DISCIPLINARY DISCERNMENT IN ASTRONOMY EDUCATION – HERTZSPRUNG-RUSSELL-DIAGRAMS

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This paper aim at investigating what astronomy students and experts discern from the multitude of different disciplinary affordances available in Hertzsprung-Russell (HR) diagrams. HR-diagrams are central to all of astronomy and astrophysics and used extensively in teaching. However, knowledge about what students and experts discern from these disciplinary representations are not well known at present. HR-diagrams include many disciplinary affordances that may be hidden to the novice student, hence we aim at investigating and describing what astronomy students at different university levels (introductory, undergraduate, graduate), and astronomy educators/professors, discern from such representation – referred to as disciplinary discernment. Data from a web based questionnaire were analysed using the Anatomy of Disciplinary Discernment (ADD) framework by Eriksson et al.(2014). Preliminary results show (1) the developmental nature of disciplinary discernment from the HR-diagram by the participants and (2) the large discrepancy between disciplinary discernment by the astronomy educators and their students. We describe and discuss the qualitative nature of these differences and implications for teaching and learning astronomy.

Keywords: Disciplinary Discernment, HR-diagram, Astronomy Higher Education

INTRODUCTION

Hertzsprung-Russell (HR) diagrams are extensively used in teaching astronomy at university level, but very little is known on what understanding students have from encounters with such disciplinary-specific representation (Brogt, 2009). It is clear that disciplinary-specific representations harbour many disciplinary affordances which are used to communicate disciplinary knowledge within a particular discourse (Fredlund, Linder, Airey, & Linder, 2014). HR-diagrams are no different in this perspective (Airey & Eriksson, 2014). However, these representations are very specialized and the astronomical knowledge that is present in such a representation could be very difficult for students to discern. For a student to be able to discern the disciplinary affordances of such a representation, (s)he needs to be able to "read" the representation using the "language" of astronomy, referred to as *Reading the Sky* (Eriksson, 2014). This is challenging for many students, but very little, research has been identified addressing this issue. In this paper, we present how disciplinary discernment from HR-diagrams can be described and addressed.

BACKGROUND

In this section, we describe the background of the HR-diagram and the theoretical framework, which this work is based upon, including the concepts *disciplinary affordance*, *disciplinary discernment*, and the ability to "read" such representations.

The HR diagram

An HR-diagram is a graphical representation of stellar luminosities versus temperature, spectral class or colour. It is commonly used in all stellar astrophysics to get a visual representation over stellar populations, and stellar evolution. It was developed in the early 20th

century, independently by Ejnar Hertzsprung and Henry Norris Russell. It was not until 1933 that the representation became more commonly accepted as a "Hertzsprung-Russell-diagram" (Nielsen, 1964). When examining such a representation, it becomes obvious that there are many disciplinary affordances not easily discerned by novice students.

Disciplinary affordances

Disciplinary affordance was defined by Fredlund, Airey, and Linder (2012) as "the potential of a given semiotic resource to provide access to disciplinary knowledge" (p. 658). This means that a "semiotic resource", in our case the HR-diagram, has some inherent affordances, defined by the discipline, and those are to be discerned by a student and understood from a disciplinary perspective. Learning astronomy can then be problematized in terms of coming to appreciate the disciplinary affordances of representations used in the discipline.

The Anatomy of Disciplinary Discernment

Learning astronomy, or any other discipline, involves a process of knowing "*what* to focus on in a given situation and *how* to interpret in an appropriate, disciplinary manner" (Eriksson, Linder, Airey, & Redfors, 2014). This process of learning can then be framed in terms of discerning the intended meaning of representations; what is referred to as disciplinary discernment. Eriksson et al. (2014) define *disciplinary discernment* as "noticing something, reflecting on it, and constructing meaning from a disciplinary perspective" (p. 170). However, disciplinary discernment depends on one's disciplinary knowledge and can be described by a hierarchy called the Anatomy of Disciplinary Discernment (ADD). The ADD "encapsulates the increasing complexity of intended meaning of representations.[..] It describes the ways in which the disciplinary affordances of a given representation may be discerned" (Eriksson et al., 2014). The process of disciplinary discernment is done by the student (Eriksson, 2014), whereas the unpacking of the representations is done by the educator (Fredlund et al., 2014).

Research Questions (RQ)

1) What do university astronomy students and lecturers/professors discern from an exemplary HR-diagram?
2) What qualitative differences in disciplinary discernment can be identified between the university astronomy students and the lecturers/professors?

RESEARCH METHOD

Using the framework described above, in particular the ADD, we constructed a web questionnaire with a number of multiple-choice and open-ended questions in relation to a specific HR-diagram (Eriksson, 2007). The questionnaire[1] was developed and tested on a group of astronomy experts for relevance and, after minor refinement, the final questionnaire was launched online and sent to astronomy education institutions in Sweden, South Africa, and the USA for distribution amongst students and astronomers. The rich data from the 50 respondents was analysed using the ADD categories, developed from a standard qualitative hermeneutic method (Eriksson et al., 2014; Seebohm, 2004).

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[1] See https://hkr.itslearning.com/test/r.aspx?XS=rsyzzasyemoyg

RESULTS

Since the analysis is ongoing, preliminary results are presented here. For RQ1 the ADD-based analysis indicates that most students discern basic parameters, such as temperature, luminosity, spectral class. The educators/professors generally correctly discern more details within the HR-diagram, even those that are not immediately given by the representation, such as AGB, stellar variability, etc. For RQ2 preliminary findings are that students struggle to interpret the many disciplinary affordances that the HR-diagram holds. From the ADD-framework indications are that most of the first-year students are found in the first disciplinary discernment category of the ADD (Disciplinary Identification). For post-first-year students' disciplinary discernment are more related to the categories Disciplinary Explanation and Disciplinary Appreciation (categories 3 and 4), whereas the educator/professors are commonly found in the top Disciplinary Evaluation category.

DISCUSSION AND CONCLUSIONS

We find that there are large discrepancies between what students and educators/professors report discerning from the HR-diagram. This discrepancy may risk affecting teaching and learning in negative ways, leading to less effective teaching and even development of misconceptions by the students, if the unpacking of relevant disciplinary aspects of the HR-diagrams is not done insightfully. Our results confirm earlier research and as an educator one need to consider these aspects in planning and performing teaching sequences. Students need to learn to *read* representations or else they may only see but not discern.

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