

Concepts and tools from the learning sciences for linking research, teaching and practice around sustainability issues

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Though the research, teaching and civic missions of the modern university have often been considered distinct, changing notions of knowledge and practice suggest increased synergy. This paper develops insights stemming from the learning and developmental sciences on the nature of learning, its relation to practice, and how one can better design environments where learning can flourish. It explores ways the learning science literature could be much more effectively leveraged in study programs for sustainability. Using the proposed requisites of sustainable education programs provided in the typology of the first article of this special issue, we examine whether and how learning science theory and research can contribute to such ongoing efforts.

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Sustainability researchers and educators have viewed learning as an active and social process of transformation (Koenig, 2015). In this article, we explore how such a view can be enhanced by explication from theory and research in the learning and developmental sciences. Sustainability science research is both challenging and exciting because of the inter-disciplinary and transdisciplinary nature of knowledge building in this area. Sustainability scientists seek wisdom from a new generation to solve some of the most pressing environmental challenges humans face. This suggests the need for creating contexts where innovation can take place. A core question arises concerning how one frames research, teaching and civic missions of universities so as to maintain vibrant practices where novices are not simply viewed as apprentices growing into fixed communities, like a hand into a glove. In this article we discuss theory

and research that highlight ways to conceptualize practice based learning as involving communities of learners where group variation is a driver of innovation. In addition to examining literature on what is known from the learning and developmental sciences about human learning, we also review theory and research about how to best design such environments to maximize their impact.

Conceptualizing learning

Learning scientists can contribute to a more nuanced understanding of transformative learning and in particular ways to deepen sustainability science goals of building ecosystems that build the transformative social learning necessary for sustainable futures. Views of learning in the developmental and learning sciences discuss learning as a situated and social activity; where emphasis is placed on deep and lasting learning as opposed to surface learning, and where learning is viewed in terms of an extended developmental process that involves both active construction on the part of the individual, as well as input from the surrounding environment. To this extent, development and learning pathways are not biologically pre-determined but co-constructed. Three ways to elaborate on the view of learning and development in this article are presented here under the headers: first, learning is situated; second, learning is deep; and third, learning is a developmental process.

Learning is situated: conceptions of learning have moved increasingly away from unidirectional models of instructionism that focus on passive reception of knowledge. As noted by Koenig (2015) sustainability science researchers have increasingly focused on engaging students in what have been called high impact experiences [1]. The focus on experiential learning is a welcome shift away from instructionist models of learning, but such work has yet to fully engage with the vast amount of theorizing and research in the developmental and learning sciences related to situated learning, a view that goes well beyond student engagement in authentic social activities.

According to situated views, learning not only takes place in and through participation but involves the adoption of practices, beliefs, and values of specific communities of practice. Communities of practice are fundamental spaces within which learning and practice take place (see [2,3,4,5]). As practitioners, members of such communities do not only engage in activity but also come together

to develop a shared repertoire of resources. The resources may include shared experiences, stories, tools, and ways of addressing recurring problems. This cultural stock provides assets for new members as they enter and further the goals of the community. In this sense, the community comes to share a wide range of practices developed over a sustained period of time through ongoing efforts at working together on common and meaningful problems (see [5]). Participation ‘refers not just to local events of engagement in certain activities with certain people, but to a more encompassing process of being active participants in the practices of social communities and constructing identities in relation to these communities’ ([5], p. 4). This perspective has much to offer sustainability scientists.

Learning is deep: the instructional model of learning is based on a form of learning known in the learning sciences as surface learning. Students acquire through rote memorization a series of disconnected facts and procedures. One problem identified with surface learning is that students have difficulty accessing such superficially learned material in future learning. Learning scientists have noted that engagement with knowledge building is central to learning. But from this perspective, experience alone does not contribute to knowledge building and the formation of expertise. Learners must draw upon a significant knowledge base and familiarity with the tools available to the communities of practice and disciplines they engage with for deep learning to occur. Learning scientists have provided a large body of evidence that the formation of expertise involves a lot more than acquiring isolated facts and procedures, and draws upon practice with applying new knowledge in situations while learning and practicing how to use and modify new knowledge in authentic situations calling for unscripted solutions.

Developmental research has highlighted that learning is enhanced when learners are placed in situations where attention is placed on a prior knowledge and beliefs that learners bring to a given learning situation. Knowledge is constructed not only within interaction but based on and in relation to prior knowledge and beliefs. Such research has emphasized that experts pull from interactive situations very different knowledge than novices. And experts have also been shown to organize the knowledge they are acquiring in very different conceptual frameworks than novices. This suggests that a major aspect of learning depends on the construction of a richly structured knowledge base. Knowledge building takes place in interaction but is a complex developmental process that takes place over extended time most frequently by engaging in authentic or unscripted problems that call for the use of new learning (see [6,7,8**]).

Learning is a developmental process: developmental and learning science researchers have suggested at least three

ways in which learning is a complex developmental process. First, students as learners enter learning at different phases of development; for instance, teenage learners and slightly older emerging adults have been noted to learn in significantly different ways [9,10]. Second, regardless of chronological age, expertise itself develops. Becoming a routine expert versus an adaptive expert involves different developmental trajectories. A routine expert is capable of repeating similar processes for ends that do not change, while an adaptive expert learns strategies for adapting for uncertain futures. Third, we know that because learning is situated, that learners are not fixed in their abilities and perform in different ways due to the environmental supports provided. We will take up each of these concepts in turn.

First, learners bring to the task of learning different capacities. For instance in a series of studies of high school and college learning of the same material (Introductory Psychology coursework), it has been found that high school and first year college students bring significant misconceptions to their studies which only after further time and experience change, when compared to the learning of upper level college students learning very similar material [10]. This work highlights the role that conceptual shifts play in learning; these conceptual shifts are reorganized across the college years as students are exposed to models and frameworks that challenge some of the knowledge frameworks they bring to their learning. One outcome of these findings highlights the important role instructors can play in conceptual shifts over developmental time by making their own theories and conceptualizations explicit and available for the students to learn from. Emphasis here is on understanding student understanding of material rather than what information teachers present. Learning is interpretive and meaning making a dynamic process [11].

Second, it is often thought that students first learn foundational material and then come to apply and revise prior learning to be an adaptive learner. Studies actually show that routine learning and adaptive learning follow distinct developmental trajectories. While routine and adaptive learners can both solve routine problems that they have become familiar with; what separates adaptive learners is their ability to solve problems that they have never experienced. One of the distinctive features is the extent to which adaptive learners have come to understand how to work in knowledge rich environments. One aspect that is characteristic of adaptive learners is their ability to draw on environmental supports through the use of the resources at their disposal [12]. This is central to work on sustainability science given the view that we are preparing students to contribute to uncertain futures and problems sustainability scientists cannot imagine. This suggests the importance of providing students with experiences where they come to know their strengths and

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