‘TECHNOLOGY-ENHANCED LEARNING’ AS AN INTERDISCIPLINARY EPISTEMIC COMMUNITY

Exploring Epistemological Characteristics of a Transnational
Research Network beyond Traditional Disciplines

Master’s Thesis

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Philip Meyer

"WE TELL MORE THAN WE CAN KNOW."[1]

L. Lindkvist, Linköping, Sweden, 2005

[1] Lindkvist (2005, p. 1205) refers to the epistemological maxim of knowledge collectives. In contrast, traditional communities "know more than they can tell".

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[2] Q = Research Question

I. INTRODUCTION

> *"Scientists tend to resist interdisciplinary inquiries into their own territory. In many instances, such parochialism is founded on the fear that intrusion from other disciplines would compete unfairly for limited financial resources and thus diminish their own opportunity for research."* [3]
>
> **Hannes Alfvén**

Nobel Prize Laureate
Founder of Modern Plasma Physics

Despite the fact that he was awarded with the Nobel Prize in 1970, Hannes Alfvén remained an outsider in the Physics scientific community (Stuewer, 2006, p. 104). His theories on plasma cosmology often stood in contrast to the mainstream view of other physicists. The commonly accepted big bang theory, from his point, is a scientific myth (*cf.* Alfvén, 1984), relying on mathematical calculations, rather than empirical observation. Due to his unconventional research he was often refused funding and forced to publish his papers in "obscure journals" (Stuewer, p. 104). This led him to become an active speaker against the ruling peer review[4] system, where committees were dominated by supporters of the big bang theory (Lerner, 2004). Even after Alfvén's death, scientists of non-standard physics still struggle for funding. They call for support in a letter to the scientific community, which is openly accessible on the internet[5].

When talking about the possibility of interdisciplinarity[6] in science, the often political dimension of financial funding is a factor that is not to be neglected. Felt (2009) includes it, when describing her concept of "epistemic[7] living spaces". It pays tribute to the intertwinedness of the "personal, the institutional, the epistemic, the symbolic and the political" dimension as determinates for scientific research (p. 19). Brew (2008), goes one step further, claiming that disciplines come into existence along requirements such as funding. Therefore, she argues, the funding committees should keep their understanding of disciplinary boundaries „open" (p. 424) and broad, in order to allow more interdisciplinary and innovative en-

[3] As cited in Peratt (1988, p. 192)
[4] The term "peer review" refers to the ruling institutions and committees, which are meant to seek and ensure quality control for scientific contributions.
[5] See: www.cosmologystatement.org
[6] The concept of interdisciplinarity is going to be defined in chapter 2. For now, it can be considered as a close and integrative collaboration between two or more disciplines.
[7] Referring to epistemology as the theory of knowledge

deavours. According to Conole, Scanlon, Mundin, & Farrow (2010), the metrics for assessing research are also part of the problem, as prestigious journals, funding opportunities, and individual research contributions tend to "mitigate against interdisciplinarity" (p. 38).

In some countries, though, there are a number of interdisciplinary funding initiatives, as it is on the agenda of leading research councils (Kerr, & Lorenz-Meyer, 2009, p. 156). The KNOWING study, funded by the EU under the 6th Framework Programme, identified the UK to put more emphasis on interdisciplinarity, in contrast to e.g. Slovakia and the Czech Republic. This was especially the case for the biosciences (p. 156), but also for the social sciences, which are more disciplinary in that comparison (p. 159).

The domain of technology-enhanced learning (TEL) gained attention in the beginning 1990s, as computers became more advanced (Westera, 2009, p. 4). It is an interdisciplinary research field by definition, as it "investigates how information and communication technologies can be used to support learning and teaching"[8]. On the technology side it features the engineering sciences, and on the learning side the social sciences, especially pedagogy, psychology, and related. Within Europe, TEL research endeavours are funded by the European Commission in its ICT programme (European Commission, 2011a). The study at hand has been conducted in context of the STELLARnet project, which is also EU funded. However as indicated before, political support is an important but never sufficient condition for interdisciplinary collaboration. Still, as Conole et al. (2010) point out for the UK context, researchers rarely work in interdisciplinary research institutions (p. 38). Therefore, emphasis is put on the 'network' concept, as networks offer ways to "assure relationships across boundaries" (Felt & Stöckelová, 2009, p. 59), be they epistemic, institutional or national. This thesis will treat networks as specific forms of communities that do not require co-location and are defined by weak social ties (Amin & Roberts, 2006, p. 7).

Along other instruments, the STELLARnet project involves the social network platform TELeurope, which allows researchers from all across Europe to network and "connect to other experts" in the field (TELeurope.eu, 2011).

For this thesis 123 researchers from the TELeurope.eu platform, which in total has around 1.000 registered members, provided detailed information about their research practices, personal and institutional backgrounds and opinions towards

[8] Short definition by the European Commission (2011a). The field of TEL is going to be characterised in more detail in chapter 3.

interdisciplinarity. The data has been combined with the TELeurope database, holding information about the relationships between the study participants. Before this study has been conducted, extensive data on academic backgrounds of TEL researchers was lacking[9]. Besides that, the thesis at hand has been inspired by a current discussion within the TEL community, whether there are TEL specific scientific features, which can be agreed on across the sciences. Conole et al. (2010) were looking into the methods used by TEL researchers, finding indicators for a shared methodology. Another example is the *TEL dictionary initiative Group* on the social network platform *Linked In*[10]. It discusses, if there is a shared terminology within the field, trying to establish a universal, cross-disciplinary dictionary.

1.1 Thesis Classification and Research Objectives

The study adds to the discussion at the before mentioned points. By comparing individual backgrounds and opinions towards interdisciplinary issues with indicators of cross-disciplinary work in the field, the nature of European TEL research is to be discovered. These indicators are e.g. epistemology, methodology, and terminology, in the sense that they are derived from one or established disciplines, such as computer science and social science. It is then to show in how far interdisciplinarity is considered as something worth striving for and if there are already shared traits in the researchers' ways of working in the field.

The following concrete research questions are to be answered:

Q1: In how far is there a *sense of joint enterprise* in the TEL community?

a) Do European TEL researchers refer to themselves as being "interdisciplinary"?
b) Do they agree with different attitudinal statements towards interdisciplinarity?
c) Do they use a similar terminology/vocabulary?
d) Are they interested in the same core research areas?

Q2: In how far is there a *shared repertoire* of TEL research practices?

a) Do European TEL researchers practice similar activities?
b) Do European TEL researchers use theories and methods from multiple disciplines? Are there theories/methods that can count as cross-disciplinary in TEL

[9] The member profiles on TELeurope.eu do provide the possibility to tell about one's academic background. This feature however is used only by few member of the community. Also, the STELLAR Delphi study (Spada et al., 2011) identified core research areas without putting emphasis on methodology and research practices.

[10] See: http://www.linkedin.com/groups/TEL-dictionary-initiative-3880196

Q3: In how far do TEL researchers embrace an *open dialogue* with the broader public?
   a) Do European TEL researchers involve the (international) public in their work?
   b) Do they publish their works in Open Access formats or do they rather use conventional publishing formats?

Q4: In how far are researchers connected to other researchers in *mutual engagement*? Do friendship relations on TELeurope.eu happen across disciplinary lines?

From a theoretical point, the research questions Q1, Q2 and Q4 are derived from Wenger's (1998) concept of *communities of practice (CoP),* which can also be applied to networks. The three core elements, which make a professional community, are in this respect a sense of joint enterprise, a shared repertoire of resources including language, routines, artefacts, and stories, as well as mutual engagement in relationships (Wenger, 1998, pp. 72-84). Here the study aims at testing assumptions raised by qualitative studies on the nature of the TEL community (Conole et al., 2010; Kraker & Lindstaedt, 2011). While much quantitative TEL research focuses on co-authorship and co-attendance of conferences (Voigt, Heinze, Herder & Kress, 2011; Ebner & Reinhardt, 2009), this thesis follows a contrasting approach by taking individual epistemological practices into special account.

The third research question Q3 involves a different concept of interdisciplinarity as introduced by Frodeman, Mitcham, and Sachs (2001, pp. 6-7). They distinguish 'deep interdisciplinarity', which involves the broader public, from the common 'wide interdisciplinarity', which happens between different science branches (p. 4). Main goal here is to find out, whether the results of a study on Open Access Publishing, which has been conducted by the German Research Foundation (DFG, 2005), can be confirmed. No major differences in the publication behaviour of the European TEL community are expected, as compared to the general German scientific community focussed in the initial study.

Taking a holistic view on interdisciplinarity, this thesis assumes that co-authorship and conference co-attendance are not sufficient indicators for a strong interconnection between disciplines. In a pragmatic fashion, interdisciplinarity is here to be viewed as 'reflective practice' (Romm, 1998, pp. 63). The thesis' questionnaire respectively asks for individual opinions and practices and is tailored to the characteristics of the disciplines that make TEL. Moreover, the study's approach corresponds to the broad OECD definition of interdisciplinarity, ranging from simple communication of ideas to the mutual integration of organising concepts, methodology, procedures, epistemology and terminology (cit. in Berger, 1972, pp. 25–26).

1.2 Thesis Structure

In order to answer the research questions, the thesis is structured as follows:

Chapter 2 deals with interdisciplinarity as a concept, which originated in modern times. At first, societal and historic conditions for the promotion of interdisciplinarity are addressed, stressing the timeliness of the thesis at hand. Then, the term interdisciplinarity is to be defined and described in detail, also taking constraints to interdisciplinarity into account. Special attention is given to open access publishing, as it is thought to contribute to interdisciplinarity in research.

Chapter 3 is about knowledge creation in scientific disciplines, with a special focus on the 'communities of practice' concept. Knowledge/epistemic/expert communities are outlined and distinguished as special forms of social groupings. Moreover, different ways of how interdisciplinarity can be fostered in academic communities of practice are going to be outlined.

Chapter 4 focuses on the domain of Technology-Enhanced Learning and the disciplines that contribute to it. First of all, the political context of TEL research in Europe and STELLARnet as a Network of Excellence are explained. Then, possible epistemological and methodological features of the young field of TEL are described. The thesis takes a look on the corresponding disciplines, i.e. the computer sciences on the one hand, and the social sciences and humanities on the other hand. Interdisciplinary aspects of these scientific fields are stressed, including also practices of open access publishing across disciplinary borders.

Chapter 5 is dedicated to the empirical part of the master's thesis at hand. With reference to the research questions the study's instrument is constructed. Methodologically, a mixed-method design is applied, including a questionnaire via an online survey in combination with process generated network data from the TELeurope.eu database.

Chapter 6 presents the results of the enquiry and makes reference to the already mentioned research questions. After stating basic sample characteristics, bivariate hypothesis tests, multivariate analysis and social network analysis are conducted and reported.

Chapter 7 discusses the results of the previous chapter. It then derives statements on the structure and fragmentation of the TEL community and its characteristics and interdisciplinary trajectories. Possible answers to the research questions are discussed and a critical examination of the study's methodology is undertaken.

Chapter 8 includes a conclusion, providing an overview of the main thesis results. The outcome then is a recommendation of procedures for the further enculturation of interdisciplinarity in the context of the European Technology Enhanced Learning community, as well as an overview on future challenges in interdisciplinarity research.

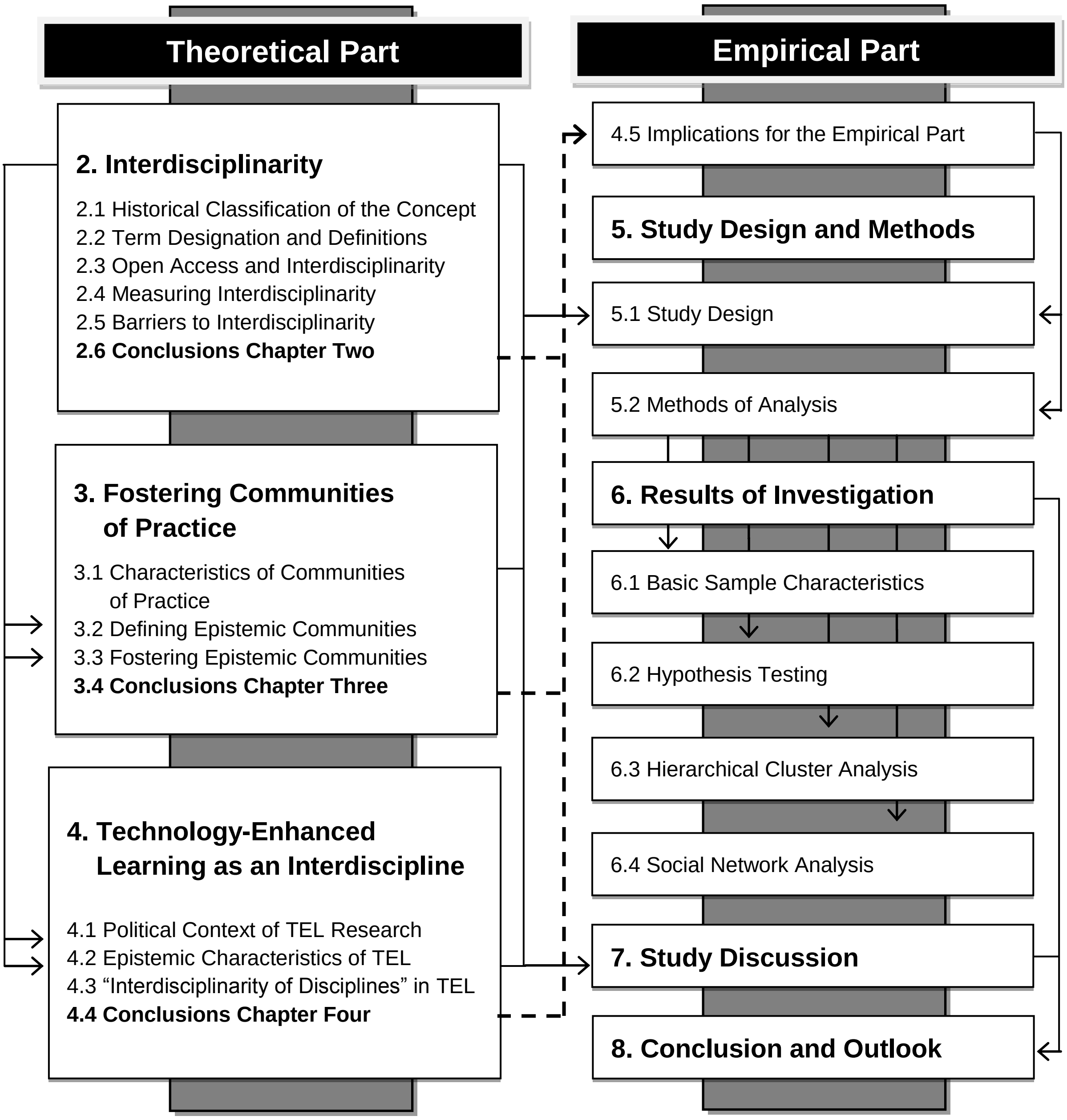

Fig. 1. *Master's Thesis Structure.*

II. INTERDISCIPLINARITY

At its very core, interdisciplinarity is about the integration of knowledge.[11] Knowledge has always been an essential factor for production in all sectors. A farmer needs to know how to till a field, a cook must know how to prepare a meal. Nevertheless the production of knowledge itself was for a long time privileged to the academic elite, who knew how to write and had the money, power and right to publish their works. In modern times this then fundamentally changed. The following chapter is going to specify these historic changes, before chapter 2.2 provides an extensive definition of the concept "interdisciplinarity".

2.1 Historical Classification of the Concept

The rise of the knowledge economy in the 20th century has led to an enormous increase of knowledge work, as opposed to manual work. A knowledge worker works with his or her head, and produces ideas, knowledge, and information[12] (Drucker, 1966, p. 3). With more people involved, the amount of information available also increases. Particularly in science, the number of study disciplines went up with the social sciences coming into existence around the 1900s. This brought up movements trying to unify the diverse scientific community, an early one being the *Vienna circle* of science philosophers in 1924. Goal was to integrate principles in order to get to a unified scientific language and a "synthesis of knowledge" (Klein, 1990, pp. 22-23).

Later on, in the 1960s and 1970s the relatively new term interdisciplinarity gained importance, as cross-disciplinary curricula, programmes and universities developed in the context of the education reforms within Europe (*cf.* Briggs, 1970, pp. 60). It is at that time, that a new mode of knowledge production was emerging, discussed later as "mode 2" knowledge creation by Nowotny, Scott and Gibbons (2003). Characteristics of this transformation are that these new forms of knowledge production are "socially distributed, application-oriented and trans-disciplinary" (p. 179). However, in the 1970s, many "social barriers to learning" (Klein, 1990, p. 35), such as gender, class, race and also epistemic barriers were still highly visible. Reform movements spoke against these barriers. In doing so,

[11] As in the definitions of e.g. Berger, 1972; Strathern, 2007; Kerr & Lorenz-Meyer, 2009.
[12] The terms "information" and "knowledge" are not interchangeable (for discussion see e.g. Newman, 1996). This thesis is going to focus on the concept of knowledge, as it is more applicable for the scientific context.

interdisciplinarity and knowledge integration therefore were their favoured "methods of reform" (p. 35).

