5.0 COLLABORATIVE LEARNING

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ABSTRACT

In this exploration of the term 'collaborative learning' we draw on an initial EPPI search (see introduction) and an in-depth study of selected articles, which reveal that the term 'collaborative learning' is placed in a spectrum between collective and cooperative learning and it involves social and material processes. The review has brought a new breakthrough insight, namely that we use the term learning collaborative learning to define a socio-material process which aligns the contributors' understanding of material artefacts and common goals without being a completely collective or merely cooperative learning. From this finding, it is suggested that efforts toward collaborative learning can be useful both internally, among the REELER researchers, and in the project work itself, in bringing roboticists and other affected stakeholders together to achieve collectively shared goals.

5.1 Opening

Collaborative learning was chosen as a key concept for the REELER project because our main hypothesis is that roboticists need new tools to improve their knowledge of and collaboration with affected stakeholders, in order to improve the creation of responsible and ethical robotics in Europe.

One inspiration for the concept was the work of the educational psychologist Anne Edwards and her work on *relational* expertise (Edwards 2010), which we see as a prerequisite for collaborative learning. The notion of collaborative learning in robotics opens up for basic discussions of what *learning* refers to. Is learning referring to the process of learning something in particular? Is it an outcome of a process? Is this process always tied to teaching and pedagogy? Is it an individual or a collective process or outcome?

Many scholars from many disciplines have sought to answer these questions. As a result, the learning sciences are far from a cumulative science, like physics for instance. Instead it has a rhizomic shape which is characterized by proliferating sprouts from many sources that are connected without being cumulative.

There are three major fields in the learning sciences: 1) the educational learning sciences, 2) the work-related learning sciences, and 3) the basic learning sciences. All of these fields overlap within each field and across the fields both in themes and theories.

In the educational learning sciences, scholars study teaching, learning and the relation between the two (Sawyer 2006). The aim of these scientific endeavours is to develop more effective learning environments, whether these are school settings or computer-based tutoring software. Another branch of the learning sciences looks at organizational learning, and asks questions about the relation between the collective and the individual from that position (Fenwick 2008). In this field, the aim is to develop work-based learning (Billett, Harteis and Gruber 2014). Still others explore what learning is as a basic process and outcome. This field of basic learning sciences discusses, for example, whether the capability for learning is what make humans a unique species (Tomasello and Rakoczy 2003). In biology, the endeavour is to explore learning as a process of cognitive material processes.

To make the path clear between the concept of collaborative learning and its importance for our research and our interest in the development of the roboticists relational agency it is therefore necessary to explain in depth what we mean by collaborative learning.

5.2 Methodology

In our scrutiny of the concept of collaborative learning, we draw on a review search combined with other sources (see Appendix 1, section ii. Collaborative Learning).[1] While the literature search was primarily approached as an EPPI search (see section 2.1 Quantitative approach), the other sources were drawn from the experienced knowledge of the scholars involved in the review as well as forthcoming publications[2]. This combined knowledge makes it possible to create an analytical approach that includes new concepts that relate to the concept of *collaborative learning,* even if this connection was not an initial purpose of the review.

The database query followed the EPPI-inspired systematic approach. The purpose of the EPPI search and this overview article is to clarify what we mean when we use a term like *collaborative learning* and how others (within or related to our field) have used the same term. Furthermore, we need to clarify when the term is not relevant for our research and finally we need to describe any breakthrough/new way in the way we use the term (see section 5.9 Conclusion).

We have identified a number of salient articles (referred to in this chapter) partly identified through the review but mainly through a combination of the reviewer's prior insights and review results. These articles have been chosen for their relevance to the REELER context. We have found that it may be useful to distinguish other concepts often discussed in relation to collaborative learning: collective learning and cooperative learning.

It can be noted that the EPPI-inspired review has shown both the strengths and weaknesses of an approach which is only superficially analytical in so far the EPPI review is mainly contributing with a quantitative insight into *where* the concept of *collaborative learning* is perceived as an important concept. It is when we dive into the articles and combine these with other sources that the concept of collaborative learning gets a deeper and more complex meaning to be discussed in the REELER project.

