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Reading the Sky and The Spiral of Teaching and Learning in Astronomy

Abstract

Teaching and learning astronomy is known to be both exciting and challenging. To learn astronomy demands not only disciplinary knowledge, but also ability to discern affordances from disciplinary specific representations used within the discourse, which we call *disciplinary discernment*, and ability to think spatially, which we refer to as *extrapolating three-dimensionality* from a two dimensional input. Disciplinary knowledge involves all the knowledge that constitutes the discipline, disciplinary discernment involves discernment of the affordances of disciplinary-specific representations, and extrapolating three-dimensionality involves the ability to visualize in ones mind how a three-dimensional astronomical object may look from a two-dimensional input (image or simulation). In this paper we argue that these abilities are intertwined and to learn astronomy at any level demands becoming fluent in all three. A framework is presented for how these abilities can be described and combined as a new and innovative way to frame teaching and learning in astronomy for optimizing the learning outcome of students - what we refer to as developing the ability to *Read the Sky*. We conclude that this is a vital competency needed for learning astronomy and suggest strategies for how to implement this to improve astronomy education.

Keywords: Reading the Sky, Astronomy Education Research, Higher education

Introduction

Learning astronomy at any level is known to be very exciting but also difficult for many students (Eriksson, 2014). Astronomy education is a particularly challenging experience for students because discernment of the ‘real’ Universe is extremely restricted, making interpretation of the many disciplinary-specific representations used by the discipline an important educational issue. The ability to ‘fluently’ discern the disciplinary affordances (Fredlund, Airey, & Linder, 2012) of these representations becomes crucial for the effective learning of astronomy, where *learning* is a function of ‘becoming fluent’ in using disciplinary-specific representations, that is achieving ‘fluency’ in a disciplinary discourse (Airey & Linder, 2009). Such learning is made possible by experiencing pertinent patterns of variation; patterns that facilitate noticing educationally critical aspects from representations (Marton & Booth, 1997). We call this ability *disciplinary discernment* and define it as *noticing, reflecting and making meaning* of something from a *disciplinary perspective* (Eriksson, Linder, Airey, & Redfors, 2014a). Furthermore, disciplinary discernment is found to be possible to describe and characterize by a hierarchy of discernment levels, referred to as an *Anatomy of Disciplinary Discernment (ADD)* (Eriksson et al., 2014a).

However, to understand the Universe, we argue that specific experiences are called for. These experiences are connected to a very important ability; the ability to extrapolate three-dimensionality from the two-dimensional input usually available to students in astronomy (Eriksson, Linder, Airey, & Redfors, 2014b). This ability is considered by many to be central to the learning of astronomy. However, only very little research exists to support this claim (Eriksson, 2014; Heyer, Slater, & Slater, 2013). Simulations could offer these experiences, where *parallax motion* is a crucial component. In a qualitative study, we have analysed astronomy students’ and lecturers’ discernment while watching a simulation video (Tully, 2012), and found a

hierarchy that characterize the discernment in terms of three-*dimensionality extrapolation* (Eriksson et al., 2014b). From these results, both the ADD and the extrapolation of three-dimensionality hierarchy are found to depend on disciplinary knowledge.

We combined these findings to define and propose a new theoretical framework important for teaching and learning of astronomy – *Reading the Sky* (Eriksson, 2014). The metaphor of “reading” something has many meanings and application. We draw on the concepts of *reading the landscape* (Wylie, 2007) and *reading nature* (Magntorn, 2007), capturing the varying ability to discern and interpret how disciplinary-specific representations get used to share perceptions, knowledge and meaning-making within a discipline. It involves observations and measurements, which have great importance for all of astronomy, but also how these are perceived. As such, *Reading the Sky* is grounded in disciplinarity and bridges the gap between the discipline of astronomy and the meaning making that gets constructed from observations and measurements by astronomy learners. *Reading the Sky* thus concerns *disciplinary discernment of any representation* belonging to the astronomy discourse. However, the discerned disciplinary affordances (Fredlund et al., 2012) will only constitute a subset of those, set by the discipline for a particular representation (cf. Podolefsky & Finkelstein, 2008). Hence, there is a potential risk of students missing educationally relevant aspects because of e.g., cognitive overload (Mayer, 2003, 2009) or, by only focussing on the most visually compelling things which might not be relevant for the task at hand (Elby, 2000; Marton & Booth, 1997).

Based on the above, the aim for this paper is to discuss and problematize:

How can the idea characterized as *Reading the Sky* inform the teaching and learning of astronomy?