Today, despite the origins that interdisciplinarity has in modernist and postmodernist movements, authors strive for a different view of the concept (Newell, 1998; Szostak, 2007): According to Szostak (p. 61), the modernist position promotes the unity of science, seeking "grand theories" that originate from one scientific community, like in the case of the Vienna philosophers circle mentioned above. Postmodernists, in contrast tend to focus on the limitations of scholarly understanding, favouring "localised analyses" (p. 61) and claiming that theories are necessarily incomplete because theorists stand in different places and see different things (*cf.* Rosetti, 2001, p. 319)[13]. Interdisciplinarians, however, are suspicious of scientific "meta-narratives" and ideological grand theories, too. Szostak describes the interdisciplinary view towards science as follows:

> "Different scholarly communities develop incomplete and biased perspectives on reality. Yet these can be integrated into a more holistic and less biased [...] perspective. If this is true for every combination of perspectives, then consistency can be sought at the level of the scholarly enterprise as a whole. Yet this will occur not in the form of some grand theory but in the form of a complementary set of theories each shedding light on different aspects of reality." (p. 61)

The statement implies that interdisciplinary approaches can be very complex in their nature, depending on how many scholarly communities combine their perspectives. Accordingly, the application of interdisciplinary efforts often focuses on concrete "problems of mutual concern" (Bruhn, 2000, p. 58), like e.g. enhancing learning by technology in a certain context. From the 1970s on, several studies identified a general trend towards disciplinary specialisation (see Hefferlin, 1969; Lattuca, 2001, p. 14-15). However, an overly fragmented academic landscape is not in the interest of any nation, who wants its public institutions to share their knowledge and collaborate, in order to increase global competitiveness. As a result, a vast amount of national and supranational funding initiatives for interdisciplinary endeavours emerged.

Integration of ideas and programmes still is a common interest (Conole et al., 2010, p. 7) of nations. In Germany for example the German Research Foundation (DFG, 2005) funds Open Access initiatives, which promote knowledge-sharing across traditional epistemological communities. These efforts find support by the techno-

[13] The statements on postmodernism here primarily refer to *sceptical* postmodernism and do not apply to all postmodern schools of thought.

logical progress, which allows overcoming communicative barriers more easily than in the past. Open Source software and web 2.0 technologies provide academia with low-cost tools for knowledge creation (*cf.* Conole et al., pp. 7-8). On an international scale the European Research Association (ERA) is, in its 2020 vision, postulating a so called "fifth freedom". According to the opening statement of the vision, by 2020, Europe should benefit from the free circulation of knowledge between countries (European Commission, 2010a). This amends the four freedoms of the European single market policy, which include "free movement of people, goods, services and capital" (European Commission, 2010b).

2.2 Term Designation and Definitions

The Latin origin of the word suggests that *inter*disciplinarity is what happens *between* two or more disciplines. This can either point to cross-disciplinary intersections or to gaps between disciplines, depending on how close those are to each other (Lattuca, 2003, pp. 6-7). What is a *discipline* then?

2.2.1 Discipline

The term *discipline* usually refers to a branch of knowledge, a domain that is specialised in its ways of producing new knowledge through inquiry in "discrete and repeatable units" (Moran, 2010, p. 2). It involves specific education, training, procedures, methods and content areas (Berger, 1972, pp. 25–26). Authors such as Steinmetz (2007, pp. 51) promote a conception of disciplines to be "clearly demarcated domains". According to observations by Kerr & Lorenz-Meyer it is the most common view of disciplines in scientific literature (2009, p. 155).

In constructivist theory though, knowledge production is a process of "dynamic adaption towards viable interpretations of experience" (von Glasersfeld, 1990). This presumes that the nature of disciplines can change as new forms of epistemology are arising. The notion of inter-subjective knowledge construction (see e.g. Rogoff, 1990; Vygotsky, 1962) also suggests that a discipline is in principal at the same an *inter*discipline, with disciplinary beliefs and practices being viable conventions rather than objective truths. It is then obvious why concrete disciplines are not always easy to locate. The domain of Education can for example be seen as a discipline in its own right, even though others state that "education is interdisciplinary" (interviewee in: Conole et al., 2010, p. 20). This explains a number of authors' preference for a more dynamic use of the term. Dölling and Hark define disciplines as being "characterised by multiple interconnections and shot through with cross-disciplinary pathways" (2001, p. 1196). A more anthropological approach is taken by Strathern (2007, pp. 123). She suggests disciplines to be viewed as cultures, merely borrowing ideas from past contexts:

> "[The concept of culture] depicts ideas and concepts embedded in disciplinary traditions [...]. This implies that there also has to be some communication about where the concepts come from, that is, about those original contexts." (p. 123)

Others, like Brew (2008), counter the anthropological viewpoint, saying that disciplinary labelling is flexible and rhetorical rather than the "expression of a shared identity" (p. 424). When scanning the literature on disciplinary interaction, one comes across a number of closely related concepts, including e.g. multi-, trans-, or pluridisciplinarity[14]. While Archibald, Buchholz, Duffy, Greenwood, Marx, Shuldman and Yoon argue that these concepts are often interchangeable (2007, p. 12), Strathern (2007) views them on a continuum, indicating different integrative potential. *Multidisciplinarity* in that sense is often described as a rather weak form of interaction, a "simple alignment of skills" (p. 124). It implies an "additive approach" (Kerr & Lorenz-Meyer, 2009, p. 155), bringing together different perspectives without fundamentally questioning disciplinary borders. *Transdisciplinarity*, in contrast, refers to "forms of intellectual transculturation" (Steinmetz 2007, p. 49), involving also non-researchers to participate in the epistemological process and the formulation of problems.

2.2.2 Interdisciplinarity

Despite the fact that there are differences between the aforementioned terms, several authors use *interdisciplinarity* as a generic term, including all the above named (see e.g. Strathern, 2007, Kerr & Lorenz-Meyer, 2009). When looking at the various definitions, many of them stress integrative aspects of the concept and its "problem-focused approach" (Franks et al., 2007, pp. 170-171). Franks et al. see interdisciplinarity as an "interaction, overlap, sharing of insights or bridging of disciplines among two or more disciplines" (p. 170). Focussing particularly on interdisciplinary *research*, the Organisation for Economic Co-operation and Development (OECD) offers a broad definition (as cit. in Berger, 1972, pp. 25-26). It includes any interaction among disciplines, ranging from "simple communication of ideas to mutual integration":

> "*Interdisciplinary* - an adjective describing the interaction among two or more different disciplines. This interaction may range from simple communication of ideas to the mutual integration of organising concepts, methodology, procedures, episte-

[14] This thesis will not go into further detail with related terms, as concepts are similar. For more definitions see e.g. Franks, Dale, Hindmarsh, Fellows, Buckridge, & Cybinski, 2007.

> mology, terminology, data, and organisation of research and education in a fairly large field. An interdisciplinary group consists of persons trained in different fields of knowledge (disciplines) with different concepts, methods, and data and terms organised into a common effort on a common problem with continuous intercommunication among the participants from different disciplines."
>
> (OECD, as cit. in Berger, 1972, pp. 25-26)

Kerr & Lorenz-Meyer (2009, p. 153) use a more narrow definition, saying that "interdisciplinarity denotes synchronising and integrating methodologies and epistemologies" across different fields. In the OECD definition a list is provided of all the aspects to be integrated, including "organisational concepts, methodology, procedures, epistemology, terminology, data, and organisation of research and education" (Berger, 1972, p. 25). Hattery (1986) offers a definition on the individual level, emphasising that integration is achieved by researchers with different backgrounds (*cf.* p. 13). This indicates that training and education of researchers play a role for interdisciplinarity, which is why these aspects have been included in the study at hand.

For *training* and *teaching* "in different fields of knowledge", i.e. disciplines (Berger, 1972), a hierarchical typology has been provided by Armstrong (1980), who was dealing with interdisciplinary faculty curriculum development. He compares four types of interdisciplinary education with different integrative strength. The weakest one is education in a selection of courses from different departments toward a disciplinary major. It is easily achieved, but the least effective (p. 53). The second one involves education, which includes opportunities to share insights from a number of disciplinary courses, such as a seminar that caps or overarches the programme of study (p. 53). A stronger type of interdisciplinarity is identified, if faculties create courses focused on interdisciplinary topics and knowledge synthesis. It varies between team teaching and the mere collection of disciplinarians within a course (p. 54). Finally, the strongest one is education which includes the integration of material from various fields of knowledge into a purpose-built coherent course that addresses epistemological and methodological understandings (p. 54).

Lattuca (2003) also set up a typology of interdisciplinary training and teaching. Main characteristics are as follows:

- *Informed interdisciplinarity* involves classical disciplinary courses informing about other disciplines, while still being rooted in the original discipline's research questions and focal points (p. 6).
- *Synthetic interdisciplinarity* addresses questions in the aforementioned "gaps and intersections" between disciplines. Therefore teaching issues bridge the disciplines (p. 6).

- *Transdisciplinarity.* As Steinmetz (2007, p. 49), Lattuca sees Transdisciplinarity as the subordination of disciplines to the development of an "overarching synthesis". Courses in that sense apply new methods, which transcend monodisciplinary thought (p. 7).
- *Conceptual interdisciplinarity* means courses, which discuss complex questions that can't be dealt with by only one discipline. It involves strong integration and critique of monodisciplinary approaches (p. 7). An example would the investigation on the structure of the earth's core, involving specialists from materials sciences, geography, statistics and mathematics, space science, engineering, biology and others.

In the following, this thesis focuses on a broad definition of interdisciplinarity, as also in the empirical part a differentiated picture of the facets interdisciplinarity is going to be drawn. It is regarded as *continuous*, it involves somehow *frequent communication* or even collaboration, it requires a form of *training/education*, and it has the necessity of a common focus, aim or vision. From now on, the OECD definition is taken into account, as it involves all of those features.

2.3 Open Access and Interdisciplinarity

Science, as it is often being funded by the public, "repays", so to say, by sharing and publishing its results. Therefore it keeps contributing to the knowledge base of a society. The interaction between academia in general and other societal institutions is described by the concept of "deep interdisciplinarity", which also involves the broader public (Frodeman et al., 2001, pp. 6-7). Without results and data being available for others to a certain extent, a basic scientific principle, that is *reproducibility*, cannot be realised. A theory must offer reproducible results, if it is to be scientific (Root-Bernstein, 1984, p. 64). If it does not do so, it is only a statement about the observation of a "very improbable event".

The idea of time- and location-independent access to scientific information has gained importance with the on-going internationalisation of science and research (DFG, 2005, p. 11). The rise of electronic communication channels and in particular the internet now allows for a new, cheaper way of publishing and receiving research results in a worldwide fashion. Already since the mid-1990s publishers have begun to build up electronic archives, offering digitalised versions of their of older, print-copy journals, as a survey of Hitchcock (2003) further investigated. However, the access to these digital journal repositories is often limited and readers, or respectively libraries are charged a fee, which is meant to cover the publisher's costs for distribution, editing and marketing of an article (Monbiot, 2011). This contradicts the interests of academics, who want their work to be widely read and want themselves to easily access published information, which is vital for their research. A viewpoint statement on information access, published by Nobel Prize laureate Richard J. Roberts and other scientists (2001), holds the statement that "unimpeded access to these archives and open distribution of their contents" should be enabled, in order to let "researchers take on the challenge of integrating and interconnecting the […] scientific literature." (p. 2318). So again, as for the concept of interdisciplinarity, *integrative* aspects play a major role also for open access to publication. According to Hitchcock (2003), electronic scholarly communication must be "integrated and interconnected, making something accessible from something else". This "something", he continues, should be accessible by everyone, "regardless of location, background or privilege" (p. 8).

Open access (also abbr. "OA") can be defined as a movement[15] towards the improvement of accessibility of the results, generated by scientific research (*cf.* DFG, 2005, p. 11). The *Berlin declaration on Open Access*, signed by several scholarly institutions within Germany and Europe, points out two key characteristics for a work to be an open access contribution (Gruss, 2003).

1. "The author(s) […] grant(s) to all users a free, irrevocable, worldwide, right of access to, and a license to copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works, in any digital medium for any responsible purpose, subject to proper attribution of authorship […], as well as the right to make small numbers of printed copies for their personal use.
2. A complete version of the work […] in an appropriate standard electronic format is deposited (and thus published) in at least one online repository using suitable technical standards […] that is supported and maintained by an academic institution, scholarly society, government agency, or other well established organization that seeks to enable open access, unrestricted distribution, interoperability, and long-term archiving."

(Gruss, 2003, p. 2)

In short, a work is „open access", if the author grants the right to use the publication material and if it is published on the server of a somehow "established" organisation that supports open access principles. Two different types of Open access works are usually distinguished (DFG, 2005, pp. 11-12): The *golden road* to open access involves a business model, where researchers themselves pay fees for publishing their works in referenced online *open access journals*. These author fees

[15] A detailed timeline of the Open access movement can be found in Suber (2011, see: http://oad.simmons.edu/oadwiki/Timeline). OA resources in the field of Education are documented by the education research global observatory at http://www.ergobservatory.info/

include all publishing costs, so that users can view the publications on the internet, without having to pay any licensing fees. In contrast, the *green* road to open access means that already published scientific results are re-published on the web after the date of their original publication. This secondary, *postprint publishing* of results in institutional or other scholarly repositories also allows for cost-free access on the web. The works are published directly by the researchers, i.e. why the term "self-archiving" is commonly been used. Another form of OA, the *preprint publishing,* refers to the publishing of a draft version, which is not yet peer-reviewed (Harnad, 2003). In doing so, the delays caused by a formal publishing process can be avoided. According to Harnad (2003), another main motivation for researchers is "to maximize their work's visibility, usage and impact" and to make "them openly accessible to all would-be users worldwide".

Several studies have been conducted, regarding the usage behaviour and opinion towards OA among researchers (DFG, 2005; Dallmeier-Tiessen et al., 2011). The DFG study in 2005, which was focussing on the German research landscape, already reported that only few researchers yet publish their works openly accessible. Only every 10th (N=1.026) respondent had yet published in an open access journal. Also, the provision of cost-free preprints on the internet didn't seem to be common. Postprints were used more often, but still rather seldom (p. 9). In contrast, researchers have a very positive attitude towards OA and would like to see it funded more extensively (p. 9). Six years have passed since that study, so one might think that things changed in the meanwhile. A two-year European study, conducted from 2009 to 2011 by the Study of Open Access Publishing (SOAP) project (Dallmeier-Tiessen et al., 2011) doesn't suggest that a big step towards OA has been achieved in recent years. While 90 per cent of researchers (N=50.000) find open access publishing beneficial for their field, only 8-10% of all works are published OA (pp. 10-11). These results do not suggest a big change since the DFG study. Another finding was that small open access publishers are proliferating, as over 50% of all ~ 3.000 identified open access journals were contributed by publishers, who only publish one single journal (Dallmeier-Tiessen et al., 2010, p. 3).

Five main reasons for supporting open access interdisciplinarity, as identified by the SOAP study, were better *accessibility* of contents; *financial issues*, meaning that it is cheaper for e.g. libraries and research institutions to have open access*; individual benefits* as visibility and readership; the perception of research results as *public goods*; and a *scientific community benefit,* fostering social exchange between researchers (2011, p. 5).

2.4 Measuring Interdisciplinarity

While it is relatively easy to measure open access publishing by counting articles, journals and publishers, "interdisciplinarity", in general, is harder to measure. There are several approaches commonly used to evaluate the interdisciplinarity of research endeavours, which are going to be briefly summed up in the following.

According to West (2011) *scholarly networks* are an appropriate model system to get a grasp on cross-disciplinary collaborations. Especially the analysis of *co-citation* and *co-authorship*[16] data of scientific works can detect structures of reference between different disciplinary branches (see fig. 2). An index developed by Porter & Rafols (2009, p. 1) indicates a modest increase in interdisciplinary publishing in the past 30 years. Looking at scholarly networks, data can be obtained by content analyses of article references in databases. However, this quantitative approach can't tell much about the nature of interdisciplinarity. Just because an article from a different discipline is cited does not necessarily mean that collaboration took place.

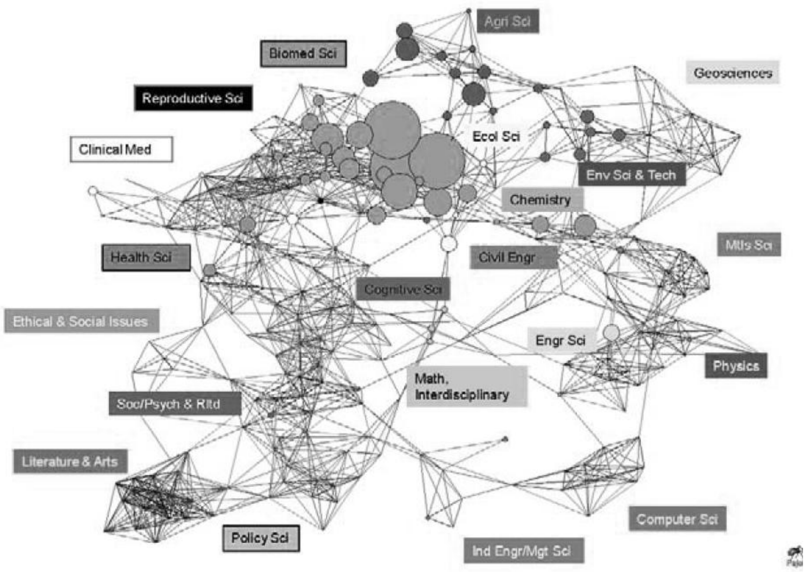

Fig. 2. *Example of a citation pattern* (Porter & Rafols, 2009, p. 19).

Another approach is to directly count *interpersonal* or *inter-institutional relationships* between researchers, either by asking about frequent collaborators via a survey (Fink, & Heinze, 2010), or by counting social media relations (Ebner & Reinhardt, 2009). The approach of *artefact-actor networks* combines publication

[16] Co-citation: citing work from another discipline; co-authorship: publishing together with a researcher from another discipline.

and social media data in a bipartite[17], i.e. double-layered network (Reinhardt, Moi, & Varlemann, 2009). Moreover, there are several *qualitative studies* that try to measure interdisciplinarity by conducting interviews with researchers and asking about individual perceptions, practices and backgrounds (Conole et al., 2010; Kerr, & Lorenz-Meyer, 2009). Qualitative approaches are especially appropriate for identifying obstacles to interdisciplinarity in a community, as they are aiming at a broader understanding of the subject. Those obstacles are going to be considered in the following chapter.