5.3 Etymology

Collaborative learning is a concept with roots in work practices. The Latin origin of collaborative is *collaborates – co-* refer to together or with and laborare refer to work or labour. Learning is a much more complex term. Originally it had both the meaning "to teach" and "to learn". It has roots in Old English where *leornian* meant "to acquire knowledge" connected to the German, Dutch and Nordic *lernen,* leeren, *lære* with roots in Gothic "lais" *I know* – with a reference to 'finding one's way'. In the Online Etymology Dictionary, it is furthermore connected to the German *Gleis* (track), and the Old English/Nordic *læst* – referring to the sole of the foot.[3]

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1 Appendix 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

2 For example, paragraphs and ideas under development for the forthcoming publication Hasse, 2018. *Posthuman Learning.* Routledge

3 http://www.etymonline.com

From c. 1200 till c. 1900, learning became associated with the transitive meaning of 'teaching' (he *learned* me English) expressed in 'a learned man'. From c. 1900, it was restricted to the concept of *learning* meaning *learning something.*
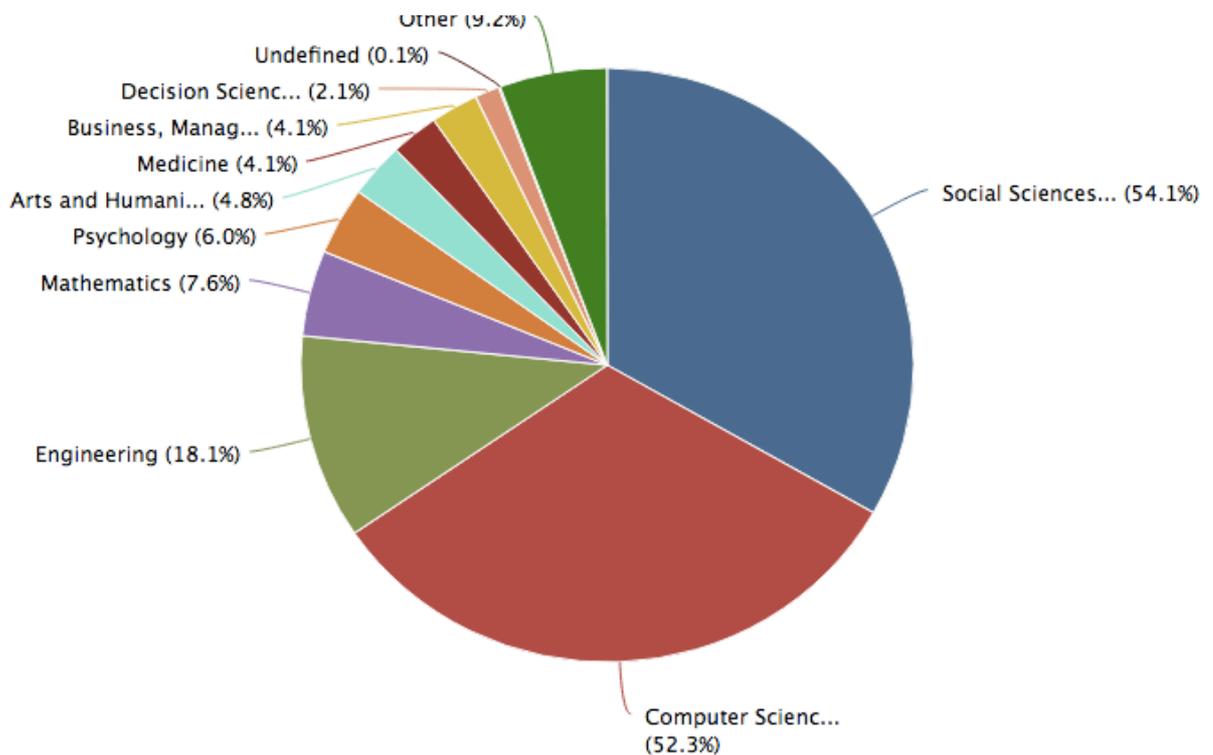
Collaborative learning first appeared as a term in education in the 1950s and 60s tied to some student's inability to enter a budding mass-educational policy and their ability to improve when engaging in peer-learning (Bruffee 1984, 636).

Thus, *collaborative learning* literally could be said to refer to people learning to find their way and gain knowledge together by working together.

