earth. However, in the simulation, the speed of travel is not related to the passing of time. The learners do not recognise this as being problematic, but they do appreciate that such a journey would take a very long time to actually undertake. On the other hand, the experts often pointed out that the video-presented journey would take too long for it to be possible for a person to experience in real life, and also that time affects the way the universe gets seen.

### **Conclusions and Implications**

Our study is situated in astronomy education research and focuses mainly on the awareness challenges university level astronomy learners' face when trying to create an appropriate visualization of the Universe – that is, in becoming focally aware of the fundamental components, structure, and interactive dynamics of our Universe. By using a realistic video, presenting the Milky Way through a virtual journey, the learners' are given a realistic opportunity to build a 3D, or even 4D (3D + time) picture of the Universe in their minds.

The number of new things that learners need to be able to bring into focal awareness from simulations that deals with properties, structures and interaction dynamics are enormous. To attain an appropriately appreciative understanding means learning to see new things and how to work with them in the context of a given observation. In doing the data analysis we saw how learners may quickly attain new awareness that underpins a deeper understanding of the structure and components of the Universe. This is an indication of the nature of representation affordance that can be evoked by a good simulation, such as the one used in our study, and how important it is for teachers to better understand this learning experience.

### **Acknowledgement**

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