2.5 Barriers to Interdisciplinarity

In short, interdisciplinarity can be described as a special form of *social interaction* between disciplines. Therefore asking for one's opinion towards interdisciplinarity is likely to results in positive attitude measures (see also C.6.2 of this thesis). Despite of all desirability, there are often very practical barriers towards interdisciplinary research, including OA publishing, which have to be taken into account.

Conole et al. (2010, p. 8) argue that "true" interdisciplinarity is difficult to achieve, because there is a *lack of criteria and standards* of validity for the evaluation of interdisciplinary research, which addresses the need to develop shared values and culture. Also, practices and vocabularies are often discipline specific, as researchers usually only have been *trained* in one specific discipline (p. 8). This was also found by Kerr & Lorenz-Meyer (2009), especially noting that there is much time and resources needed, in order to "build a common language and expertise" (p. 157). Also, results indicated that especially young researchers often perceive disciplinarity and the "identification with a body of knowledge" as necessary for their career advancement (p. 163). This perception might come from the fact that interdisciplinary contributions are "often judged by people with a single disciplinary perspective" and therefore viewed from a narrower perspective (Conole et al., p. 39). Conole et al. describe the problem as follows:

> "Journal publications remain crucial to building an academic reputation. One could contend that it is easier to be interdisciplinary as an established researcher, when research reputation has already been established."
>
> (Conole et al., p. 39)

Interdisciplinary research can be facilitated by giving programmes their own funding streams, in order to "self-consciousness about interdisciplinarity and integra-

[17] For more information on network analysis methodology, see C.5.2 of this thesis.

tion" (Augsburg, & Henry, 2009, pp. 238-239). Still, even the establishing of networks and institutions can be counted and measured, the real integration of epistemology and methodology is harder to evaluated, as it is true forms of interdisciplinarity are "situation-specific" (Conole et al., p. 9). The study at hand takes both groups of indicators into account: formal interconnections between researchers of contrasting disciplines, locations and institutions, and their shared culture, methodological and epistemological practices.

Interdisciplinarity in the form of *open access* faces similar difficulties. The more prestigious journals are often not only linked to a traditional discipline, but also very expensive. This is because journals with the "highest academic impact factors, in which publication is essential for researchers trying to secure grants and advance their careers" are held by the big, "closed access" publishers like e.g. Elsevier, Wiley-Blackwell and Springer (Monbiot, 2011). This leads to the "paradox situation" (DFG, 2005, p. 11) that the publicly funded libraries have to pay huge amounts, in order to provide access to research, which in the first place had often been enabled and supported by public stipend funds and grants. Dallmeier-Tiessen et al. (2011, p. 7) identified various obstacles to OA in their survey among European researchers (see tab. 1).

Accessibility: the author has had a bad experience with an OA journal, their paper has not been accepted or the respondent thinks there are no OA journals on their field (8%).
Funding: publication fees or lack of funding for it was mentioned (39%).
Habits: respondents prefer to publish their papers only in certain established/traditional journals (4%).
Journal quality: OA journals are perceived/assumed not to be of good quality or they do not have an impact factor (30%).
Next time: respondents intend to start publishing in OA journals or are already doing so for their next article (2%).
Unawareness: the respondent is not aware of OA or OA journals on their field (7%).
Other: issues such as, but not limited to, the use of green OA to achieve widespread distribution, the inflation of OA journals, the decision taken by other co-authors and other less-frequent concepts (10%).

Tab. 1. *Reasons for not publishing open access journal articles;* percentage indicates frequency of category (N= 4.976, adapted from Dallmeier-Tiessen, 2011, p. 7).

The various reasons for not publishing openly or working interdisciplinary are very often related to *funding* or *quality* issues, as indicated by the Study of Open Access Publishing (p. 7). It takes money or resources to enforce communication across the ruling institutional, epistemological or economic power structures, and standards of validity for new paths of cross-disciplinary communication often are not present or not perceived as effectual and hard-and-fast.

2.5 Conclusions Chapter Two

Despite the barriers, interdisciplinarity receives a lot of attention in higher education policy, as it is seen as a means to increase innovation and competitiveness. In a model of the public sphere (see Jäckel, 1999, p. 225) interdisciplinarity is located as well within academia, connecting separate disciplines, as also linked with other societal systems like culture, industry, politics and law in a *public* dialogue (see figure 3). However, the strength of these connections is hard to measure. Interdisciplinarity often is a reflective practice (Romm, 1998), really appearing mostly in situational occasions, for example when a psychologist meets an engineering scientist in the hallway to have a chat about their work. Although most of the aforementioned studies view interdisciplinarity as something worth achieving, it should be noted that it also has been criticised. Kerr & Lorenz-Meyer (2009) note that it can “undermine intellectual inquiry”, for the reason that “commercial considerations” might “impact on project choice and limit academic freedom”, (p. 155) if too strong ties between academia and industry exist. Still, such ties need to be enabled. Concerning academia, it can preferably be realised by co-locating researchers from different disciplines in shared institutions that work on a common problem. Also, the organisation of interdisciplinary conferences can provide chances to bring disciplines together, which usually work apart from each other.

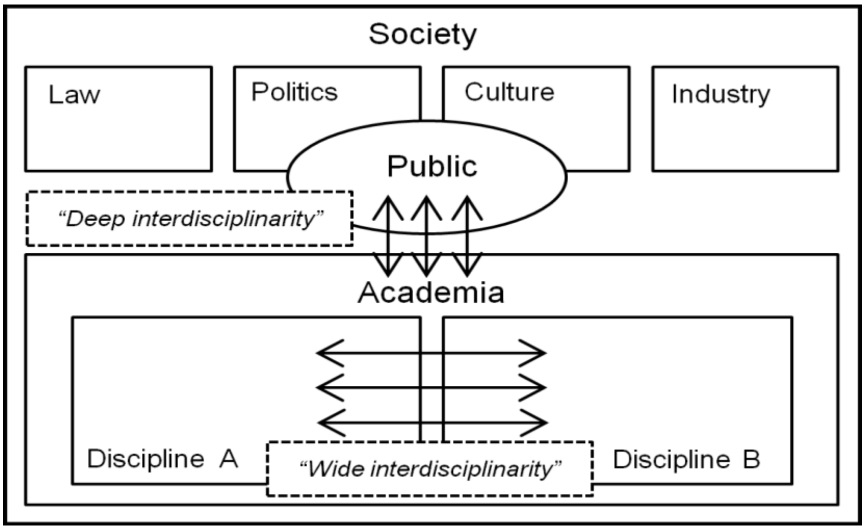

Fig. 3. *Locating interdisciplinary in the public sphere*
(own figure, based on Jäckel, 1999, p. 225 and Frodeman et al., 2001, pp. 6-7).

Frodeman et al. (2001, p. 7) point out that interdisciplinarity needs to be seen as a form of learning, with the scientists learning from non-scientists as well. They state that only if academia repeats to the "public's increasingly insistent demand that publicly funded research and education clearly show their connections to community needs", interdisciplinarity can be successful (p. 6). Otherwise, it is likely to ultimately lead to more disciplinarity, dividing academia from the rest of society.

The next chapter is going to look at several educational and managerial approaches that focus on fostering interdisciplinarity, especially in spatially distributed professional networks, as this is the focus of the study at hand.

III. FOSTERING COMMUNITIES OF PRACTICE

Manathunga (2003, p. 3) stresses the relation between interdisciplinarity and "communities of practice", as a concept developed by Wenger (1998). She suggests that interdisciplinarity is not to be viewed solely in an organisational, project-driven context, or as limited to outcome-focused collaboration. Beyond that, communities and their culture are an important contextual factor for interdisciplinarity. This assumption brings up questions of knowledge management within those communities, as well as also concerning the interaction between them, e.g. several scientific disciplines. The former is referred to by Faber and Scheper (1997, p. 53) as "interdisciplinarity of [related] disciplines", whilst the latter would "interdisciplinarity of sciences", involving different schools of thought.

3.1 Characteristics of Communities of Practice

In the very general sense of Wenger's concept, communities of practice (CoP) are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, McDermott, & Snyder, 2002, p. 4). Wenger et al. also are cited that communities of practice can be found "everywhere" (p. 7). This led to the concept being applied in a lot of different contexts in the field of education and knowledge management (see fig. 4). Originally it had been developed by Etienne Wenger, an educational theorist and practitioner, and anthropologist Jean Lave, who were studying situated learning in very practice-based communities. These included e.g. tailors, naval quartermasters and meat cutters (p. 4). Focussing on how apprenticeship takes place in such communities, they found three main factors for individual learning, competence development and the creation of knowledge within the community. Those are, as reported in the introductory chapter C.1.1, a sense of joint enterprise, a shared repertoire of resources including language, routines, artefacts, and stories, as well as mutual engagement in relationships (Wenger, 1998, pp. 72-84). The technology-enhanced learning community on TELeurope.eu, as subject of this study, to some extent matches the criteria and can count as a practice community: members share an interest in the field of TEL, and in conducting practices that lead to TEL artefacts and the creation of new knowledge. Also, the platform interaction between the members indicates engagement in relationships. However, there are specifications and variations of Wenger's original CoP concept, which have been studied and address several aspects of the TEL community in a more fine-grained way.

Through a literature analysis, Amin & Roberts (2006) found that the term "communities of practice" is applied to various social groupings, such as business organisations, extra-organisational environments, financial services, innovation and manufacturing and online communities (p. 2). Statistics from the EBSCO Business Source Premier database[18] show that the concept is gaining popularity, even now, 20 years after it had been invented by Lave and Wenger (see figure 4).

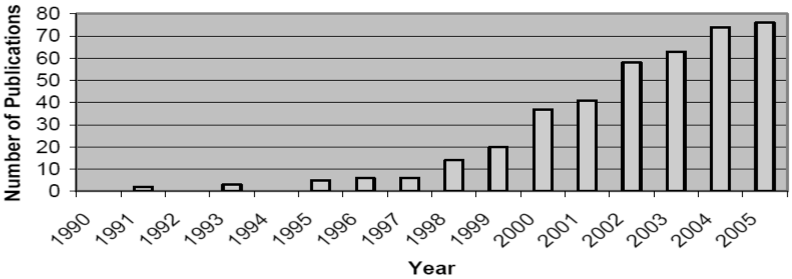

Fig. 4. *Publications with reference to Lave & Wenger's CoP concept.*
(from: Amin & Roberts, 2006, p. 1)

The authors (Amin, & Roberts, p. 7) identified four reoccurring types of CoPs, including *craft-based* communities, *professional* communities, *expert* (or *epistemic*) communities and *virtual* (or *online*) communities. The community forms differ particularly along dimensions like activities, types of knowledge, forms of social interaction; including the nature of communication, temporal aspects and the nature of social ties; innovation and organisational dynamics (p. 7).

Craft-based communities generate mainly "aesthetic, kinaesthetic and embodied knowledge" (p. 7) and are therefore less relevant for this thesis. An example is the notion of informal student project groups, where members gain competencies by crafting and designing works such as television-programmes, magazine articles and IT related products (*cf.* Sporer, Sippel, & Meyer, 2009).

Professional communities focus on "apprenticeship-style learning", which is necessary for the development of professional competencies in a domain. It involves the co-location of a newcomer with experienced members of a CoP (Amin & Roberts, 2006, p. 12). For example management professionals in consulting firms learn and gain experience in informal interaction with other professionals of a domain through the means of communities of practice (*cf.* Bredl, 2005, p. 67).[19]

[18] EBSCO Business Source Premier "provides full text for [...] 7,600 scholarly business journals" in many different disciplines (Amin & Roberts, 2006, p. 1).

[19] As the thesis at hand is not putting focus on the integration and the competence development of younger researchers or their training in the domain of TEL, professional and craft-based communi-

A ***virtual community*** is a community in which "social interaction [is] mediated through technology" (Amin and Roberts, 2006, p. 7). Communication happens between spatially distributed members, e.g. through a wiki. The study at hand doesn't put major emphasis on the question, whether the virtual TELeurope.eu platform is a place, where community building and learning actually takes place. Also, alternative online communication channels have not been investigated by the study. Membership on the technological platform is viewed as a simple indicator for interest and a certain expertise in technology-enhanced learning research. Pragmatically speaking, the platform also has been a valuable source of network data and email-addresses for sending out the survey. With not focussing on virtuality, this thesis excludes a huge discussion on whether online platforms "can be classed as learning communities and, if so, how they differ from communities that depend on social familiarity and direct engagement" (p. 21). As technology is becoming more advanced and most communities at least partly operate spatially distributed through the internet, it does not seem that the distinction between "real" and "virtual" is particularly crucial. Also Wenger, White, Smith and Rowe (2005) were researching on technology mediated communities of practice. Wenger et al. state that although communities reach out across much greater distances "participation is richer and can be more meaningful despite limited 'face time.'" (p. 1). For them technology tools "provide new resources for making togetherness more continuous in spite of separation in time and space". Factors for successful communities, however, are communication features enabling rich synchronous and asynchronous interaction and "technology stewardship" to handle these features (p. 2). If this is supported, technology-mediation does not have a diminishing effect on community-related learning.

The fourth type of CoP, the ***epistemic communities*** have "are primarily concerned with creating new knowledge" (Amin and Roberts, 2006, p. 5). As those CoP communicate "through a combination of face-to-face and distanciated contact", they are most appropriate for addressing the interdisciplinarity of European technology-enhanced learning research.

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ties have less relevance. However, there are instruments generated by the STELLARnet project, focussing especially on early-career researchers, like e.g. the doctoral summer school (see C. 4.6).

3.2 Defining Epistemic Communities of Practice

Researchers are basically *knowledge workers*, as described by Drucker (1966, p. 3). They are usually "highly educated individuals who […] have been trained in a particular profession" (Knights and Willmott, 1987; as cit. in Creplet, Dupouet, Kern, Mehmanpazir, & Munier, 2001, p. 1519). According to Creplet et al., knowledge workers share that they demand a "significant degree of autonomy" in their work, which is often related to problem-identification and -solving. A knowledge worker would incorporate four different levels of knowledge, or "professional intellect" (Anderson, Finkelstein, & Quinn, 1996, p. 72). In short, those levels can be described as "know-what", "know-how", "know-why" and "care-why".

- *Cognitive knowledge* (know-what): "the basic mastery of a discipline that professionals achieve through extensive training and certification. This knowledge is essential, […] for commercial success."
- *Advanced skills* (know-how): "translates 'book learning' into effective execution. The ability to apply the rules of a discipline to complex real-world problems is the most widespread value-creating professional skill."
- *Systems understanding* (know-why): "deep knowledge of the web of cause-and effect relationships underlying a discipline. It permits professionals to move beyond the execution of tasks to solve larger and more complex problems – and to create extraordinary value. […]"
- *Self-motivated creativity* (care-why): "the will, motivation, and adaptability for success. Highly motivated groups often outperform groups with greater physical or financial resources. […]"

(Anderson et al., p. 72)

Creplet et al. (2001, pp. 1529) make a distinction between knowledge workers in traditional communities of practice and in *epistemic communities*. While the former focus mainly on the hands-on practice, the latter engage in "knowledge creation" as a core activity. Especially a combination of both forms of communities, according to the authors, leads to the emergence of the "new mode" of transdisciplinary knowledge creation, as described by Nowotny et al. (see C.2.1). The notion of epistemic communities has been coined by Peter Haas (1992) [20], in the context of international relations, using the following definition.

> "An epistemic community is a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area".
>
> (Haas, 1992, p. 3)

[20] Before that, it was also referred to as "scientific communities", as in Knorr-Cetina (1981).

In contrasts to CoPs, epistemic communities rely more on *professional expertise*, a *network-shaped* structure and have the aim to *strategically* enhance the knowledge of a domain. Epistemic communities especially arise in uncertain contexts, calling for a “new paradigm” (Creplet et al., 2003, p. 1530; in reference to Kuhn’s theory of scientific revolutions, 1962). Therefore they always have obvious links to policy-relevant issues, and consist of inter- and transdisciplinary experts, who produce knowledge” that is above the members of disciplinary communities, but which can modify them (*cf.* p. 1531). Epistemic communities are characterised by the members’ autonomy and self-organisation, but, unlike CoPs they have some kind of procedural authority, e.g. a formal, political actor as the European Commission. The actors then rely on the common understanding of a subject or a solution to a problem, which is found by often transnational elites of experts or “knowledge societies” (Sundström, 2001, pp. 1-2).

Amin & Roberts (2006) mostly refer to *expert or creative* communities of practice. Their multidimensional comparison of those CoP forms (see tab. 2) sums up the major differences between Wenger’s original CoPs and the epistemic CoPs.

	Expert/Epistemic CoPs	Other CoPs[21]
Type of knowledge	• Specialised and expert knowledge, including standards and codes • Exist to extend knowledge base. Temporary creative coalitions; knowledge changing rapidly	• Embodied knowledge • Specialised expert knowledge acquired through prolonged periods of education and training.
Proximity /nature of communication	• Spatial and/or relational proximity. • Combination of face-to-face and distanciated contact.	• Co-location important for demonstration
Temporal aspect	• Short-lived • drawing on institutional resources from a variety of expert fields	• Long-lived • Developing of structures and formalisms
Nature of Social Ties	• Trust based on reputation and expertise • weak social ties	• Strong interpersonal or institutional trust.
Innovation	• High energy, radical innovation	• Mostly incremental
Organisational dynamic	• Group/project managed • Open to those with a reputation in the field • Management through intermediaries and boundary objects[22]	• Hierarchically managed • Open to new members, if not institutional.