5.4 Collaborative learning explored

It appears from our database searches that the term *collaborative learning* has been used and explored as a concept in different disciplines with significant portion in educational research. The search results also show that within a range of publication years spanning from 1975-2017, 2009-2016 was the year range with the absolute highest number of publications. 2009 was therefore chosen as the right publication year under selection criteria. As mentioned in the chapter methodology section, the initial outcome of the database search provided a quantitative overview of disciplines in which the term is used and types of documents. The following numbers are taken for the search in SCOPUS, which elicited the most hits; Collaborative learning without references to robots elicited more than 11.000 hits spread over the following disciplines and 103 referred to robots and collaborative learning (see Appendix 1, section ii. Collaborative Learning).4

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4 Appendix 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

Pie chart with the following segments:
- Social Sciences... (54.1%)
- Computer Scienc... (52.3%)
- Engineering (18.1%)
- Mathematics (7.6%)
- Psychology (6.0%)
- Arts and Humani... (4.8%)
- Medicine (4.1%)
- Business, Manag... (4.1%)
- Decision Scienc... (2.1%)
- Undefined (0.1%)
- Other (9.2%)

Model 1. First word query of 'collaborative learning' within SCOPUS

Further scrutiny of the connection between robots and collaborative learning reveal that these connections are mainly made in the learning sciences where collaborative learning is often connected to the STEM-related areas (Science, Technology, Engineering and Mathematics) (Sawyer 2006).

Collaborative learning has in our further explorations of the term shown to be placed in a spectrum between collective learning as the most basic alignment process of meaning-making and cooperative learning as the less aligned process of engagements between humans – though all of the three concepts are also sometime used interchangeably. As a basic concept, collaborative learning can be explored partly in relation to basic research in the learning sciences and partly in relation to basic research in how humans learn and develop collectively. In the following we explain three main ways of use and scientific exploration of collaborative learning of relevance to the REELER project: the basic process of collective, collaborative and cooperative learning as they have been understood in educational, policy and work-related research.

Collective   Collaborative   Cooperative

5.5 Basic processes: collective learning

The first thing to note is that learning is not explored solely in educational research. It is a basic concept tied to cultural and societal change (e.g. Mantzavinos 2004). Furthermore, some argue that human capability for learning is the fundamental process defining humankind as a species (Tomasello 1993). This approach to learning is not about individual but collective, collaborative and cooperative learning. Humans are not only social but are characterized as a species as ultrasocial learners (Tomasello 1999, Hermann et al. 2007). The most basic process for ultrasocial learners is 'collective learning' as this apply

to a general aspect of humankind. Collective learning is the learning where we align our beings through meaning- and material makings in the world. Collaborative learning and cooperative learning are depending on the collective learning that forms shared perceptions of artefacts, shared basic mental models, and shared word meanings (Hasse 2015).

Collective learning of some concepts, beliefs, etc. ensures a common ground for collaboration:

> "A common ground of mutual understanding, knowledge, beliefs, assumptions, pre-suppositions, and so on, has been claimed to be necessary for many aspects of communication and collaboration. Grounding is the process by which agents augment and maintain such a common ground."

> (Baker et al. 1999, 33)

It is in this field of basic learning research, whether dealing with education, organizations or human evolution, that the question is posed: what is the difference between individual and collective learning? The basic answer given by learning scientists like Michael Tomasello is that humans are naturally born collaborative learners with a propensity for altruism (e.g. Tomasello and Rakoczy 2003). When culture allows, this propensity can grow and develop because as children we already show a salient shared intentionality with others (Tomasello and Carpenter 2007).

Philosophy does not refer to collective intentionality as emerging from a collective learning process (Schweikard and Schmid 2013), but following Tomasello, it is the cultural learning tied to upbringing and material resources that will determine whether a natural propensity for collectively shared intentionality will develop or will be impeded. This approach challenges the general psychological approach to learning as a primarily individual process. We are not born as individuals but learn to become more individual than collective through cultural learning processes. In anthropology, studies have argued that our Western culture is much more individually focused than most other cultures (e.g. Dumont 1986). This kind of boundary confirming thinking separating the West from the Rest has however also been challenged (Bubandt and Otto 2010, 8-9). It may be that how we define ourselves as individuals or collectively is tied to conceptual boundary-making more than how we actually learn.

In organizational studies and learning we also find a basic interest in moving away from individuals as learners to a more collective and network based understanding of learning (e.g. Engeström 1987). Tara Fenwick (2008) has found eight different ways that scholars have discussed the difference between individual and collective learning in organisations. The way learning is understood ranges from purely individual learning to organisations as learners.

When learning is seen as purely individual knowledge acquisition, individual human development through learning may become organizational resources. The environment is seen as separate from the individual learners, who are also seen as autonomous in relation to a community. Within this line of thinking, learners can have different views of organizational work.