Discussion

In this paper it is argued that becoming part of the discourse of astronomy involves being able to fluently *Read the Sky* by interpreting, understanding and using the many different representations that astronomers use to communicate disciplinary knowledge. Using a disciplinary discourse perspective (Airey & Linder, 2009), *Reading the Sky* calls for the two abilities, ‘Disciplinary Discernment’ and ‘Extrapolating three-dimensionality’ to be linked to ‘Observations and Experiences’ and ‘Disciplinary Knowledge’ in order to be able to ‘see’ through vision, and ‘interpret’ through the affordance of disciplinary-specific representations, the Universe. See Figure 1. From the hierarchies for the ADD and the Extrapolation of three-dimensionality (Eriksson et al., 2014a, 2014b), we propose that *Reading the Sky* can be seen as a competency highly important for learning astronomy. Building on the results from Eriksson et al. (2014a, 2014b) *Reading the Sky* can be described by intertwining these hierarchies with disciplinary knowledge into a 3D *Spiral of Teaching and Learning of Astronomy*, see Figure 2. This framework provides the clear connection between the abilities needed for competently both teach and learn astronomy. Learning astronomy involves all three abilities, and research has shown that novice learners have very limited abilities when it comes to both disciplinary discernment and extrapolation of three-dimensionality (Eriksson et al., 2014a, 2014b; Hegarty, 2014). Consequently, teaching astronomy must involve much more than disciplinary knowledge; the astronomy teacher need to take into account both disciplinary discernment, which is very different for students compared to teachers (Bransford, Brown, & Cocking, 2000), and the ability to extrapolate three-dimensionality, which takes lots of practice to competently master (Eriksson et al., 2014b), by providing learning situations and exercises that particularly address all these issues. To do that, teachers must first probe for where the learners are in the discernment hierarchies before starting any teaching sequence (cf. Ausubel, Novak, & Hanesian, 1978). As a result, the role of the teacher becomes very im-

portant in generating the scaffolding needed to help students *cross over category boundaries* in the hierarchies in *the Spiral of Teaching and Learning* in achieving *Reading the Sky* - competency.

Conclusion

The argument in this paper is that the proposed theoretical framework should be seen by astronomy teachers to offer a new way of planning teaching and learning spirals to enable students to become part of the disciplinary discourse of astronomy. Students need to learn to *Read the Sky*, or else they will only see and not discern.

