Contribution ID: **130** Type: **Oral Presentation**

Probing introductory astronomy students' notions of relative size and distance of celestial objects. Part II

Tuesday, 2 October 2018 09:10 (20 minutes)

How is the present collective view of our place in the cosmos reflected in the mind of an individual? This is an important question to consider when teaching astronomy, as the descriptions involve the seemingly familiar, like space and time, yet on scales that are not easily comprehensible within simple mental models.

As outlined in Part I of the present work, we explore how students in an introductory astronomy course conceive cosmic-scale sizes and distances. We present our analysis of student responses from the IAQ_R, the modified version of the IAQ [Rajpaul et al. 2014. Phys Rev] described in Part I.

Our preliminary findings confirm previous findings with regard to the notions held by both cohorts of these students (South African and Norwegian) not only in terms of the presence of these notions but also insofar as the proportions of students is concerned [Lindstrøm et al. 2016. 2015 PERC Proc.]. Amongst these notions are perceptions that stars are smaller than planets, the overestimation of earth's atmosphere extent into space, and the presence of other stars "within" our solar system. As noted in the previous work, we also explore the correlation between students' quality of knowledge of celestial objects and their ranking in size and then consider what limitations such a correlation (or lack thereof) may have in revealing the importance of spatial awareness in astronomical knowledge.

As extensions to the previous IAQ analysis, we discuss in detail (a) how the extra level of freedom (including =) in the size ranking task plays itself out in the results obtained and (b) how size ranking correlates with distance ranking. With regard to the latter we show that a higher proportion of the respondents who underestimate star size in the ranking task also appear to underestimate the relative distance of the nearest star to the sun.

We suggest that the results of the present and previous studies are clear indications that learning about cosmic scales is challenging from a fundamental cognitive perspective. Eriksson has used a social semiotic framework to show clearly that Disciplinary Discernment is key to learning astronomy [Eriksson et al. 2017. EJSME]. We suggest there may be an even more fundamental aspect that underpins the cognitive structure on which Disciplinary Discernment may depend. An embodied cognition perspective places spatial engagement as a central component of much abstract thinking as evidenced in the cognitive linguistic literature on conceptual metaphor [Lakoff 2000]. Thus, we theorize that the key challenge arises from the difficulties of "compressing" the cosmic scales to within human comprehension. Furthermore we suggest that the embodied cognition standpoint allows us insight into developing intervention methods that tap into the same neural mechanisms that allow people to spatially map their immediate surroundings, thus aiding students in building spatial mental models of the cosmos. Such interventions would potentially be done with planetarium and virtual reality technologies, projects currently being explored by the authors as doctoral research.

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PhD

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Session Classification: Parallel Session 2

Track Classification: Track L - Other (Please elaborate under comments below)