> "Learning is portrayed in terms of the effects of social, cultural cognitive contexts and the involvement of relational dynamics such as identity and trust, but the fundamental focus remains the learning individual. Environment is only a mediating factor on individual learning and cognition, separate from the individual, not entwined with it."

Other ways of understanding learning are as learning in communities of practices (Lave and Wenger 1991). In this approach, the focus is on the practices of the community, not the individual learner. Learning is not a cognitive acquisition of knowledge, but as participation:

"…embodied in the joint action evident in a community of practice (CoP)…the individual does not receive particular attention as separate from the community: the relation of individual learning processes to collective processes is rarely actually theorized, so individual difference in perspective, disposition, position, social/cultural capital, and forms of participation is often unaccounted for."

(Fenwick 2008, 7)

Learning can also be seen as a series of utility networks within and across organizations, often electronically-enabled. In this approach learning is thus conceptualized as "receiving information that moves around in a linear fashion: the information itself is portrayed as remaining undisturbed by its movements or by the tinkering of individuals and groups that receive it" (Fenwick 2008, 5). Between these severed ways of understanding the relation between individuals and collectives we find a 'third way' that emphasizes the intermingling of individuals and collectives.

In a more dialogical learning is seen as both an individual and a collective construction of new or altered meanings. In these approaches the humans involved are affected by learning. The approach can also be one of co-participation or co-emergence. This approach to learning is hard to pin down due to a variety of ways of defining the merging between individuals and collectives:

"yet all appeared fundamentally to share an emphasis on emergence, co-participation and mutual constitution. In this orientation, individual and social processes are each unique but enmeshed, and deserve examination at micro and macro levels of analysis. Learning is knowledge creation through social participation in everyday work. The conception is of mutual interaction and modification between individual actors, their histories, motivations and perspectives, and the collective (including social structures, cultural norms and histories, other actors)."

(Fenwick 2008, 8)

In policy, too, collective learning is important because:

"Learning among policy actors can play a key role in shaping whether and how actors come to agreement around their understanding of policy problems, such as solving the budget crisis, adapting to climate change, or making critical diplomatic and strategic decisions. Learning also plays a role in shaping the types of policy solutions policy actors devise and implement. It is not just how individuals learn in policy processes that is important but also how groups of individuals in collective policy contexts learn that is critical for understanding policy issues and solutions and translating that knowledge into policy change. These collective policy contexts may include interest groups, public agencies, coalitions, policy networks, commissions, and legislatures, to name a few."

(Heikkila and Gerlak 2013, 484)

Collective learning differs in degree from collaborative and co-operative learning. When referring to collective learning there has been an alignment of meaning-making among the actors (Hasse 2015). This co-productive understanding of collective learning processes may be the most interesting for us to proceed with in our exploration of collaborative learning.

5.6 Collaborative learning

Ultimately collaborative learning is how humans have moved from controlling their environments with stone-carved hand-axes to modern oil drilling platforms and heated housing, electricity and robots. Though collaborative learning may also be defined as collective there are nuances in relation to how much the participants engaging in collaborative learning may share with one another. What is necessary, however, it that collaborative learners acknowledge each other as collaborators. In collective learning (implying a sameness) this may not be required. There is a vast literature in educational research on how collaborative learning enhances the knowledge and critically-informed thinking of all participants (e.g. Gokhale 1995).

In a more basic understanding, collaborative learning relies on a concept of the reflective agent and involves integrated perspective-taking (reflective intersubjectivity) (Tomasello et al. 1993, 495). In collaborative learning participants share a common goal, but not necessarily all meaning-making tied to reaching the common goal (Dillenbourg 1999).

As is clear from our review (see Appendix 1, section ii. Collaborative Learning)5, collaborative learning has received extensive attention in educational research especially related to the (Science, Technology, Engineering, and Math) STEM-related areas. It has also increasingly become a meaningful term in work-related research where it is often connected to other concepts like 'team-work' or 'group-work' (Bell, Kozlowski and Blawath 2012) dating back to Peter Senge's acknowledgement (1990) that in organisations it is not individuals, but teams, that learn.