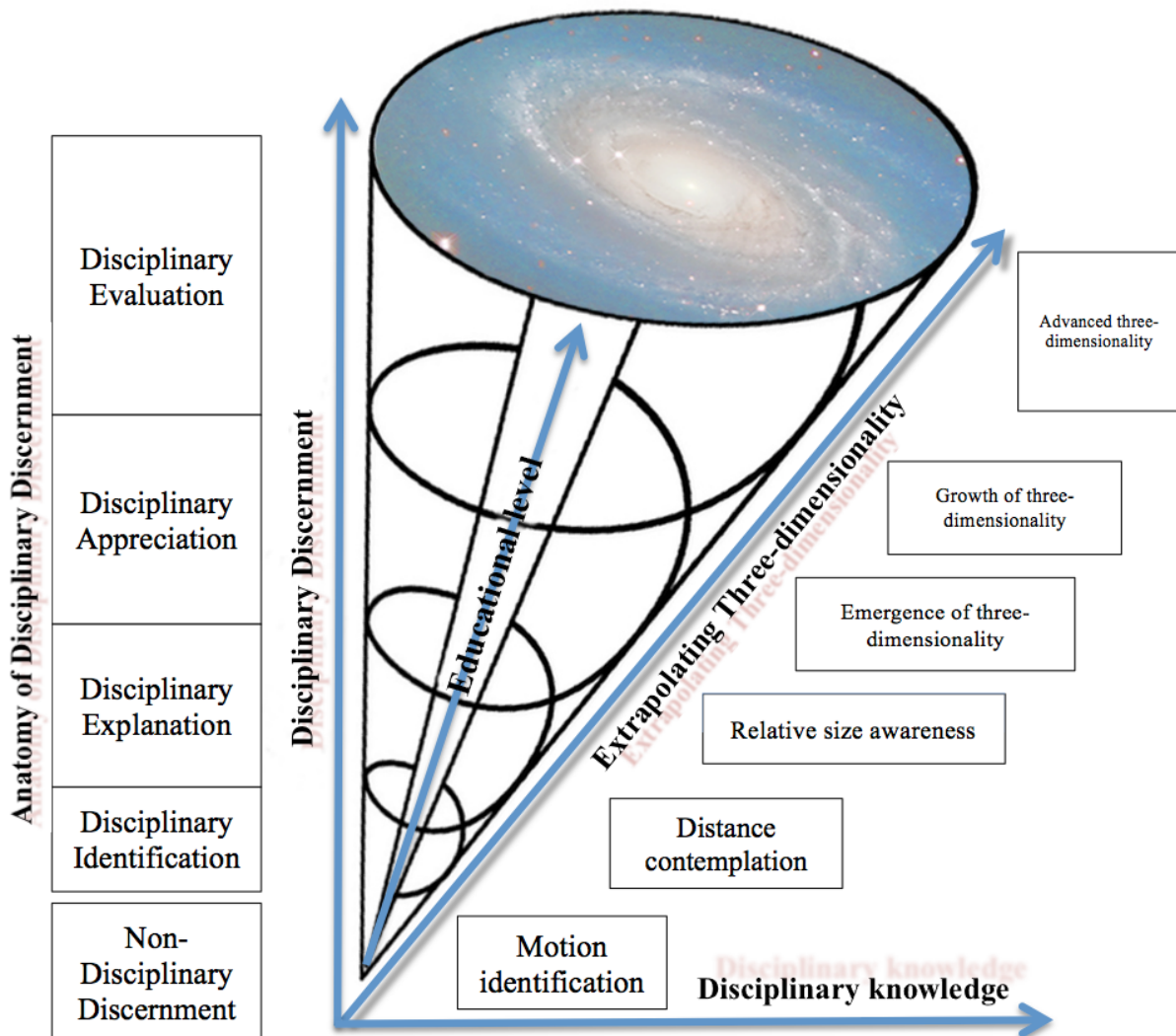


Figure 1. A concept map illustrating the competency *Reading the Sky*.

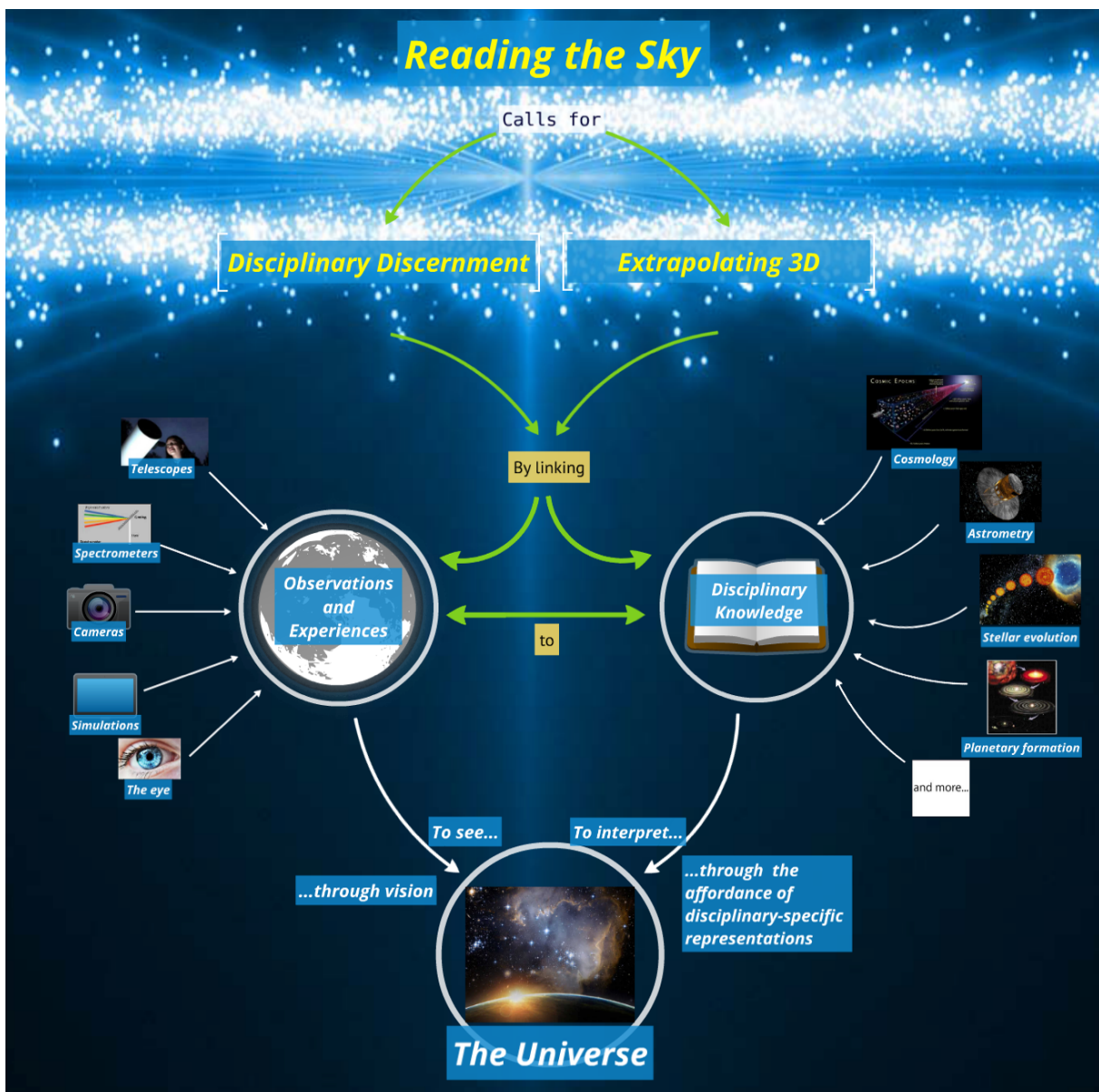


Figure 2. This idealized representation illustrates Reading the Sky as constituted by three abilities: Disciplinary discernment, Extrapolating three-dimensionality, and Disciplinary knowledge. We refer to this three-dimensional space as the ‘spiral of teaching and learning’. Since these abilities are intertwined with each other, there are numerous possible learning trajectories for the teacher to consider.

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