Tab. 2. *Comparing expert and other CoPs (table modified).*
(adapted from: Amin & Roberts, 2006, p. 7)

[21] In this row, the characteristics of “craft-based” and “professional” CoPs have been merged. For a distinction between the two forms, see C.3.1. Virtual communities are left aside here.
[22] “Boundary objects” have the potential to bring communities together and allow different groups to work together on a task (*cf.* Wenger, 1998, p. 106).

Expert communities deal with codified and specialised knowledge, have standards of what counts as "good" or valuable knowledge and strive to extend their knowledge base. There is as special focus on the re-codification of often complex knowledge bases (Creplet et al., 2001, p. 1530). Other CoPs often have more embodied knowledge and expert knowledge, too, but which is slowly acquired and incrementally progressed. While, in Amin & Roberts typology, classical CoPs require co-location, a relational or just partly face-to-face communication is seen as sufficient for expert communities. The latter are also "short-lived", drawing on resources", have "weak social ties" (p. 7), and are radically innovative. The trust is based mainly on reputation, while other CoPs are more consisting of interpersonal or institutional trust mechanisms. The organisational dynamic is characterised by expert communities often being project managed and open to everyone who has the capabilities and the reputation to contribute. Other communities often have one or several leaders or project coordinators; they are usually open, though in a corporate context not so much.

It is interesting to note however, that expert or scientific communities are defined by a certain form of interdisciplinarity, which is the basis for their progression, or as Amin & Roberts put it:

> "[The] expert ecology thrives on difference, more accurately, on the juxtaposition of variety. An essential spark in expert networks and teams working on new or complex problems is the combination of not only complementary skills and competences but also diverse perspectives and capabilities."
>
> (Amin & Roberts, 2006, p. 17)

Therefore disciplines are never only disciplines, but always have the need and tendency to consist of actors with diverse perspectives and complementary skills.

To address this, Lindkvist (2005) makes a distinction between knowledge (~epistemic) *communities* and knowledge *collectives.* The former are more characterised by "knowledge base similarity" (p. 1205), which is driven by some sort of enculturated paradigm. Those might represent more disciplinary CoPs. The latter Lindkvist describes as market-driven, consisting of well-connected knowledge bases and oriented towards the networked distribution of knowledge. Those might better reflect interdisciplinary communities, which yet have to stand the test of time and have a particular need to establish visibility and standards of validation, like e.g. the TEL community. In Creplet et al.'s (2001) words experts are the creators of new knowledge, who deal with problems, no one has ever dealt before (p. 1520). They separate their role from those of *consultants*, who have been trained on the existing knowledge of one or several scientific community and can apply best-practices from one to another field (pp. 1517–1535). The former have a more strategic, transdisciplinary and policy- and innovation-oriented focus. However, distribution and interdisciplinarity has been made easier with the progress of advanced ICT technology, which allows all stakeholders to engage across epistemic communities (p. 1531). Kerr & Lorenz-Meyer use the term of *hybrid epistemic living spaces* (2009), emphasising the context-relation of scientific disciplines. Those spaces are characterised by "breaking down barriers between subject areas" and therefore forging "new forms of more fluid, responsive and often marketable arrangements of togetherness" (p. 154). This relocation of "togetherness", for them, defines the term "interdisciplinarity" (p. 155).

3.3 Fostering Epistemic Communities

Haas (1992) describes four factors for an epistemic community to develop. These include 1) a "shared set of normative beliefs", providing the basis *for social action* of the community members 2) "shared causal beliefs", i.e. an agreement about which *practices* lead to the solving of a problem. 3) "shared notions of validity", focussing on standards, which help to judge the validity of new *knowledge in their domain,* and 4) a "common policy enterprise", being aware that the problems, addressed by professional competence, are a common policy concern and also being convinced that "human welfare will be enhanced as a consequence" (p. 3).

Amin & Roberts (2006, pp. 16-20) name other factors, including the "psychology of disclosure and peer-recognition", which means that experts have a high sense of "self-worth" (p. 18) and autonomy, leading them to expect rewards, challenging project and peer-recognition in exchange for their engagement in an epistemic community. Such incentives must be created, in order to profit from the experts' positive personality traits like charisma and logical capability, which have been identified by Creplet et al. (2001, p. 1522). Another factor identified by Amin & Roberts is to acknowledge the existence of what they call an "ecology of weak ties". It is implied that epistemic communities are not really "communitarian" in their collaborative dynamic. Ties are more characterised by the affiliation with a problem and a domain than by the strong interpersonal relationship with other community members. Indicators for this have also been found by Grabher (2004), studying not scientific but creative communities in the advertising industry. He points out that sociality in the communities "essentially relies on networked reputation" (p. 1504). A third factor is the existence of a "culture of the interactive milieu" (Amin & Roberts, p. 18), involving interactive possibilities to informally "hang out together", without hierarchy and bureaucracy. This cultivated informality can be achieved by the availability of interactive surroundings ranging from e.g. an informal online meeting space, to a pool table in an institution where experts meet (*cf.* Amin & Roberts, p. 18), to an urban environment, which is likely to spark creativity and togetherness. As fourth factor the authors identify the important role of intermediaries, as to the fact that a "division of labour among experts" (p. 19) is not sufficient for a functioning community. Tacit knowledge must be explicated and codified. Therefore shared artefacts and technologies are means to foster collective sense-making. An example would be the work on a shared dictionary of terms, which are circulating within a community, as done by the TEL dictionary initiative group mentioned in C.1.

Often epistemic communities are associated with "project-specific knowledge creation" (Grabher, 2004, p. 1493), which is likely to be only temporary, as projects usually have a specific task to accomplish (see also Knorr-Cetina, 1981). However, the project context of this study tends to be different, as the goal of the STELLARnet project is specifically to strengthen the TEL community within Europe. The context of this project and the characteristics of the domain are going to be outlined in chapter four.

3.4 Conclusions Chapter Three

With many concrete references to the context of the study at hand, chapter three provided an insight into the concept of practice communities. It showed that the notion of a community, despite its craft-based origins, has often been applied to the context of knowledge-generating, expertise-based social groupings, including weakly tied networks. Links between the concepts of interdisciplinarity and epistemic communities have been pointed out. The title of this thesis discusses technology-enhanced learning as an "interdisciplinary expert community". The previous chapters hold the reasons for doing so: TEL is inherently *interdisciplinary* in the general sense, as different disciplines, such as the computer and social sciences, form it. It is highly epistemic and knowledge-generating, with *expertise*-rich and policy-involved research stakeholders. Implied by the aforementioned, it is also some kind of networked *community*, even though the nature of social ties and the communal specifics are subject to investigation.

IV. TECHNOLOGY-ENHANCED LEARNING AS AN INTERDISCIPLINE

Strengthening expert communities, as the ones described in the previous chapters, is also a core interest of the European Union. The Bologna Agreement and the Lisbon Strategy aim for Europe to become a "dynamic competitive knowledge-based economy" in terms of research, education and innovation (European Commission, 2011b). This political context, related to the funding of technology-enhanced learning research in Europe, is going to be addressed in the next chapter (4.1), before looking at the nature of the TEL research community (4.2) and the contributing disciplines (4.3).

4.1 Political Context of Technology-Enhanced Learning Research

The European Commission (EC) funds information and communication technologies (ICT) in its framework programme for research and technology-development. This programme started back in 1984, as FP1, and has now reached its seventh phase, FP7, from 2007 until 2013. It holds an increasing annual budget of around eight billion euro (Euresearch, 2009). Goal of the programme is to improve science and technology, to encourage international competitiveness and to promote research that has an "European added value", i.e. involves transnational collaboration[23] (European Commission, 2007, p. 7). One funding stream or "challenge" of the framework programme for ICT is dedicated in particular to "ICT for Learning and Access to Cultural Resources". Technology-enhanced learning, or in short "TeLearn", is part of that challenge (European Commission, 2011c).

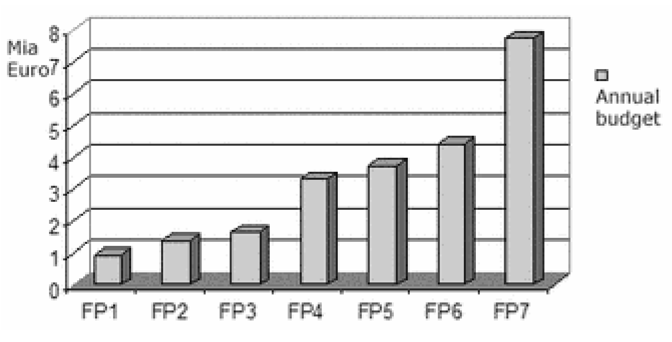

Fig. 5. *Funding of research programmes by the EC.*
from: Euresearch (2009)

[23] An exception is the vague field of "fundamental frontier research", where nation-based teams of researchers "add value" by contributing to the international competition.

Currently, there are 26 TEL projects[24] funded in FP7. They cluster along three aspects, which is the *learning context*, the advancement and exploring of *technologies, methods and theories,* and the *support of EU-research policy* in TEL (European Commission, 2011d). For the years 2011 and 2012, the projects have the following five overarching aims ("expected impact"):

- Firstly*, adapting* and *personalising educational technologies*, especially…
- …the improvement of *ICT-based tutoring*, so that it can be widely implemented in schools and at home. Also, …
- …*science* should be made *visible and accessible* for *young people,* e.g. through enabling virtual experimentation with "laboratory equipment".
- Other points are the enhancement of ICT for the up- and re-skilling of professionals, which is of use for small and medium enterprises…
- …as well as the *emergence* of *new learning models*.

Adapted from: European Commission (2011e)

The European Commission, as the major funding institution of TEL research, also provides one of the few relatively clear definitions of the term *technology-enhanced learning*. On its website, the commission states that TEL "investigates how information and communication technologies can be used to support learning and teaching, and competence development throughout life." (European Commission, 2011a). There is no agreed definition for TEL, as it is hard to distinguish technologies that do contribute to learning, from those that do not (*cf.* Dror, 2008, p. 216). Often it is used synonymously with terms like "e-learning" and "educational technology" (Schneider, 2011).[25]

4.1.1 The STELLARnet project as a Network of Excellence

Included in the EU funded projects are particularly the so called *networks of excellence (NoE)[26].* Those are projects with partners from many EU member nations, which can be funded for a prolonged period of up to seven years, holding a relatively high budget of annually 1-6 million euros. NoE projects especially aim at a "progressive and durable integration" of resources and expertise the covered field (European Commission, 2003, p. 1). In doing so, it is stressed by the EC, that part-

[24] The most relevant projects are going to be outlined in C.6.1

[25] It is quite likely that educationalists would rather choose the former and computer scientists the latter term.

[26] Excellence refers to "the state, quality, or condition of excelling; superiority" (American Heritage Dictionary, 2009a).

ner institutions should not act as "closed clubs" but also transdisciplinary fashion to work against disciplinary fragmentation in Europe. These strategic projects address the aforementioned problem that expert communities are usually "short-lived" (Amin & Roberts, 2006, p. 7). To ensure community building, also "training" is an "essential component (European Commission, p. 1).

One of those networks of excellence is the STELLARnet project[27]. It hosts and develops the TELeurope.eu platform, which provided the sample of researchers for the study at hand. Since 2009, STELLARnet integrates two former European projects, funded by the 6th framework programme: the mainly pedagogically oriented "Kaleidoscope network" and the IT-related "Prolearn network"[28]. Core aim is to strengthen the "diverse community of technology enhanced learning", "which consists of "researchers, developers, teachers industrialists and others" (STELLARnet, 2011). Instruments to achieve this endeavour and reduce the fragmentation, are diverse and organised in work packages (see tab. 3, Fiedler, 2010). This work packages (WP) are measured against four overarching project objectives:

A. Set a mid-term agenda and strategic direction for TEL research in Europe
B. Increase international visibility and reputation of TEL research in Europe
C. Increase interdisciplinary collaboration in TEL research in Europe
D. Establish and institutionalise discourse and exchange with selected stakeholders in Europe (list from: Fiedler & Kieslinger, 2010, p. 4).

The first objective (A) is especially reflecting the strategic element of channelling TEL as an *epistemic community*. Objective B refers to the aspect of distributing knowledge in an open, transdisciplinarity fashion, which increases international visibility. More operationally focussed, the third objective (C) seeks to establish a wide dialogue between the disciplines, and the fourth one (D) a deep interdisciplinarity (*cf.* Frodeman et al., 2011), where TEL research reaches out to non-academic stakeholders. As do the objectives, the work packages (see tab. 3) also aim at different actors within the community. There are special instruments for supporting early-career researchers, established researchers, and the broad community of stakeholders (including the TEL Europe platform as an instrument for that means). In the following chapter empirical studies on TEL research are going to be presented, which outline the known characteristics of this research field.

[27] STELLAR stands for "Sustaining Technology Enhanced Learning at a LARge scale"
[28] For descriptions see C.5.1.4, or visit http://cordis.europa.eu/fp7/ict/telearn-digicult/telearn-projects-fp6_en.html

WP[29]	**Short Description**	**Instruments[30]**
WP1	Grand Research Challenge for TEL	*Delphi Study, Trend Scouting, Roadmapping*
WP2	Building Strategic Capacity	*Meeting of the Minds, Podcasts*
WP3	Building Researcher Capacity	*Alpine Rendezvous, Theme Teams, Incubators*
WP4	Building Next Generation Capacity	*Doctoral Academy Events, Doctoral Community of Practice, Doctoral Mobility Programme*
WP5	TEL Community Level Capacity	*Stakeholder Events,* ***TELeurope.eu***
WP6	Science 2.0 for TEL	*Open Archive, Tools & Services*

Tab. 3. *STELLAR Instruments to strengthen the TEL community.*
(shortened version of: Fiedler, 2010, p. 6-10)

4.2 Epistemic Characteristics of Technology-Enhanced Learning

This chapter is going to be divided in two parts. The first one addresses findings, which provide insights into the general epistemological nature of the field of TEL, including *common* theories, methodologies and research fields. The second one includes those results, which in particular show *specific* differences between TEL disciplines.

4.2.1 Describing Technology-Enhanced Learning as an Interdiscipline

In order to comprehend the full scope of TEL research in Europe, the STELLAR Delphi Study (Spada, Plesch, & Kaendler, 2011) asked a panel of experts for the identification of core research areas and trends. Eleven different areas have been found, which are going to be briefly characterized in the following.

Computer Supported Collaborative Learning (CSCL), according to Stahl (2002) focuses not on the learning of an individual, but on "the groups themselves that learn" (p. 1). As part of the term, "computer support" means the fostering of networked communication processes, which would not exist without means of technology (p. 2). A second core area[31], *Formal Learning* is about "improving practices of formal education" (Plesch, 2011, p. 2), e.g. in schools and universities, and to

[29] WP7 and WP8 are left aside, as they solely deal with monitoring, management and evaluation.
[30] The enormous complexity of the STELLARnet project and the variety its instruments for community building go beyond the scope of this thesis.
[31] Presented in the order of relevance, discovered by the empirical part of the study (C.6.2)

support educators, who work in those location. Offside the school and university grounds, TEL research also explore other contexts of learning. An area named *contextualized learning* implies that students interact and learn with internet-capable devices in any context, even after school hours. The transfer between e.g. schools and other environments like libraries is dealt with by TEL researchers in the core area *between formal and informal learning*. Emphasis is put on a two-way knowledge exchange between all learning-related institutions. The *personalization of learning* is another common field. It is a "structured and responsive approach" to each individual's learning, in order that "all are able to progress, achieve and participate"(Gilbert, 2006, p. 6). The core area of *emotion and motivation* relates to especially psychological aspects. Those are studied in respect to both technology and learning (Plesch, p. 2). Similar to the aforementioned contextual learning, *informal learning* is an area where learning takes place outside educational institutions. It happens in informal settings, like e.g. an online community, which hold high "motivational aspects". *Interoperability* is a more technology-focused core area. Challenge is to balance the development of specifically tailored education applications, tools and devices, while maintaining the possibility to openly interact with other technology (*cf.* p. 2). Another core area is *workplace learning*. As the name suggests, it seeks to understand how technology can give evidence about an individual's work-related progress and support the gaining of new skills. Furthermore, the study of the increasingly ubiquitous mobile *technologies* and its possibilities for learning has a special role within the TEL community. A final core area identified by Plesch, Spada et al. is the study of the *digital divide* in society. This concept refers to the problematic gap between persons of "different socio-economic levels with regard both to their opportunities to access information and communications technologies (ICTs) and to their use of the Internet for a wide variety of activities" (Patricia, 2003, p. 32).

In an UK context, Conole et al. (2010) were looking at the methodologies used by researchers, who are working in the field of TEL. Beside a wide focus on qualitative social science research methodology[32], they found a some common methodologies, namely *socio-cultural research and activity theory*[33] *design research methodology*,[34]. It is interesting to note, however that there were new methodologies developing. Two of the new methodologies, which were mentioned, are *socio-cognitive engi-*

[32] Including grounded theory (Glaser & Strauss, 1967).
[33] Sociocultural and activity theory research "addresses the dynamics of qualitative transformation within organised practices as found among individual, groups and organisations." (CSAT, 2011)
[34] Design based research is a "systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang, & Hannafin, 2005, p. 6).

neering (SCE) and *collective intelligence*. Socio-cognitive engineering, according to Sharples (2004, p. 542), is a "framework for the human-centered design of technology-based systems to enhance human knowledge working, decision making, collaboration and learning." It is similar to the approach of *user-centered design (UCD)*, which Sharples sees as drawing on "the knowledge of potential users and involves them in the design process." Different from UCD, SCE also looks at activity systems of people and includes social interactions with regards to communication and working styles. *Collective intelligence*, as Pór (2011) describes it, is research on the "capacity of human communities to evolve towards higher order complexity and harmony, through […] innovation mechanisms". However, there are other TEL methodologies coming up, as one interviewee of Conole et al. (2010) is quoted:

> „Some of the methodological approaches I have been adopting I am not sure if we have a label on them yet. I think we are starting to…see some new methodological approaches developing but that‟s a risky thing to say. (p. 25)‟

Also, Conole et al. note that mixed-method approaches, combining quantitative and qualitative aspects, were often found among TEL researchers (p. 26).