In educational research, there are general definitions of collaborative learning, made by e.g. like Pierre Dillenbourg:

> "The broadest (but unsatisfactory) definition of 'collaborative learning' is that it is a situation in which two or more people learn or attempt to learn something together. Each element of this definition can be interpreted in different ways:
>
> • 'two or more' may be interpreted as a pair, a small group (3-5 subjects), a class (20-30 subjects), a community (a few hundreds or thousands of people), a society (several thousands or millions of people)... and all intermediate levels.
>
> • 'learn something' may be interpreted as 'follow a course', 'study course material', 'perform learning activities such as problem solving", 'learn from lifelong work practice'....
>
> • 'together' may be interpreted as different forms of interaction: face-to-face or computermediated, synchronous or not, frequent in time or not, whether it is a truly joint effort or whether the labour is divided in a systematic way.

5 Appendix 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

These three elements of the definition define the space of what is encountered under the label 'collaborative learning': pairs learning through intensive synchronous joint problem solving during one or two hours, groups of students using electronic mail during a one-year course, communities of professionals developing a specific culture across generations."

(Dillenbourg 1999, 1-2)

In educational research, many see collaborative learning as tied to a neo-Vygotskyan framework emphasizing peer-learning, collective concept-formation, and the zone of proximal development (Vygotsky 1978). Though there is some discussion over what the zone of proximal development refers to, it is generally perceived as a mental construction of the learning process tied to development. Though originally developed to understand diversity of learning and development of children in school, it has since been expanded to include human activities in general (e.g. Engeström 1987). We learn more than we know and can reflect upon – yet by collaborating with peers and other more knowledgeable persons we can open for a new zone of collective development. This development is, of course, relative to the environment and to the task at hand (Hasse 2001).

Learning is not development but as dialectical process between learners (Vygotsky 1997) and their material surroundings. What we learn will spur our next developments. Over time, learning with peers in this way aligns our ways of conceptualizing the material world and our ways of communicating about it (Hasse 2015). Through collaborative inquiries we may build up a collective meaning-making (Lee and Smagorinsky 2000). However, as noted by Anne Edwards, a collaboration is not making us alike, but giving a group a collective direction in the shape of common motives and mutual understandings for each other's diverse expertise (Edwards 2010).

Pierre Dillenbourg (1999) make the same point when he discusses why robots cannot collaborate. He says that robots' contrary to humans do not have the ability to have neither personal nor common goals. Though they may have been coded to do the same task, they will not react if their actions affect the conditions for actions of other agents. Humans on the other hand can learn to share a goal even if their goals initially differ: "If one transposes this notion of common goal from artificial agents to real people engaged in real life situations, one cannot simply assume that partners have completely shared goals, even if some external agent fixes this goal" (Dillenbourg 1999, 8). Dillenbourgh recounts a case of two nurses and a physician, who despite sharing a common goal, are not entirely aligned:

"[They] have different expectations with respect to the joint project, because what they learn will affect differently the work practice in their own professional community. Shared goals can only be partially set up at the outset of collaboration, they have themselves to be negotiated (and probably revised as work progresses). Establishing common goals is part of constructing common grounds, since actions cannot be interpreted without referring to (shared) goals, and reciprocally, goal discrepancies are often revealed through disagreement on action. Through the negotiation of goals, agents do not only develop shared goals, but they also become *mutually aware of their shared goals*."

(Dillenbourg 1999, 8)

In collaborative learning, humans in a group do not learn as a collective (collective learning implies here learning exactly the same). In collaborative learning, they can make use of their diverse competence and thus divide the *labour* among group members. However, through a process of

collaborative learning there will gradually be a convergence of knowledge, which aligns how the partners understand the common goal (Jeong and Chi 2007, Roschelle 1992). This convergence is not tied to collectively shared cognitive representations of all tasks between the group members, but rather to an alignment of word-meanings and understandings of materiality like robots. Word-meaning is, in the Vygotskyan tradition, an aligned process of forming complex connections between words, meanings and a material world (Vygotsky 1987). This is not all together a rational process but draws on intuition, emotion, and engaged perception (Vygotsky 1971).

Following Edwards, collaborators need to share motives working towards common goals, but not core expertise (Edwards 2010). Though collaborative learning requires that all parties are equally *engaged* when working towards a common goal, they do not need collectively to share all the expertise needed as long as they can make use of each other's diverse expertise. They need the relational agency required to 1) recognize the resources and motives that others bring to bear as they begin to interpret the common problem space (the object-motive) and 2) resourcefully participating in expanding the problem space by "aligning one's own responses to the newly enhanced interpretations with the responses being made by the other professionals while acting on the expanded object" (Edwards, 2010, 14). Collaborative learning demands a relational agency that builds on an evolving expertise where the engaged parties recognize: "what others can offer a shared enterprise and why they offer it; and being able to work with what others offer while also making visible and accessible what matters for you" (Edwards 2012, 26).

