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A pedagogical approach to solar energy education

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ABSTRACT

The aim in this paper is to upgrade experiences from traditional studies on solar energy education to include social, sociological and pedagogical aspects. This is done in order to develop insights *beyond* production of artifacts. The aim is promotion of educational means for utilization of the artifacts developed. This includes upgrading knowledge about hardware as well as about software, and in this process also to upgrade our ways of thinking. This implies changing our neurological *mindset* in accordance with continuous development of knowledge within these domains.

The scope of this paper is thus to discuss development of curricula and pedagogical means for teaching and learning within the domain of renewable energy education. The paper also aims to make a tentative approach to include solar energy education within the framework of an *upgraded version of the socio-cultural theory for learning*. A tentative approach is also made, with the intention, to connect this educational domain to *educational neuroscience* and to contemporary research on *creativity*.

1. Introduction

1.1. Research questions

1. Could renewable energy education be enriched by creating links to the socio– *cultural theory of learning* and to *educational neuroscience* or by being framed within an *Innovative Learning Environment*, according to how this concept has been developed and presented by OECD?
2. Does implementation of renewable energy systems and/or education in our society imply *Revolution, Evolution, Enrichment or Provocation* education in or utilization of traditional energy resources?"

1.2. Theoretical and didactical background

The aim in this paper is to upgrade experiences from our earlier studies of solar energy education (Ott and Broman, 1988, Blum et al. 1988) to include modern and up to date aspects of educational theories. This study is thus founded on application of recent development and upgrading of *the socio-cultural theory for learning,* which was founded by the Russian psychologist Lew Vygotsky (1896–1934), (Vygotsky, 1978). In order to, try to extend this theory *beyond*, the legacy from Vygotsky, we might have reason to study, in a tentative way, a theory named;: "*design oriented didactical thinking*" (Selander, 2017).

The *socio-cultural theory for learning* is founded on three key concepts: *The Learning Subject; The Physical World* and *Mediating Artifacts.* In this theory *the Subject* is exploring or exploiting *the Physical World* using *Mediating Artifacts*. These artifacts may consist of physical, material - or nonmaterial artifacts which are employed as tools. These artifacts include, for example, *language, signs or theories.* By utilizing this theoretical approach we get access to a useful theoretical and conceptual "*toolbox*" which grants us access to powerful theoretical concepts as for example: *Mediation, appropriation, Zone of Proximal Development, enculturation etc.*

In this upgraded version of the socio – cultural theory for learning, the *Subject* is regarded as a *biological* creature having a *learning brain* of *biological* and *evolutionary* origin containing *phylological* and *ontological* qualities. The *mind* is regarded as being embodied within the *brain* while the brain is embedded in the continuously changing socio-cultural environment. The Subject is thus, by heritage, enculturated into an ever changing *historical, social, societal* and *cultural* context. The *Physical World* is continuously changing depending and affected by human interventions, inventions and actions. *The Mediating Artifacts*, which are our tools for interaction with different aspects of our world, are also changing and developing rapidly since they are created by the human innovative and creative brain.

The *Physical World* has, according to neuroscience (Spitzer, 2007, Dweck, 2006) a counterpart in our mindsets. Thus *internal representations* of the Physical World are created within our brain. The

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neuroscientist Steven Pinker (Pinker, 1997) argues that: "*Mind is what Brain does* ". This view is however challenged by David Siegel. Siegel argues that the human mind is not just enclosed in the brain but at the same time distributed in our body and also affected by the minds that these other humans we interact with. In some applications, the Physical World may, in our postindustrial epoch, be substituted by *Virtual Reality* which is taking place in a *Virtual Cyberworld.*

The theoretical approach of this paper, relates to a theoretical aspect proposed by Selander (ibid), which extends beyond, and exceeds, the Vygotskian legacy. According to Selander, the Physical World may be regarded from a point of view which takes into account current trends in sociology like *globalization and digitalization.* This approach points out that our physical and mental worlds interact which each other and thus are in a state of continuous change.

These aspects might however become increasingly more important in the context of renewable energy education. Especially important is a mental process named *mind change* as indicated by the English neuroscientist Susann Greenfield in her book *Mind Change,* (Greenfield, 2014). She argues that mind change, according to her view, is caused by modern digital technologies, and is as threatening for pollution of the minds of future generations as the reality of climate change, which is caused by pollution of our atmosphere.

A seminal citation by Tom Brown (Brown et. al. 2009) is mentioned in Selander (2017):

> "*Design has the power to enrich our lives by changing our emotions through images, form, texture, colour sound and smell. The intrinsically human – centered nature of design thinking points to the next step: we can use our empathy and understanding of people to design experiences that create opportunities for active engagement and participation."*

The aim of the present paper is however to try to exceed further beyond this design inspired theoretical and didactical perspective. The aim is to make a constructive and fruitful connection to *educational neuroscience.* An important and inspiring connection between neuroscience and creativity is presented by Vartanian et al. (2013).