Regarding shared TEL-specific theories, the authors especially found theories from the fields of knowledge management, cultural psychology, and artificial intelligence. Three of the many cross-disciplinary theories between the domain of technology and educational/social science are focused, as they are to be presented to researchers in the survey of this study[35]. These are the already highlighted communities of practice approach (Wenger, 1998), the Actor-Network Theory (Callon, 1986) and Constructionism (Papert, & Harel, 1991). The *CoP theory* is often used within TEL for the likely reason that it can describe the development of any informal community of learners, who arrange around, or by means of, technology. *Constructionism* is, to say it simplified, "learning-by-making" (see Papert, & Harel, 1991) It holds that learning happens best, when people are also active in making tangible objects in the real world. In that respect, constructionism is connected with experiential learning and can be applied to learners, who engage with technology. *Actor-Network Theory* is a framework and systematic way to consider the infrastructure surrounding technological achievements. It allows analysing the "co-evolution of society, technological artifacts, and knowledge of nature" (Callon, 1986, p. 20). None of the theories that came up in the study by Conole et al. are particularly new. Most of them go back to systemic and socio-

[35] The decision, which theories and methods to include, was not an easy one. Many discussions with STELLARnet project colleagues lead to the nine methods and respectively theories, which have been included in the final version of the survey (see appendix)

technological/cultural approaches of the eighties and early nineties. Still, comparing it with the age of classical social science (e.g. Emile Durkheim) and computer science theories (e.g. Alan Turing) the identified TEL theories are less established.

4.2.2 Disciplinary Fragments of Technology-Enhanced Learning

So what are the disciplines that make TEL and what are their respective practices? The phrase "technology-enhanced learning" itself implies a dualism. There are persons with a "technology"-oriented perspective, and there persons are with a "learning" perspective. In an ideal case it may be both. Throughout all TEL related studies a range of different disciplines is named, which can hardly be complete.

In their UK based TEL study, Conole et al. (2010, p. 19) note that many TEL researchers come[36] from *science-based disciplines* like Mathematics, Physics, Geography, Psychology, Computer Science, Artificial Intelligence, Engineering, and even Dentistry. A few are from what they called *non-science-based disciplines* like English literature, Sociology and Economics. The labeling of social science/sociology as "non-science" is debatable here and it is surprising that none of the participants has studied education/pedagogy. The term *science* is not going to be discussed in further detail. One might note though that in the theory of science (Popper, Kuhn, etc.) physics is the ideal. It says that "science is the investigation of natural phenomena" (The American Heritage Dictionary, 2005). However, it is not limited to natural science. Maybe because of that reason, Conole et al. stick to a safer dualism, which is between *computer scientists* and *educationalists* (still, note the difference to "education scientists") in the result reporting chapters of the article on their study (p. 37).

Kraker (2010) studied TEL research practices and new media usage, conducted an online discussion with two focus groups (n=6/8), initially asking for the discipline, people identify with[37]. Participants were allowed to choose several out of eight disciplines, including also interdisciplines like TEL and "Human-Computer Interaction", or name a discipline in a free text field. The distribution of answers is visualized in figure 6. Most participants identify with computer science or TEL, but many also have chosen Tel, which might indicate the aim to establish TEL as a legitimate scientific discipline and to strengthen the community. Social scientists (in

[36] The participants were explicitly asked for their disciplinary background

[37] No information on the sampling method has been given. From the STELLARnet context, it is assumed that the participants come from various European institutions, which engage in TEL projects.

the broad sense) were scattered between psychology, education, social science/sociology, and anthropology.

Other findings of the study were that there are "only few" shared TEL research practices with regards to the web (p. 26). Even though many web technologies are being provided by the TEL related EU projects, practices lack behind (*cf.* p. 27). However, they showed interest in Open Access, especially features "such as open peer review, and providing data sets along with papers".

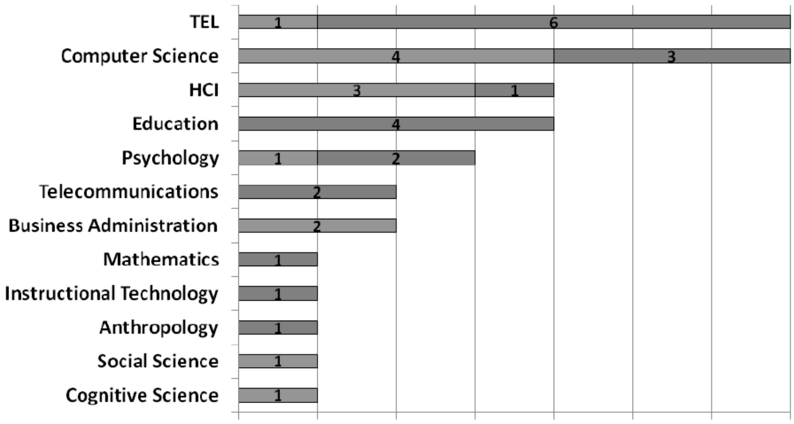

Fig. 6. *Example: Disciplines in a TEL focus group study.*
(from: Kraker, 2010, p. 14)

The German research foundation (DFG, 2008) divides the academic landscape into four different scientific fields, i.e. "life sciences", "natural sciences", engineering sciences" and "humanities and social sciences" (see appendix). The two fields, which are likely to be most relevant for the study of TEL research, are the *engineering sciences* on the technology side and the *humanities and social sciences* on the learning side. However, within those fields mostly the disciplines "computer science" and all of the many learning[38] related social sciences and humanities are of interest. The following two chapters are going to briefly sum up disciplinary and interdisciplinary aspects of those fields. The study at hand is going to stick to the distinction from the DFG study, though informally referring to the former as "computing researchers", "computer scientists", "persons with a computer science/engineering science background (CSB)", and to the latter respectively as "social scientists", "social science researchers", or "persons with a social science/humanities background (SSB)".

[38] "learning" is here to be understood in its broadest sense of knowledge acquisition

4.3 "Interdisciplinarity of Disciplines" in Technology-Enhanced Learning

"Interdisciplinarity of disciplines" – What at first sight seems like a contradiction in terms, is actually not at all one. A knowledge collective (*cf*. Lindkvist, 2005) with several contributing disciplinary communities can only be as open and integrated as its subunits. It is notable because it seems that – despite of a lot of funding (see C.4.1) – relatively few[39] studies in European TEL focus on the different styles and cultures of knowledge creation across the engineering and social science disciplines. An UK-based example for such a study would be the one mentioned conducted by Conole et al. (2010).

4.3.1 Locating Interdisciplinarity in the Social Sciences

The KNOWING study (Felt, 2009; Kerr & Lorenz-Meyer, 2009) studied interdisciplinarity, mobility, gender questions and internationality of researchers in institutions in the fields of bioscience and social science. In general, they found that social scientists in Europe tend to focus on "national disciplinary traditions and histories" (Kerr & Lorenz-Meyer, p. 159), finding it more important to work together with their disciplinary colleagues than in an interdisciplinary way. However, an exception was made by more experienced researchers from the UK, who often had received multidisciplinary training in the course of their career. Also the institutions itself, though offering some cross-disciplinary specialisations, were often headed by researchers, who had a strong identity in the "mother discipline" (p. 160). Those established researchers were often seen as "redrawing" the borders on what counts as a "good" theory or methodology, in particular in sociology. Overall, quantitative approaches were favoured, though especially, younger, female researchers were slowly beginning to establish more qualitative[40] methods (p. 161). In the cases where interdisciplinary work happened, it was often published only as a "hobby", mostly by junior researchers in smaller research institutions, who had the feeling that it is not helping the credibility and reputation, according to the authors of the KNOWING study.

In contrast, most of the eighteen TEL researchers from the study by Conole et al. see themselves as multi- or interdisciplinary, stressing that education research is

[39] I found not a single one. It is symptomatic that studies on web-based research practices (Kraker, 2010) are conducted before studies on traditional research practices have been done. This is what Kraker (2010) indicates, when he concludes that more focus on actual, existing practices instead of technology is needed (p. 27). This includes looking at, and digging into, weak spots of the contributing TEL institutions, where integration of methods is absent.

[40] For the difference between qualitative and quantitative approaches see the appendix

inherently interdisciplinary (pp. 19-20). This confirms with the aforementioned finding that UK social science research tends to be more multidisciplinary. Still, there were tensions and stereotypes mentioned, which relate to a "lack of understanding and respect" (p. 37) between the disciplines. Social scientists were seen as mostly characterized by the *conception* and *evaluation* of learning scenarios, being depended on technologists to design and implement their ideas. Therefore their work is sometimes perceived by computer scientists as mere *context* for their actual research. Also, educational social scientists are stereotypically characterised as "less well defined" (p. 22), without clear "rules and methods" and therefore "methodologically weak" (p. 37). Sociologists were less exposed to this criticism, as they tend to have "laborious" evaluation instruments, like e.g. narrative analysis (p. 26). However, the "identification, demonstration and measurement of success" (p. 37) is difficult for social scientists, who deal with learning processes. In particular social scientists from the education discipline have not yet been contributing much to pedagogical theory, as some researchers criticised (p. 34).

Levitt, Thelwall, & Oppenheim (2011) have investigated in how far the social sciences have become more interdisciplinary in recent years. As a measure for that, the authors look at percentage of documents in the Social Sciences Citation index that cite cross-disciplinary. They noted a decrease between 1980 and 1990 and a sharp increase between 1990 and 2000. For the past ten years they suggest a slow but steady increase, strongly varying between subdisciplines. Most increase is found for the library sciences and information sciences (p. 1). Especially the field of "Education Research" surprisingly has a low PCDCD[41] value of 51% (see figure 7), while sociology and psychology are above average (p. 5).

Subject	PCDCD 1980	PCDCD 1990	PCDCD 2000
Business	48.9%	51.4%	58.7%
Economics	31.3%	32.0%	43.1%
Education & Educational Research	43.0%	41.1%	50.7%
Information Science & Library Science	19.5%	26.3%	57.8%
International Relations	58.2%	55.2%	60.9%
Law	62.3%	23.5%	42.8%
Management	52.7%	49.5%	55.4%
Neurosciences	61.4%	50.4%	48.0%
Political Science	53.6%	51.5%	55.1%
Psychiatry	48.6%	46.9%	53.2%
Psychology	74.3%	74.7%	81.5%
Public, Environmental & Occupational Health	65.9%	65.7%	68.0%
Social Sciences, Interdisciplinary	78.3%	82.4%	82.0%
Sociology	58.5%	62.0%	66.9%
Median	55.9%	50.9%	56.6%

Fig. 7. *The percentage of cross-disciplinary citing documents*
(from: Levitt et al., 2011, p. 5)

[41] PCDCD = Percentage of Cross-Disciplinary Citation Documents

As outlined in earlier chapters, open access (OA) publishing can also count as a form of interdisciplinarity. The publishing practices of the social sciences (including the humanities) tend to differ from those of other science branches, like e.g. the engineering scientists. The OA study by the German Research Foundation (DFG, 2005) showed that social scientists publish fewer articles, as well in conventional journals as in conference proceedings. Longer formats are more common, including e.g. book chapters and monographs[42] (p. 24).[43] As an audience, on the one side social scientists address more researchers from neighbour disciplines (as there are many) and more interested non-professionals. On the other side they target less applied and much less international audiences (p. 28). Looking at OA journals and postprint OA, the social sciences also lack behind (pp. 44-45). The European Open Access study (SOAP, 2011) showed that many social scientist and educationalists find it difficult to access funds for OA publishing (p. 10). As other reasons for not publishing OA they identified *unawareness* about OA possibilities, and *accessibility* doubts, which were more obvious than in other disciplinary fields. Only when it comes to prepublishing drafts in archives, the social science are more involved, even though natural science preprints outnumber all others by far (DFG, p. 48).

4.3.2 Locating Interdisciplinarity in the Computer Sciences

Computer sciences can also be seen as an inherently interdisciplinary field (Conole et al., 2010, p. 21). Especially the domain of Artificial Intelligence (AI)[44] has strong connections to cognitive psychology (*cf.* McCarthy, 2007). Other interdisciplinary links exist with regards to e.g. bioinformatics, linguistics, immersive computing, and quantum physics (*cf.* Heitmann, 2007). Still, in the first place, publications of the past decades were looking at the specifics of computer science as a unified *discipline* (see: Denning et al., 1989; IDEA League, 2001; Dodog-Crnkovic, 2002) mostly because the field is relatively young and computers often tend to be viewed "solely in their capacity of tools" (Dodog-Crnkovic, 2002, p. 8).

In the domain of TEL, persons with a computer science background are often involved in the capturing of "requirements" and specifications, the development of a

[42] A monograph is a scholarly piece of writing of essay or book length on a specific, often limited subject (American Heritage Dictionary, 2009b)

[43] Side note: The BA/MA theses written by students of the social sciences are also usually longer than those of students from other disciplines (according to my own working experience in a computing department).

[44] Artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable." (McCarthy, 2007)

system, and its evaluation by using paradigms and methods (p. 20). The more technological perspective on learning systems development is sometimes criticised as overly "precise", "lacking in ethical consideration" and focused on "formalisms and specifications" (p. 37), rather than reality. There is a perceived lack of respect towards the *science* part of computer science, treating it as a functional "service element", without noticing computer scientists' need for clear definitions (p. 34).

Concerning the publication culture, computer scientists generally publish a lot more in conference proceedings and less in journals. In contrast, monographs and book chapters are uncommon (DFG, 2005, p. 24). Many computer scientists know about open access journals (p. 41) and use them more often than e.g. social scientists (p. 44). In case that they do not use them, it is rather a question of funding than of habits or unawareness (SOAP, 2011, p. 8). Interestingly enough, the computer sciences are the discipline where researchers perceive it as mostly easy to access funds for OA journal publishing, only exceeded by the "earth sciences" (see fig. 8, p. 10). Green postprint OA publishing is also often done in the computer sciences (p. 45), while preprint publishing is no specialty of the computing domain (pp. 47-48). Audiences addressed by computer scientists are very often application-oriented and not at all non-professionals (p. 28).

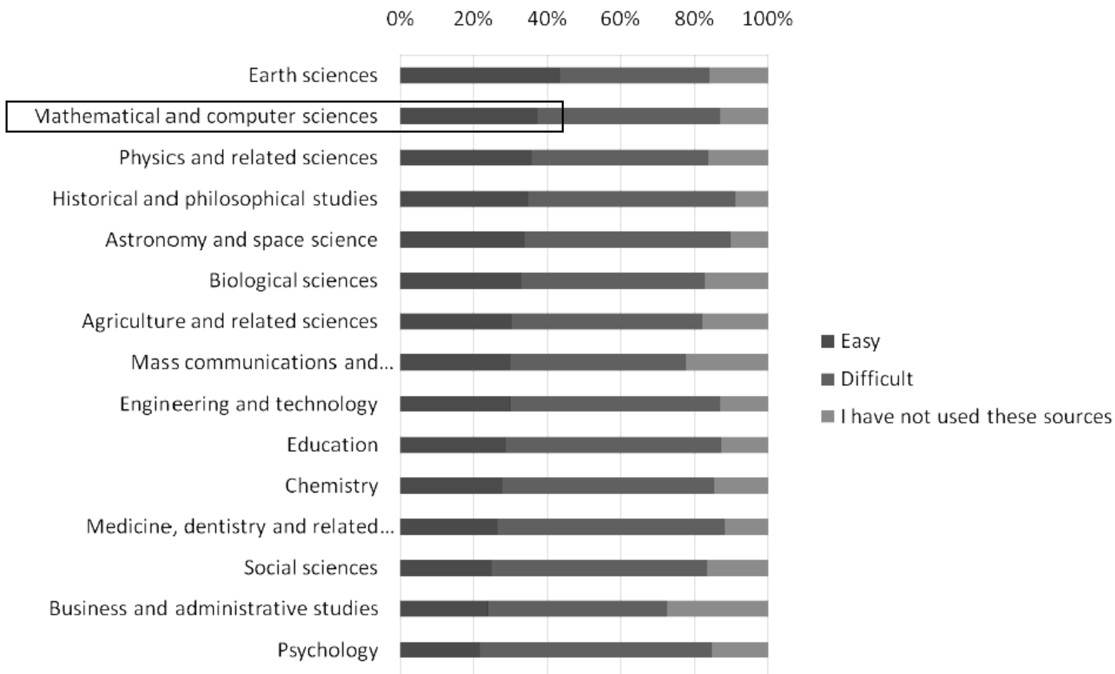

Fig. 8. *Ease of access to funds to pay OA publications across disciplines.* (from: SOAP, 2011, p. 10).

4.4 Conclusions Chapter Four

Chapter four looked into both the political and epistemological dimension of TEL. Empirical insights into the fields of computer science, social science and technology-enhanced learning have been reported. The reported findings are far from complete, as a literature analysis is not the core part of this study. However, it was the preferable way of looking at a new field, an interdiscipline in the making. It is not yet possible to just open an introductory text book and read about the basics of a technology-enhanced learning science, because it simply does not exist. Maybe it will exist in ten years, when the fields are better integrated. This thesis aims to make a small step towards the integration of the aspects of learning and technology. Too often the focus is more either on the learning side or on the technology side and most e-learning books so far, are unlikely to appeal to a computer scientist, as they leave out the computing-specific bit.