5.7 Cooperative learning

In the learning sciences, it is common to make a distinction between 'collaboration' and 'cooperation':

> "Collaboration and cooperation are sometimes used as synonymous terms, while other scholars use these terms distinctively according the degree of division of labour and learning. In cooperation, partners split the work, solve sub-tasks individually and then assemble the partial results into the final output. In collaboration, partners do the work 'together'."

> (Dillenbourg 1999, 8)

Both collaborative and cooperative learning share a rejection of learning as purely individual (Stahl et al. 2006). They differ in how the they view the way individuals and/or groups contribute to a common goal and share a common motive. In collaboration, there is an alignment towards a shared understanding (Roschelle 1992) whereas in the cooperation each party (individual or group) contributes without necessarily sharing the overall understanding of a common goal. Thus, in cooperative learning, that learning can remain within a local group or individuals *without* attempts of sharing how the local group or individual themselves view the obtained knowledge or insights. What is shared may be papers with information, but there are not processes of aligned negotiation or attempts to understand the others perspective. So, what makes collaborative and cooperative learning differ from each other is that there are no attempts to negotiate and share meaning-making processes (Stahl et al. 2006).

As noted by Pierre Dillenbourg (1999), the actual division of labour and sharing is a matter of degree, but he makes an important distinction between a horizontal and vertical division of labour in learning something together:

"When one partner does the task-level and the other the meta-level, this leads to a *'horizontal'* division of labour into reasoning layers. This is quite different from the *vertical* division of work into independent sub-tasks as in cooperative situations. The difference is two-fold. Firstly, the layers have to be highly interwoven (one subject monitoring the other) while sub-tasks are independent. Secondly, the horizontal division of labour is unstable in collaboration (it is stable in coaching for instance), roles may shift every few minutes, with the regulator becoming the regulated, while cooperation refers to a more fixed division of labour."

(Dillenbourg 1999, 8)

Thus, the difference between collaboration and cooperation is that true collaboration requires that the partners take turns in contributing to the meta-level of the task at hand, and engage themselves in the negotiations that can develop the mutual learning process. Whereas in cooperative learning, it is enough to learn about a specific area without negotiations leading to a wider shared understanding. However, as also noted in the literature, collaboration and cooperation are often used interchangeably as when collaborative learning is defined as cooperation: "a purposeful relationship in which all parties strategically chose to cooperate in order to accomplish a shared outcome" (Rubin 2002, 17).

5.8 Materiality and collaborative learning

In the learning sciences (Sawyer 2006) there has been an increasing focus on the materiality and situatedness of learning (Johri and Olds 2011). This new perspective emphasises that material artefacts are implicated in all learning (Sørensen 2009). Often, the connection between materiality and collaboration is viewed rather functionally as how best to support inquiry processes through e.g. computer-supported collaborative learning (CSCL) (e.g. Roschelle and Pea 2002). That approach leaves a lot of unanswered questions about how materiality and collaboration actually inform each other in situated practice.

One attempted answer concerns, in a more basic way than the instrumental approach, how we can study the relation between material surroundings. Our material surroundings are in a way so boring and mundane (Star 1999, 377) that we tend to overlook their importance for learning together. Yet, it is these materials that connect human endeavours whether writing articles, doing research or building a robot. We cannot study directly what goes on in people's heads when they handle materials and how they learn from each other engaging with shared material surroundings (Roth 2011). A focus on the material aspects of how we learn to work together will, however, reveal that humans do not collectively not share understandings of all the materials they are supposed to collaborate about.

In a distributed cognition perspective (Hutchins 1993) this may not be a problem because we distribute our expertise in order to achieve a goal like making a ship sail. This distribution acknowledges that our situated perspectives on the ship and its materials may differ as when a captain and a sailor focus and understand different aspects of the sailing process. Distributed cognition may even be embedded in the instruments used like measuring devices (Hutchins 1995). When it is noted that: "Materiality is evident not just in physical objects or tools, but in representations as well" (Sørensen 2011, 161) that raises the question how we should differ between 'physical objects' and representations and what effect that may have for studies of collaborative learning.