The connection, of this paper, with sociology is expressed by the philosopher Zygmund Baumann who characterizes our Industrial Modern era as *"solid modernity"*. This is in contrast to the post-industrial and postmodern era which he denotes as a "*a liquid modernity*" (Bauman, 2015). Thus a socio-historical approach is introduced into the field of renewable energy education. This approach is also discussed in its connection to education by the author Andy Hargreaves, (Hargreaves, 1994).

Our theoretical approach will finally also be connected to OECDs model of an Innovative Learning Environment, *ILE,* (Dumont et al. 2010). This approach is extensively discussed in "The ILe Handbook", (Online, 2015).

2. Discussion

In our discussion we have to take into account a number of ***challenges*** to our contemporary tradition in regard to education (Didau 2015, Ravitch 2011). These challenges might affect and threaten our subjective and mental "*comfort zone"*. When we respond to these challenges we should instead find it fruitful to leave this "bounded" zone in order to enter the "unbounded" Vygotskian "*Zone of Proximal Development" ZPD,* (ibid.)

The acronym ZPD represents a theoretical mental zone which characterizes operational possibilities for optimizing learning efficiencies for learners. This zone could be regarded as the mental area which is situated beyond the mental area in which the learner already has acquired sufficient and functional personal subjective knowledge, but hither to that mental area where learners have no useful subjective knowledge at all. In the ZPD, the learner may be scaffolded by either her teacher or more knowledgeable peers, in approaches for learning subject knowledge.

2.1. The first challenge

The first challenge regards the fact that it is of value to introduce the learning process by formulation questions about the meaning of the pedagogical concept *education.* This concept includes aspects of teaching, as well as of learning. Selander (ibid) point out that the modern design aspect of didactics implies that we should try to exceed beyond these classical theories for teaching and learning, which are based on the *"transmission paradigm*." This implies a paradigmatic change and a challenge of traditional educational process in which teachers subject knowledge is supposed to be possible to be, often verbally, transferred to the learner. The learner has, at a later test, to try to reproduce this information.

In the Swedish school system a paradigmatic curricular change occurred in the year 1994. Earlier the national Swedish curriculum included a great amount of facts which were to be learned by heart by students. As time went by, these collections of facts, which teachers had to try to transfer to their students, tended however to become cumbersome and enormous extensive.

This paradigmatic curricular change implicated a change from the traditional mode of teachers transferring facts, to teaching with an aim of developing skills and abilities so that students should be able to locate matter, which makes sense, about a topic and thus be able to create functional knowledge by themselves. The mantra, describing this process, was formulated as: "*No one can teach anybody anything. The learner is the sole agent for her own learning. Learning in the brain is an inaccessible and invisible process"*. According to educational psychology and educational neuroscience no one is able to look into a learners brain. It is obvious that learning takes place in the brain of the learner by changing synaptical connections and thus creating neural networks. Therefore we think it would be fruitful to introduce aspects of educational neuroscience for application in renewable energy education.

This paradigmatic change was by some educators regarded as a real threat to the Swedish traditional educational system. It was regarded as an explanation to why Swedish students, after this paradigmatic change, started to show poor results in international rankings lists as, for example, in a sequence of PISA studies. An interesting discussion of this issue, from the US perspective, was made by Diane Ravitch (2011). Her conclusion was that the wellbeing of a nation does not depend on the results of achievements of 15 year old students in PISA studies.

The concept *design* might not only be regarded as associated with for example industrial design, which focuses *form and function.* As a matter of fact design has its origin in the unification of *form* and *the creation of meaning.* In the design oriented didactical perspective, which is an evolution of the socio-cultural theory for learning, the student is asked to interpret the teacher's instructions according to her own mindset, (Dweck, 2006).

This implies that the student has to act as a proactive co-producer of knowledge, instead of being a passive recipient. This implies also a challenge for teachers, who maybe, are teaching according to more traditional manners.

In this context, the importance of *creativity* is touched upon. By making connections between renewable energy education and educational neuroscience it is fruitful to try to involve this important concept. Shelly Carson (Carson, 2010) has written a book with the telling title *Your Creative Brain.* Other scientists follow suite (De Bono, 2015, Kaufman and Gregoire, 2015).

The important point is that instead of applying a *top – down flow* of academically established information, our intention is to try to initiate a *bottom –up counter-flow* of demand for meaningful information from learners. This flow of information should be transformed to personal knowledge by the student – and on her own terms be integrated with existing knowledge in her neural network.

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