4.5 Implications for the Empirical Part

For the empirical part, a survey has been constructed, which builds on the findings of the more theoretical part of this thesis. This includes the different facets of the term interdisciplinarity (C.2), the epistemic practices in the community (C.3) and the more or less discipline specific theories, methods and publication practices (C.4). It is only with this knowledge about interdisciplinarity and the corresponding disciplines in TEL, that a study on the TEL interdiscipline can be conducted. Therefore the approach taken by the study at hand is quite straightforward. By confronting the TEL researchers with different versions and definitions of interdisciplinarity, different methods and theories, they have to reflect on their relation to disciplinary bodies of knowledge. As interdisciplinarity is a reflective practice (*cf.* Romm, 1998), this was thought of an appropriate way of conducting research on it. By looking at fragmentation from a more reflection-oriented point of view, this study hopes to induce further research on reflected disciplinary fragmentation within the scientific field between learning and technology.

V. STUDY: INTERDISCIPLINARITY IN TECHNOLOGY-ENHANCED LEARNING

For the study at hand, several methods are being combined, proposing a 3-step approach, as visualised in figure 9. In a first step, disciplinary *differences* are focused, with the researchers' study background[45] as the independent variable and several depended variables (see C.6.2). Therefore, three groups are formed. The first group contains persons with a background in the engineering discipline, the second one those with a social science background and the third group contains everyone, who has a background in both disciplines, i.e. a multidisciplinary background. The first step allows for analysing specific features of the corresponding disciplines, as they have been outlined in C.4.2 of the theoretical part.

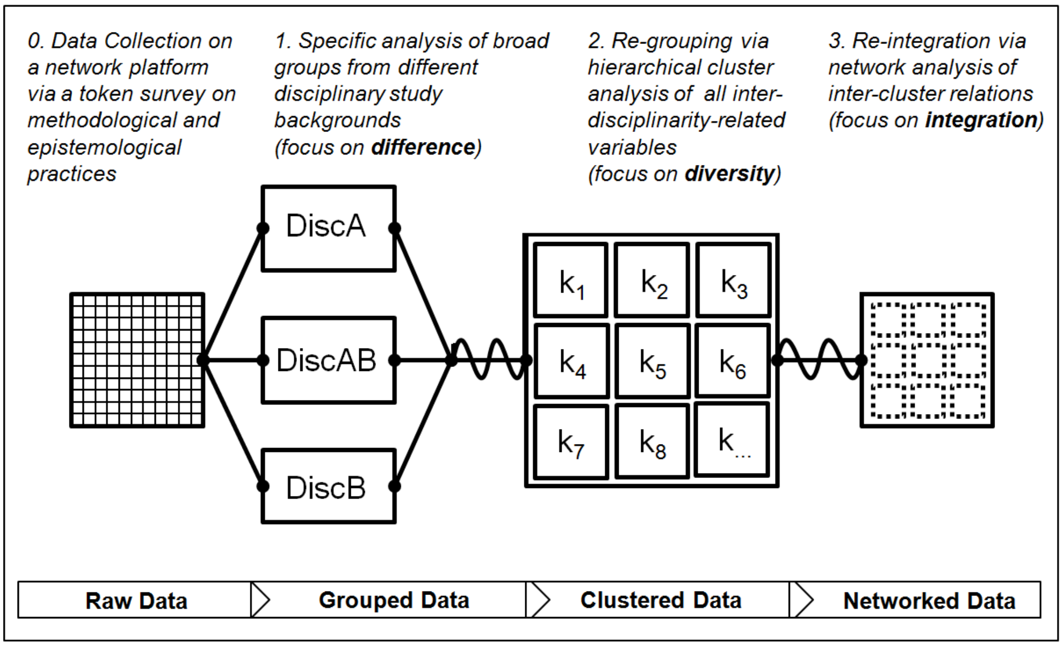

Fig. 9. *3-step re-integration method for the analysis of interdisciplinarity in networks.*

The second step (see C.6.3) then aims for a more fine-grained grouping of the researchers, based on all their responses for questions that deal with interdisciplinarity[46], e.g. their attitudes, disciplinary identification, knowledge on theories, methods, publication practices and several others. This is achieved through a hier-

[45] Involving all formal degrees, e.g. BSc, MSc, BA, MA, PhD etc.
[46] For the study at hand this accounts for almost all questions, which had been included.

archical cluster analysis resulting in an optimum of k = 5-10 clusters[47]. The clusters allow for describing the *variety* of interdisciplinary subgroups, and it raises awareness for structures in the community that remained tacit before conducting the cluster analysis (focus lies on TEL features of the subgroups as in C.4.2).

Finally, in the third step (C.6.4), *integration* is focussed. This means looking at how persons from different "meaningful" cluster are connected on the TELeurope platform. This is achieved through network analysis, which allows investigating inter-cluster relations.

5.1 Study Design

The main empirical foundation of this thesis is an online survey which has been sent out via email to all persons, who at the time of June 2011 were members of the academic research network platform TELeurope.eu.
In general, platform registration is open to anyone. However, for participation in the questionnaire an affiliation with research was demanded, so that questions about scientific methodology can be answered properly. This fact did not necessarily exclude other TELeurope.eu target groups, as long as research activities are to some extent part of their work.

> **Other TELeurope.eu target groups** (list from TELeurope.eu, 2011)
>
> *Policymakers*: People influencing policy in education and training, research, or innovation.
> *Teachers in Formal Education:* Educators within schools, colleges and universities.
> *Continuing Professional Development:* Human Resource Professionals, management consultants, or corporate change manager.
> *ICT/TEL Industry:* Representatives of SMEs and large enterprises working in the field of technology-enhanced learning.

With a considerable amount of members and the clear focus on technology-enhanced learning researchers and practitioners, the TELeurope.eu community may possibly be representative for European TEL as a whole. Still, the exploratory study at hand with its relatively few participants (N=123) can only be representative for the corresponding TEL network. Main goal was to account for the research

[47] For bigger networks, involving more disciplines, a higher number might be appropriate.

cultures and practices of all contributing scientific disciplines and their opinions towards interdisciplinarity. Moreover it was to be tested, whether there are differences in publication behaviour and attitude, regarding early career social and computer science researchers, in contrast to more established researchers.

5.1.1 Sampling Procedure

In a first step after retrieving the members' e-mail addresses from the TELeurope database, a huge amount of fake accounts and spam bots had to be detected and filtered out from the dataset. This left 1.149 valid addresses from a total of 1.748.

Each of them then has been given a token, in order to be able to track responses. This was necessary to combine individual survey responses with the collective data of member platform interconnections (see network analysis, C.5.2.3). In choosing all platform members as sample for the European TEL research community, nonprobability sampling has been used in this study. There are several purposive sampling methods, which can justify choosing a particular community as the target sample (methods from: Trochim, 2006):

- → *Expert Sampling:* Expert communities have already been discussed in the theoretical part of this thesis. On its cover page, TELeurope.eu claims that a member can "engage with experts in the field" (TELeurope, 2011), when becoming part of the network. This implies that many experts of technology-enhanced learning are registered members. According to Trochim expert sampling means "the assembling of a sample of persons with known or demonstrable experience and expertise in some area". This is, to a noticeable extent, the case for TELeurope.eu.
- → *Heterogeneity Sampling:* European TEL research is considered to be quite diverse, in involving also non-university stakeholders, as mentioned before. This study is interested in the opinions of all members, even the ones with less expertise in the field. Heterogeneity sampling aims at this diversity so it matches the study's approach.
- → *Modal Instance Sampling:* This method takes a closer look at "typical" or "modal" (Trochim, 2006) representatives of a group. Persons, who register on a platform under the banner of European TEL research, can be regarded as relatively typical in that respect.

However, neither the nature of the heterogeneity and expertise is sure to be known about the TELeurope.eu community, so a major goal of this study is to shed light on these issues. In plain words, the survey looks at the “typical heterogeneity” of a group of experts, working in an interdisciplinary field. For what is noted about the community, its members come mostly, and about equally distributed, from the scientific fields of engineering science and social science/humanities. A table (see tab. 4) provides an overview of the areas of expertise, which are included in each of the four scientific fields, taken from a classification of the German research foundation. Sample characteristics along the disciplinary background are the main focus of analysis in the following chapters.

Discipline	Research Area	Scientific Field
Ancient Cultures	Humanities	Humanities and Social Sciences
History		
Fine Arts, Music, Theatre Studies		
Linguistics		
Literary Studies		
Social and Cultural Anthropology		
Theology		
Philosophy		
Education Sciences	Social and Behavioural Sciences	
Psychology		
Social Sciences		
Economics		
Jurisprudence		
Production Technology	Mechanical and Industrial Engineering	Engineering Sciences
Mechanics and Constructive Mechanical Engineering		
Process Engineering, Technical Chemistry	Thermal Engineering/ Process Engineering	
Heat Energy Technology, Thermal Machines / Drives		
Materials Engineering	Materials Science and Engineering	
Materials Science, Raw Materials		
System Engineering	Computer Science, Electrical and System Engineering	
Electrical Engineering		
Computer Science		
Construction Engineering and Architecture	Contruction Engineering and Architecture	
[…]	Biology	Life Sciences
[…]	Medicine	
[…]	Agriculture and Forestry	
[…]	Chemistry	Natural Sciences
[…]	Physics	
[…]	Mathematics	
[…]	Geosciences (including Geography)	

Tab. 4. *The scientific landscape (abbreviated list, based on DFG, 2008).*

5.1.2 Questionnaire Construction

Main purpose of the questionnaire was to encompass understandings and attitudes towards interdisciplinarity, as well as to investigate disciplinary backgrounds, identities and practices in the community. Introductory questions therefore were trying to locate the researchers' roles in technology-enhanced learning, their activities and study background, in order to be able to put other questions into context. The questionnaire has been developed from scratch, building on the experiences of a qualitative TEL study (see Conole et al., 2010) and a study looking into open access publication, conducted by the German Research foundation (see DFG, 2005).

The first draft of the questionnaire has been discussed with researchers from the STELLARnet EU project, taking into account formal construction, content and empirical-methodological accuracy. After that, a pre-test helped to further enhance its conclusiveness, integrity, comprehensibility and validity (see C.5.1.3). In consideration of the pre-test results, the final questionnaire consisted of six blocks with a total of 24 questions, which are forming 22 variables (see tab. 5).

V1	What are your main work activities in the field of Technology Enhanced Learning?	**Block 1:** TEL Basics
V2	Which of the following TEL research areas reflect your work?	
V3	In which scientific fields have you been studying (for Bachelor/Master/PhD)?[48]	**Block 2:** Interdisciplinarity and Background
V4	Would you consider your study background as "interdisciplinary"? Please answer for different definitions of interdisciplinarity.	
V5	Would you consider your current work as "interdisciplinary"? Please answer for different definitions of interdisciplinarity.	
V6	On the whole, which scientific field do you identify with the most?	
V7	What is your opinion on the following statements about interdisciplinarity? (Note: Interdisciplinary research here defined as: "Strong and integrative collaboration of researchers from different scientific fields working on a common research aim.")	
$V8_{abc}$	Please tell how you use the following terms that are often relevant to TEL research. There are no right or wrong answers. Please finish the following sentences by ticking the option that best reflects your gut feeling. "When I use the term "a;b;c", it is usually about ..."	**Block 3:** Terminology
V9	Which of the following methods do you use in your research?[49]	**Block 4:** Methods and Theories
V10	On which of the following theoretical perspectives do you base your research?	
V11	What audiences do you typically address with your publications?	**Block 5:** Publishing and Open Access
V12	Do you address researchers outside your work country with your publications?	
V13	In 2010, how many of your works did you publish in a conventional way (through publishing companies with charging a fee)	
V14	In 2010, how many of your works did you also publish for open access on the web (preprint as well as postprint)?	

[48] A table with a list of scientific fields (Social Science & Humanities, Engineering Science, Life Science, Natural Science) and corresponding subdisciplines was made available (see appendix), in order to avoid a flawed evaluation of one's study background.

[49] Comprehensive descriptions of all named methods and theories have been provided to reduce the amount of "I don't know" answers and therefore to enhance the quality of the data.

V15	What kind of workplace have you mainly been working in for the past 12 months? (Note: If you have been working in more than one place, please consider the one where you spent most of your time)	**Block 6:** Demographic Data and EU Projects
V16	What is your work position?	
V17	What academic background do most of your colleagues have?	
V18	Where is the institution located? + City*	
V19*	What age-group do you belong to?	
V20*	For how many years approx. have you been working in the field of TEL?	
V21*	Gender	
V22	Do you participate or have you previously participated in any European TEL project?	

*not mandatory

Tab. 5. *List of survey variables incl. questions.*[50]

The first group was covering basic questions about the researchers' activities and interests in the field of technology-enhanced learning. Next, the second group was determining the (inter-)disciplinarity of study backgrounds and current work, also addressing attitudes towards the concept of interdisciplinarity. In the third group, participants were asked to define common TEL terms that were thought to be ambiguous and which meanings may vary, depending on the academic culture you come from. After that, the fourth group of questions was looking into the utilisation of theories and methods from Computer and Social Science as well as a range of supposed "TEL theories and methods", which might be multidisciplinary. The fifth group was dedicated to publication related questions about targeted audiences and publication formats, with special consideration for Open Access. Finally, the last questions were covering demographic information, like e.g. country or institution, which is essential for an in detail analysis of the questionnaire answers. For statistical purposes and only partly of interest for this study, also the participation in European TEL projects has been collected.

The questionnaire consisted mainly of closed questions, even though sometimes room was left for open answers. For example, the participants were enabled to name an individual study background, work position, project affiliation and publication audience. Another open text field appeared on condition that a participant did not agree on any of the definitions in the terminology section more than once. It was then possible to give a reason for not choosing a definition. At the end, feedback on the survey was requested in an additional, non-mandatory comment box. The questionnaire has been built using LimeSurvey open source software and was sent out via Microsoft Office Mail Merge.

[50] For a detailed list of all answer options see appendix.

5.1.3 Pretest and Questionnaire Adaptions

In May 2011, a pre-test of the questionnaire has been conducted, involving researchers, who in the broadest sense work in technology-enhanced learning or related fields, like human-computer interaction or CSCW[51]. Researchers already registered on TELeurope were asked not to participate in the pre-test, in order to avoid an overlapping in both groups. Participants came from three different institutions, CRAFT[52] of the university École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, as well the Open University's Knowledge Media Institute[53] (KMi) and Institute of Educational Technology[54] (IET) in the United Kingdom. 11 researchers took part in the pretest. At the end of every page they were asked to leave voluntary comments on perceived difficulties and errors. Most of them needed more time to fill it out than the promised 5-7 minutes, which is why the estimation was set higher, up to 10-12 minutes. Also, a set of questions, concerning the use of online media, had to be left out. Another one, asking for the size of the work institution, was removed because respondents often couldn't recall a correct answer. However, beside some minor rephrasing and reordering adaptions, most questions seemed to work well. The question V10[55] about theories e.g. indicated that there are expected differences in the use of theories in TEL research, depending on the disciplinary background. A question, which didn't work too well, was the one about preferred terminology (V8). It did not at all show excepted tendencies towards a language difference between the disciplines, but appeared to produce flawed responses, highly influenced by the concrete phrasing of the question. In the pretest version V8 had been put in the following way:

> **V8** "Please choose the most plausible meaning of the following TEL related terms. Which of the definitions seems more likely to you? If you find more than one plausible, choose your favourite. If no option seems plausible to you, tick "none of them". There are no right or wrong answers. Please answer quickly by ticking the option that best reflects your gut feeling."

The term definitions had been derived from dictionaries and several scientific articles. Each of them was meant to address a particular discipline or school of thought. Their origins were not communicated to the participants, in order to obtain more spontaneous responses. Given definitions for the term *"scenario"* were for example:

[51] Computer Supported Collaborative Work
[52] http://craft.epfl.ch/
[53] http://kmi.open.ac.uk/
[54] http://www8.open.ac.uk/iet/
[55] See list of variables and corresponding questions in C. 5.1.2

1 Situation or context that exposes learners to issues, challenges and dilemmas[56]
2 Narrative, describing foreseeable interactions of users and a learning system
3 Model which defines what learners can do with a given set of resources and tools
4 None of them

The respondents had to choose one of the terms, as a ranking was considered too complex at this point. What happened is that for this question, seven out of eleven persons chose the third definition. This fact could mean that the TEL community agrees on this definition, but just as well it could be simply the most well-phrased one of the three. With the items being too diverse to test them properly, a more standardised way of testing the terminology has been chosen for the final version of the questionnaire. After the adaptions, V8 had a more abstract form, asking to complete statements, like "When I use the term *x*[57], it is usually about …". They could then choose between a social, technological and systemic meaning. In the scenario example the final options looked like this:

"When I use the term *scenario*, it is usually about ...
1 ... describing Human-Computer interactions"
(e.g. narratives and interactions in a system involving people and technology)
2 ... describing steps or actions between people"
(e.g. role plays, team work, teaching strategies)
3 ... describing technology interactions"
(e.g. use cases with abstract actors, such as external software or manual processes)
4 None of them

Another question, which had to be adapted, was V1 about TEL activities. A simple "yes" or "no" choice, as in the pretest, seemed to be too definite. For example, everyone would put a yes to the activity "researching", even though it may not be the main activity. It then was replaced by Likert-scale items. Also, activities such as "teaching" or "programming" were added, as it might reveal cultural differences within the TEL community. The "programming"-item is also suitable to double-check, whether persons with an engineering background are really involved with computing, which in TEL seemed reasonable, but was not surely known.