If materiality is evident in representations, the opposite is not the case. Representations are not evident in materiality; and maybe representations are not even the right concept to capture the complexity between a material world and how we come to share our meaningful engagement with it. In an STS perspective Bruno Latour has suggested that what we can study is not meaning-making of material artefacts, but the distribution of agency. When a hotel manager decides to make hotel keys heavier in order to ensure that the guests do not forget to leave the keys at the reception desk, agency is delegated to the keys themselves that 'remind' guests of leaving the keys with the clerk because of their increased weights (Latour 1990). Humans and non-human artefacts (like keys, or computers) act as hybrids with entangled human and non-human agency (ibid). From this perspective, learning occurs not just as a "product of social interaction, but as a hybrid, socio-material process" that engineering educations should acknowledge (Sørensen 2011, 161). Furthermore "learning differed when different materials were involved" (Sørensen 2011, 162) – a point also made by Jamie Wallace (2012).

In the sciences, we make visual representations available for each other in the form of graphs, photographs, drawings, diagrams, tables, or equations (Roth 2003). When psychologists explain how we learn collaboratively from these visual representations, they emphasise that these material artefacts are mental representations (images). This however, does not explain how material instantiations become something we think with. As noted by Roth: "no distinction is made between what scientists and science students make available to each other in face-to-face interactions or in written media (journals, books, Web pages, chalkboards, read-outs from instruments) and the unobservable processes of the mind" (Roth 2011, 164). This discussion has been ongoing in anthropology since its beginning: "namely, how to conceptualize the dialectic between the crystallization of such directive "patterns of meaning" and the concrete course of social life" (Geertz 1973, 250-251). The new focus on materiality it its own right has focused on the properties of materials and how the materials may be bearers of affordances (e.g. Ingold 2007). Though many have acknowledged that when engaging with materials we cannot exclude the observers from the material world we engage with (e.g. Karen Barad's concept of 2007 'intra-activity'; Donna Haraway's concept of 'material-semiotic' 1999), there is not much understanding of the process that link materials and the observer's collaborative human perceptions.

In underlining the study of the properties of the materials, Ingold (2007) argues that the notion of materiality has been replaced to a focus on the materials in themselves and their effects rather than abstract conceptions of 'materiality'. From an anthropological point of view collaborative learning still open questions about the very processes through which a group of humans come to perceive external materials as representations. How do we learn to interpret material inscriptions (like graphs and models) in the same ways and what are the learning processes involved? And do the interpretations of such materials as graphs differ fundamentally from interpretations of other material objects like robots?

As external, cultural-historical forms, robots can be studied as material artefacts, but one of the questions raised from a material approach to collaborative learning is what it takes for 'users' or affected stakeholders and roboticists to align their perceptions, and ultimately visions, of robots. Following Vygotsky, human thinking is first social and then individualized (1987-1999). Whereas mental processes in themselves are unobservable, from an anthropological point of view we may be

able to study of alignment processes when roboticists and affected stakeholders meet to learn from each other. We cannot assume that this happens just because we sit in the same room and listen to each other. There are complex processes involved when our mindsets become aligned. We can, however, follow the communicative processes as they evolve, as argued by Wolff-Michael Roth (2011). Furthermore, whether an aligned communication will evolve into new collaborative practices will remain to be seen.

5.9 Conclusion

It was through readings and discussions in the group that we found collaborative learning to be connected to two other concepts: collective and cooperative learning. Though the EPPI-search did not in itself reveal the importance of placing collaborative learning in a wider analytical spectrum including collective and cooperative learning the EPPI search confirmed that collaborative learning is a multidisciplinary concept with a significant presence in educational research. For our purpose, collaborative learning refer to a process of learning together through a mutual engagement where each participant brings their expertise to bear on a collectively shared goal.

When we use a term like 'collaborative learning' we may by now conclude that the term refers to a collaborative process of learning by mutual engagement in a project with a common goal. In education, the common goal of collaborative learning is often pre-defined as a particular outcome which is not the case in REELER. In basic research, there is an evolving approach, where each new insight may lead to a reformulation of the initial basic research questions. Our way of using the term is both tied to the work-based research as well as education and basic research. The review has brought a new breakthrough insight, namely that we use the term collaborative learning to define a socio-material process which aligns the contributors' understanding of material artefacts and common goals without being a completely collective or merely cooperative learning.

In REELER, collaborative learning may be the key to achieving common goals across the disciplines of SSH and robotics, but also between roboticists and affected stakeholders, and society at large.

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