While during the pretest the concrete ordering of the questions was still work in progress, a decision had to be made for the final questionnaire. As a result, questions on the perceived interdisciplinarity of one's study and work background

[56] The first definition comes from the social sciences, respectively pedagogy, as it focuses on the learner and his/her situation. In contrast, the second one is a computer science definition, as it treats learners as users of a technological system. Focussing on the learner plus the "tools", the third definition is a rather cross-disciplinary one.
[57] Three terms have been chosen, viz. "intervention", "evaluation" and "scenario". Among other terms like "design" or "method", these were expected to be ambiguous in their meaning for technology- or social-focused researchers.

were put right after the introductory, easy-to-answer TEL questions. This was done to generate more spontaneous results than if "interdisciplinarity attitude" had been put after the "theory", "methodology" and "publication" questions, as they might raise awareness on one's (inter-)disciplinary background. Theory, methods, publication etc. were held in the respective order, because this mirrors the typical research process, with at first knowledge generation and afterwards publication and knowledge distribution. As recommended for survey construction, demographic data was asked for at the end. Membership in EU projects was the very final question, as there was a huge list of projects to choose from. If respondents had left the questionnaire at that point, all the other more important data would still have had been saved.

5.2 Methods of Analysis

As already indicated, the study at hand combines several methods of analysis, such as bivariate hypothesis tests, multivariate hierarchical cluster analysis and social network analysis. These methods and their characteristics in reporting are going to be explained in the following chapters.

5.2.1 Nonparametric Hypothesis Testing

In social statistics, nonparametric tests are used for ordinal data, e.g. Likert-scales, which are frequently occurring in the study at hand. In comparison to parametric tests, they make fewer assumptions on the distribution of the data (Plonsky, 2009). This means they do not require a normal data distribution. Categorical data, e.g. V8 "What category of terms do you prefer?" can be analysed as well as ranked Likert data. Still, nonparametric tests have disadvantages in comparison to parametric tests, as they are less strict and powerful in the ability of finding a difference when there really is one and less robust, meaning they cannot tolerate violations of prior assumptions (*cf.* section III).

The null hypothesis H_0, which states that there is no difference between the three big disciplinary groups, is tested by the Kruskal-Wallis H test for independent samples. Therefore the disciplinary study background (V3) makes up the grouping variable, treating computer science background[58] (only), social science back-

[58] From this point on, engineering science and computer science is going to be treated synonymously, as results (see C.6) indicate that the vast majority studied computing related subjects.

ground (only) and multidisciplinary background as three independent groups. The Kruskal-Wallis H test is designed for testing differences between three or more level of one independent grouping variable and an ordinal scaled depended variable. In other words, it is the non-parametric version of ANOVA (UCLA, 2007).

If the probability (p) value is lower than the significance level ($\alpha = 0.05$), the null hypothesis is to be rejected. In that case or even if the value is slightly over this limit ($p < 0.06$), it is worth testing, if any of the three groups is particularly different. This can be done by pairwise comparison, using the Mann-Whitney *U* test of two independent groups. For example a test can consist of one group, who studied in a certain discipline and the rest, who did not. The Mann-Whitney is similar to the Kruskal-Wallis *H*, with the only difference that it is not capable of comparing more than two different groups within the independent variable (UCLA, 2007). As *means* are usually not reported for ordinal data (Gamble, 2001, p.13), in this study *percentage* of group discipline is going to indicate the differences between the groups in more detail. Therefore sometimes parameter values are summed up in order to present the results in a more comprehensive way, e.g. “strongly agree” and “agree” make up the “agreement”, “strongly disagree” and “disagree” make up “disagreement”.

Besides bar, column and pie charts, also *box plots* are visualisation formats used for reporting the results. Box plots allow a more precise interpretation of the answer distribution. It does not only take means into account, but shows also minimum and maximum values, quartiles and medians (McGill, Tukey, & Larsen, 1978, p.12).

5.2.2 Hierarchical Cluster Analysis

Cluster Analysis in general describes a set of techniques, used to segment data into a number of clusters. Elements within a cluster are closely related to one another, while they are less related to elements from other clusters, regarding multiple predefined variables (Hastie, Tibshirani, & Friedman, 2009, p. 501). In statistical data analysis, clustering is used in a huge number of different fields, e.g. machine learning, pattern recognition, image analysis, data mining, information retrieval and marketing research. In the latter, the aim is the identification of market segments (Sheppard, 1996, p. 49). Similarly, it is also a suitable technique for describing the field of European technology-enhanced learning as it is possible to detect target audiences and to better position the “product”, which in this respect is the TELeurope.eu social network platform. Cluster analysis, in general, like factor analysis and others, is an interdependent method, as it does not distinguish between dependent and independent variables. The entire set of relationships is examined. For clustering, there are "bottom-up" and "top-down" approaches. The former starts with each case, i.e. participant, being a separate cluster. Those are then agglomerated into larger clusters, based on similarity. The latter starts with one big cluster, which is then divided into a larger number of segments.

Hierarchical clustering is a special variant of cluster analysis. In contrast to e.g. k-means clustering, the number of clusters is not predefined. Instead, the user must specify a measure of dissimilarity between groups of observations. Given two hypothetical groups G and H, the dissimilarity *d(G,H)* between those is calculated from pairwise observation of dissimilarities *dii′*. One member of the pair *i* is in G and the other *i′* is in H. *Single linkage (SL)* or *nearest neighbour* measure does now compare the groups along the closest (least dissimilar) pair in each group (Hastie et al., p. 523)

$$d_{SL}(G,H) = \min_{\substack{i \in G \\ i' \in H}} d_{ii'}$$ (Hastie et al., p. 523)

For *complete linkage (CL)*, intergroup comparison is done by taking the dissimilarity of the *furthest neighbour*, i.e. the most dissimilar pair into account.

$$d_{CL}(G,H) = \max_{\substack{i \in G \\ i' \in H}} d_{ii'}$$ (p. 523)

Another common technique computes the average dissimilarity in a group and uses it to compare between the groups. *Group average linkage (GA)* represents a compromise between the single and complete linkage. Aim is to produce relatively compact clusters that are relatively far apart. The clustering used in the study at hand is based on the average intergroup comparison.[59]

$$d_{GA}(G,H) = \frac{1}{N_G N_H} \sum_{i \in G} \sum_{i' \in H} d_{ii'}$$ (p. 523)

After deciding what to compare, one must decide how to compare. The measure for correlation can be several coefficients, which tell the strength of dependence

[59] There are more techniques like Ward, Median and Centroid (SPSS, 2011), which are not going to be described in this thesis.

between two variables. The variety of intervals to choose from is quite big, a selection of the most common ones, like Pearson, Euclidian distance, cosine etc. Several coefficients have been tested, coming to the conclusion that the Pearson coefficient provided best results for clustering the data[60]. In hierarchical cluster analysis, results are visualised using a dendogram (see fig. 23). It shows all cases (survey respondents) grouped by similarity.

The Y-axis refers to the rescaled distances between the cases. The dendogram provides information about the appropriate number of clusters to keep. It is then up to the researcher to decide on it. Hierarchical cluster analysis is an exploratory method (Andrews, 2005, p. 3). Therefore all results are recommended to be treated as tentative, until they can be confirmed by testing a selected set of independent and dependent variables. As Chan (2005) puts it, cluster analysis "is an art, rather than science" (p. 159), not without also calling it "an invaluable tool to identify latent patterns in a huge dataset that could not be discerned by any other multivariate statistical method."

5.2.3 Social Network Analysis

Central aim of network analysis as a method[61] is the identification and explanation of network structures. Therefore, several nodes of a network are examined, with every node representing an actor. In *social* network analysis, these actors are humans, who are usually to be viewed at as individuals in their collective relations. (Newman, 2006, p. 1). Relations between individuals are called edges. They can be either directed (pointing from one edge to another) or undirected (having no direction). The overall construction of edges describes the relationships that make up a network. Looking at both nodes and edges, statements about the nature and functionality of the investigated network can be deduced. Primary focus lies on the network "as a whole" rather than single actors or relationships, which form it. This marks a crucial difference between network analysis and more conventional methods of empirical social science, which tend to look at the individual attributes of persons or artefacts (Jansen, 2006, p. 18). Therefore, network analysis can iden-

[60] Note: In order to conduct the cluster analysis in greater detail, all data has been transformed to interval type and rescaled to a 0-1 scale. This procedure is common in applied sociological research (Mayer, 1971, p. 519). For example, a Likert scale holding the items "never", "sometimes" and "always" or respectively "disagree", "undecided" and "agree" produces the values, "0", 0.5" and "1". In accordance, means and standard deviation are going to be reported in the following.

[61] Network analysis in sociological research exists since the 1930s. This thesis won't go into detail with the method's historical development.

tify cliques[62] of persons in larger networks, which often show a "natural modularisation" as some persons are more connected than others (Newman, 2006), as exemplified in fig. 10.

When analysing networks, one can distinguish between mono- and bipartite variations. Criterion is the character of the nodes, which form the network (*cf.* Wasserman & Faust, 2009). Monopartite networks only consist of nodes, which lie on one semantic level, e.g. only persons, texts, etc., whereas networks with bipartite character display several types of nodes at the same time. This can be e.g. persons and projects in TEL. A person would then be connected to a project, if she is affiliated with it. Therefore these kinds of networks are called "affiliation networks" (p. 40).

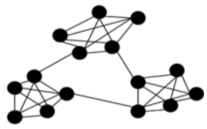

Fig 10. *Example of a modularised network.*

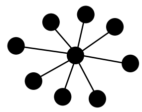

Fig 11. *Example of a star-shaped network.*

Network analysis allows "a specific, systematic and quantifying" description of networks (Jansen, 2006, p. 13) and can be combined with other methodology, as in this study. It is especially conducted in sociological and developmental research, to generate recommendations for e.g. information management in organisational contexts. Therefore, persons are identified, who are either central or peripheral within the network to restructure and rearrange decision-making or informational processes (Cross, Borgatti, & Parker, 2002, p. 7). In the following, basic terminology of network analysis will be explained.

The **density** (Δ) of a graph describes the degree of connectedness with regards to all points. In general, the network density is the relation between the realised connections and the possible connections. A network is considered as "dense", if at least two thirds of the connections are realised (Renz, 2007). Professional networks are usually less dense than private networks (Jansen, 2006, p. 95). The maximum number of possible pairs n_{max} is calculated as follows[63]:

$$n_{max} = [N \cdot (N-1]/2$$

[62] The term clique is used interchangeably with similar terms like "cluster", "module", "group" or "block". So are the terms "network" and "graph".

[63] N refers number of network nodes

Fig. 2 shows a star-shaped network. With N=9 it has 36 possible pairs, of which 8 are realised. Thus, the graph has a density of $\Delta = 8/36 = 0{,}22$. If a graph is complete, its density is 1.

On the individual level especially the term *centrality* is of importance. The centrality reflects the prominence of an actor. Different measures for centrality exist, which can results in strongly varying values for a single actor. Specific forms of centrality are expressed by the degree value $d_{(i)}$, which refers to the number of edges that connect the actor to others. If an actor has no „neighbours", then the degree equals null (Jansen, 2006, p. 127). In general, the highest degree of centrality for a single actor can be found in star-shaped networks (see fig. 11). Accordingly, ring-shaped networks are least centrally structured (p. 130). The most common measures of centrality are „degree"-, „closeness"- and „betweenness"-centrality (Serdült, 2002, p. 132). They all share the theoretical assumption that more prominent actors have access to valuable network resources and control instruments.

Degree centrality assumes that an actor is most central, if it is very active and has a large number of direct relationships (Serdült, 2002). In a graph, the degree centrality is calculated simply as the sum of all direct connections to other actors. Another measure, the *closeness centrality*, looks at the closeness of a node to all other nodes in the network. Hereby an actor is central, if it is in the position to reach many nodes over as few indirect contacts as possible. High closeness centrality indicates a high effectiveness within the network.. In contrast to the former two, *betweenness centrality* accounts for the circumstance that a position *between* actors can be of special importance (p. 133). For this purpose, three actors are considered: a pair of nodes and one node, which lies on the shortest path between those. Centrality is assumed, if an actor lies on as many paths as possible. Persons with a high betweenness are likely to act as agent between other actors, who are dependent on them for quickly reaching indirect contacts (Jansen, 2006, p. 135).

Network analysis and visualisation has been conducted using the open source graph visualisation and manipulation software Gephi (www.gephi.org).

VI. RESULTS OF INVESTIGATION

Combined with a cover letter email, the final questionnaire was sent to the around 1.000 members of TELeurope in June 2011. One week later, an email reminder was carried out in order to increase the response rate. The cover letter explained the context and aims of the study. It included a contact email address for eventual questions and was signed by members of the STELLARnet research team and Peter Scott, the director of the Knowledge Media Institute. A personalised html-link in the email led to the start page of the online survey. This page further explained the study, gave information about the author, the estimated time and included a small, witty illustration to motivate for participation. Data collection was closed on the 30th of June 2011. 123 persons completed the survey, which makes out response rate of around 10%. For analysis the data had been exported into an Excel table. This was converted into a file containing only number values for each variable, so that advanced calculations can be done, using SPSS software.

6.1 Basic Sample Characteristics

To tell about the representativeness of the participating researchers for the TELeurope.eu community, it is useful to take a look at the distribution of basic variables, like disciplinary study background, age and gender (tab. 6). There is a slight bias towards social science background, but gender and age are well distributed. The largest group of participants is between the age of 31 and 40. The experience in the field of technology-enhanced learning ranges from one year to the impressive number of 36 years of experience. Still, with 73%, the majority of researchers have a background of up to 10 years in TEL.

Looking at discipline differences, a majority of the social science researchers and only on third of the engineering science researchers are women (tab. 6). The proportion of the 23 professors, who responded to the survey, is similar for the disciplines. However, few persons, who studied computer science, are over 30 years old. Person with a background in social science are usually older and almost every multidisciplinary researcher is over 30 years old.

Almost all of the participants have been working in a university or tertiary school setting (84%) in the 12 months before the survey. Only a total of 20 persons state to come from private companies, schools, non-profit organisations, individual enterprises or public cooperation. Besides the professorship-holding researchers, there are several lecturers (27%), research associates (25%) and assistants[64] (21%), who participated[65]. Interesting enough, just as many PhD students as professors participated in the survey, so attitudes of established and early career researchers have been measured in equal amount.

V3 Study discipline	Basic variables	N [66]	% of group discipline	% total
Social science	*male*	18	35%	15%
	female	33	65%	28%
(studied only social science)	**V19** Age-group			
	30 years and younger	12	24%	10%
	Over 30 years	39	77%	33%
	V16 count of professor	7	14%	6%
	group total	**51**	100%	43%
Engineering science	*male*	25	70%	21%
	female	11	31%	9%
(studied only engineer. science)	**V19** Age-group			
	30 years and younger	17	47%	14%
	Over 30 years	19	53%	16%
	V16 count of professor	7	18%	6%
	group total	**39**	100%	30%
Multidisciplinary	*male*	17	55%	14%
	female	14	45%	12%
(studied in several fields[67])	**V19** Age-group			
	30 years and younger	4	13%	3%
	Over 30 years	27	87%	23%
	V16 count of professor	9	29%	7%
	group total	**31**	100%	26%
Other background	group total	**2**	100%	1%
Total		**123**		100%

Tab. 6. *Response rate statistic and distribution of basic values in the final sample.*

Researchers from 31 different countries have participated, including 25 within Europe, as well as the United states (5), Canada, China, Japan, Israel and South Africa (each 1). All major European countries, such as Germany, UK, Spain, Italy and France, are represented in the survey. The number of participants can be compared with the population count of a country, in a form that the *degree of represen-*

[64] In contrast to a research assistant or research officer, a research associate often has a doctoral degree. In some cases it can be synonymous with postdoctoral ("postdoc") research. However, it is not always that strict, as Bennett (2011) says "some are just out of college, but there are also people [...] who have PhDs, and others who have taught in the past or worked in consulting."
[65] For this question it was possible to select multiple answers
[66] Gender and Age were non-mandatory statements and therefore some values are missing.
[67] 18x social science and engineering science, 7x social science and natural science, 6x others

tation d_{rep} equals the number of participants (N) divided by the population (P) of a country and multiplied by 10^{-7}. Table 7 shows all participating European countries and their degree of representation on TELeurope.

Country	Participants (N)	Population (P)	d_{rep} [68]
United Kingdom	21	60271000	3.5
Spain	15	40281000	3.7
Germany	14	82425000	1.7
Netherlands	9	16318000	5.5
Italy	7	58057000	1.2
Romania	5	22356000	2.2
Switzerland	5	7451000	6.7
Austria	5	8175000	6.1
France	4	60424000	0.7
Estonia	3	1342000	22.4
Norway	3	4575000	6.6
Belgium	3	10348000	2.9
Portugal	2	10524000	1.9
Slovenia	2	2019614	9.9
Serbia	2	10826000	1.8
Denmark	2	5413000	3.7
Bulgaria	2	7518000	2.7
Croatia	2	4497000	4.4
Sweden	1	8986000	1.1
Greece	1	10648000	0.9
Turkey	1	68894000	0.1
Czech Republic	1	10246000	1.0
Finland	1	5215000	1.9
Luxembourg	1	463000	21.6
Moldova	1	4446000	2.2
[other countries]	0	178281386	0.0
Europe (continent)	113	700000000[69]	1.6

Tab. 7. *Representation of European countries on TELeurope.*

The continent Europe as a whole is represented with a d_{rep} of 1.6. Looking at the bigger countries, especially Switzerland, Austria and the Netherlands lie above this value, while e.g. Italy and even more France lies below it. In total numbers, most researchers come from the United Kingdom, Spain and Germany (fig. 12).

Looking at membership in EU projects, 56% of researchers on TELeurope participate or participated in at least one project in the *European Framework programmes* FP5, FP6, FP7 or the *eContentPlus* programme. Researchers of higher age groups, not surprisingly, are more likely to be part of TEL projects. In total, as expected, the ***STELLARnet*** project (22) has been named the most.

[68] $d_{rep}=N/P \cdot 10^{-7}$
[69] This number is the approx. estimated population of the European continent (WWP, 2011).

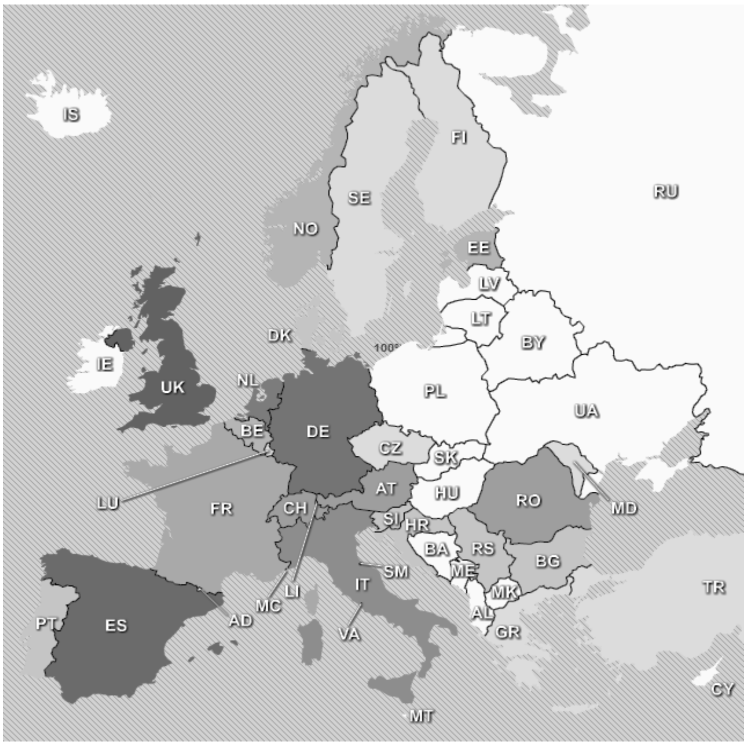

Fig. 12. *Heat map of Survey participation in Europe*
(dark grey indicates high participation)

Also quite common is the ***Kaleidoscope*** project (11), which had been funded by the European Union from 2004 until 2008. It dealt especially with pedagogy and science issues concerning TEL research, like integrating theoretical and practical research foundations, and developing new methodology (Sutherland, 2011). The ***LTfLL*** project (9) is more technology oriented, providing "language technology for lifelong learning". It is directed towards text-based artefacts and uses a number of different language technologies to analyse them and to give feedback about them back to the users, in order to increase awareness and reflection skills (LTfLL, 2011). Another project, ***Share.TEC*** (8) is providing digital resources for the teaching education community. An online platform for teacher educators has been built, which "helps to learn about and exchange resources of various kinds, and [...] supports the sharing of experience about the use of those resources" (Axdorph, 2010). ***ROLE*** (7) delivers and tests prototypes of responsive TEL environments. These environments can be adapted and personalised (ROLE Consortium, 2011). The ***ICOPER*** (6) project is a best practice network, which adopts standards for open educational content. It collects and further develops best practices for interoperable and open content in higher education (ICOPER, 2011). For ***PROLEARN*** (5), the predecessor of the STELLARnet project, the mission was to "bring together the most important research groups in the area of professional learning and training"

(Herder, 2005). Other EU projects, which have been mentioned more than once are *TENCompetence*, *IntelLEO*, *PALETTE*, *APOSDLE*, *iCamp*, *iCLASS*, *TARGET*, *GaLA*, *COOPER*, *NEXT-TELL*, *TEL-Map*, *CALIBRATE*, *MATURE* and *ADAPT-IT*.

Besides project affiliation, also the cooperation within an institution might play a role for the researchers' perception of the field and it might influence other variables. 42% of the community work together mainly with colleagues[70], who have a social science background (computer science: 31%). Only one in four researchers works in multidisciplinary institutions (25%).

It is notable that the study background largely determines the current work institution (see fig. 13). Computer scientist usually work together with colleagues of the same background (72%). About the same accounts for social science researchers (65%). However, multidisciplinarians very often have more colleagues from the social sciences (42%).

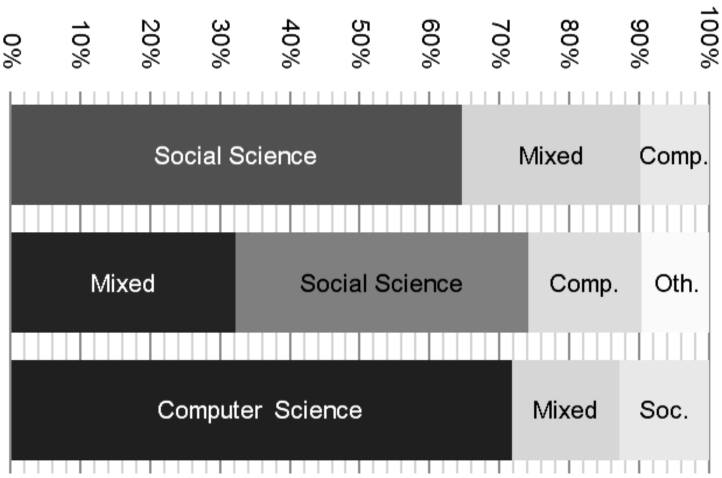

Fig. 13. "*What academic background do most of your colleagues have?" (V17, N=121)*
(upper=SSB, middle=MSB, lower=CSB)

[70] Aim of the question V17 was to determine the nature of a person's workplace, without asking to explicitly put it in a category, but focussing on the persons, who work there.

6.2 Survey Results: Hypothesis Testing

The presentation of survey results is going to be structured along the four broad research questions, which had been formulated initially (see C.1). For each of those, the independent variable *V3 study discipline* is going to be compared with several dependent variables using bivariate hypothesis tests.

6.2.1 Research Question 1: "Sense of Joint Enterprise" in the TEL Community

To recall, the first research question about a *sense of joint enterprise* in the TEL community is about attitudes and identities of TEL researchers. It is addressing the following concrete points:

a) Do European TEL researchers refer to themselves as being "interdisciplinary"?
b) Do they agree with different attitudinal statements towards interdisciplinarity?
c) Do they use a similar terminology/vocabulary?
d) Are they interested in the same core research areas?

Several hypotheses are going to be tested in each of these categories. In general, the independent variable is *V3 study background.* It is suggested that the study background has an influence on a researcher's (inter-)disciplinarity, which is represented by many dependent variables. Tests are the aforementioned Kruskal Wallis *H* and Mann-Whitney *U*. For better reading, the three independent groups to be tested are sometimes abbreviated "SSB" (Social Science & Humanities Study Background), "CSB" (Engineering/Computer Science Study Background) and "MSB" (Multidisciplinary Study Background).

a) Interdisciplinarity and Identity

Most researchers across all involved disciplines perceive TEL as a scientific "interdiscipline" (see tab. 8). A Kruskal-Wallis test therefore was not significant $H(2, N = 121$[71]$) = 1.63$, *ns.* Concerning their own interdisciplinarity, 78% claim that they "bridge different scientific fields" in their research methods. A multidisciplinary study background correlates with a high perception of current work interdiscipli-

[71] Kruskal-Wallis statistics in brackets are not going to be further reported, as they stay the same.

narity (87%[72], Mann-Whitney U = 1032, p = .014). This accounts in particular for researchers, who work in institutions where they have multidisciplinary colleagues (Mann-Whitney U = 967, p = .004, see statistics in the appendix).

It is not necessarily the case that persons, who studied *more* subjects, also perceive their studies as *more* interdisciplinary. On the contrary, a majority of multidisciplinarily trained researchers feel that their studies were rather made of "several unconnected programmes" (58%, all groups: 37%). A Mann-Whitney U test showed that this is a significant difference U = 977, p = .007. Other statements on interdisciplinary studying involved an integrative interdisciplinarity rather than mere multidisciplinarity. One weak form, where courses from neighbouring departments have been studied towards a disciplinary major, was noticed by two thirds of the respondents. For former social science students this value was significantly higher (88%, Mann-Whitney U = 1036, p < .001). Concerning a strongly integrative interdisciplinarity, still over 30% of researchers tell that they studied a programme, which combined epistemology and methodology of traditional fields. No significant difference between the groups can be reported by a Kruskal-Wallis test even though computer science researchers tend to agree less (23%), H= 3.75, *ns*.

Regarding general disciplinary bonds, more than half of the researchers have an identity mostly related to the social sciences and only few have a multidisciplinary identity (see fig. 14). Across all fields, study background highly correlates with the overall identity. It is notable that 48% of MSB researchers do not have a multidisciplinary identity, but identify with the social sciences (statistics see appendix).

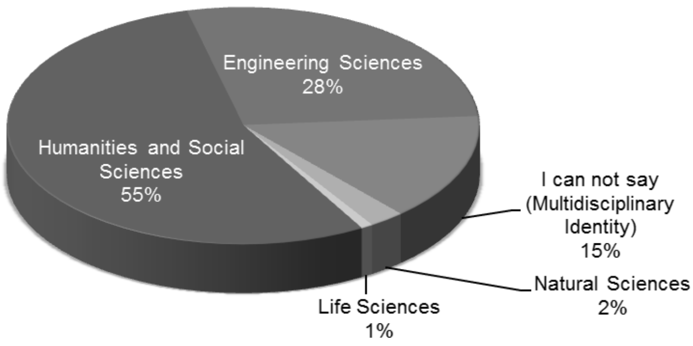

Fig. 14. *"On the whole, which scientific field do you identify with the most?" (V6, N = 123)*

Summing up, the researchers of the TEL community perceive themselves, and especially the field they work in, as very interdisciplinary. However, there is indication that SSB researchers view their background as more interdisciplinary. MSB

[72] Percentage of independent group agreement

researchers and persons in mixed disciplinary institutions agree more on the interdisciplinarity of their current work. However, most researchers see their identity rooted in the field(s) that they once studied.

DV	Subvariables	*p*-Value	Agreement
V4a	"I studied courses from neighbouring departments towards a disciplinary major, rooted in only one scientific field (e.g. in the Social Sciences). "	< .001	67%*[1]
V4b	"I studied several unconnected study programmes from different scientific fields (e.g. Humanities & Engineering Sciences)."	.022	43%*[1]
V4c	"I studied courses focused on topics from different scientific fields in one study programme."	*ns*	48%*[1]
V4d	"I studied in an academic "interdiscipline" (e.g. Biomedical Engineering), that methodologically and epistemologically integrates different scientific fields."	*ns*	33%*[1]
V5a	"I work in an academic "interdiscipline" (e.g. biomedical engineering) that integrates different scientific fields."	*ns*	76%*[1]
V5b	"I interact with neighbour disciplines in my research."	*ns*	94%*[1]
V5d[73]	"I involve specialists from different scientific fields (e.g. Humanities & Engineering Sciences) in my research."	*ns*	85%*[1]
V5e	"I bridge different scientific fields (e.g. Humanities & Engineering Sciences) in the research practices and methods I use."	.038	78%*[1]
V6a	Identity: "I cannot say (Multidisciplinary Identity)"	.009	15%*[2]
V6b	Identity: "Humanities and Social Sciences (incl. Education, Psychology, Economics, etc.)"	< .001	55%*[2]
V6c	Identity: "Engineering Sciences (incl. Computer Science, Materials Science, Mechanics, etc.)"	< .001	28%*[2]
V7e	"Technology-enhanced learning is an academic "interdiscipline" that bridges different scientific fields."	*ns*	91%*[2]

Tab. 8. *Overview of general agreement and group differences: interdisciplinarity and identity* (Kruskal-Wallis *H* test).

b) Opinions on Interdisciplinarity

To know not only about the background of researchers, but also about their attitudes on interdisciplinarity, statements have been presented to the participants. Included in the survey was a note, saying that interdisciplinarity is to be considered as in the strongest sense of the concept[74], for answering the questions. The concrete statements are summed up in table 9.

[73] V5c ("I involve the broader public in my research"), is left out at this point, as it thematically fits better in chapter 5.2.6, which deals with publishing practices.

[74] Interdisciplinarity as "strong and integrative collaboration of researchers from different scientific fields working on a common research aim".

DV	Subvariables	*p*-Value	Agreement
V7a	"Interdisciplinary research pushes researchers intellectually. "	*ns*	94%
V7b	"Interdisciplinary research is hard to publish.	*ns*	48%
V7c	"Interdisciplinary research is hard to achieve."	*ns*	65%
V7d	"I prefer working interdisciplinary to working in a single discipline."	*ns*	78%

Tab. 9. *Overview of general agreement and group differences: opinions on interdisciplinarity* (Kruskal-Wallis *H* test).

The whole community admits that there is an intellectual value to interdisciplinarity. Almost four in five researchers also prefer this kind of work to single-disciplinary approaches. Two thirds of the respondents think it is hard to achieve an integration of disciplines. There seemed to be a lot of indecision about the question, whether interdisciplinary research is "hard to publish" or not. 13% of researchers did not have an opinion on this issue. No differences along the study background can be reported for all statements (details see appendix).

However, there were significant differences between age groups[75]. More experienced researchers (31 and above, N = 86) often disagree on the claim that it is hard to conduct interdisciplinary research (Mann-Whitney $U = 1060$, $p = .01$). They also prefer interdisciplinary work more than early-career (under 31, N = 34) researchers do ($U = 1017$, $p < .01$).

c) Terminology and Interdisciplinarity

The meaning of various terms is very ambiguous in TEL and indicates a major gap between disciplinary parts of the community. This was especially the case for the term "evaluation" (see fig. 15), where the study background correlates with the choice of terminology. TEL researchers, who studied social science, often state that they use the term for the evaluation of people, i.e. persons like teachers, students, employees and others. Researchers with a computer science background in contrast often evaluate technology and "the performance of hardware and software". A Kruskal-Wallis test revealed significant differences $H(2, N = 116) = 9.81$, $p < .01$. Many multidisciplinarians chose a system-oriented meaning of the term, evaluating "a system involving people and technology" ($H = 4.33$, *ns*). Similar results occurred for the term "intervention" (see statistics in appendix. For the term "sce-

[75] See appendix for full Mann-Whitney *U* statistics

nario" differences were less clear, but still persons preferred definitions according to their disciplinary background.). In general, most researchers chose systemic term meanings, they account for half of all answers (50%).

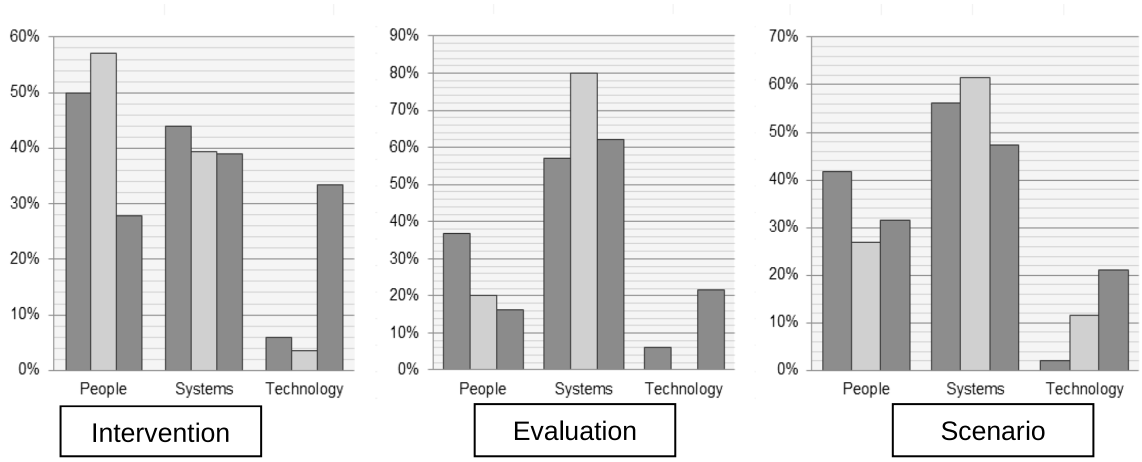

Fig. 15. *"When I use the term 'x' it is usually about ..."*
(V8; N =114/116/112; left column = SSB, middle column = MSB, right column = CSB)

Technology-oriented term meanings are least common. Their usage varies most strongly between the disciplines: nearly only researchers, who studied computer science, refer to them. A table sums up the results in this section:

DV	Subvariables	*p*-Value	Agreement
V8a1	Intervention: "... changing people (e.g. change in teaching and learning which is implemented in the classroom)	.04	41%
V8a2	Intervention: "... changing technology (e.g. user intervention, user input to a device in Human-Computer Interaction)	< .001	13%
V8a3	Intervention: "... changing systems (e.g. activity to improve the performance of a socio-technical system)"	*ns*	38%
V8b1	Evaluation: "... evaluating people (e.g. the performance of teachers or learners)"	.07*ns*	24%
V8b2	Evaluation: ... evaluating technology (e.g. the performance of hardware and software)"	< .01	11%
V8b3	Evaluation: ... evaluating systems (e.g. the usability of a system involving people and technology)"	*ns*	61%
V8c1	Scenario: "... describing steps or actions between people (e.g. role plays, team work, teaching strategies)"	*ns*	32%
V8c2	Scenario: "... describing technology interactions (e.g. use cases with abstract actors, such as external software or manual processes)	.02	10%
V8c3	Scenario: "... describing Human-Computer interactions (e.g. narratives and interactions in a system involving people and technology"	*ns*	50%

Tab. 10. *Overview of general agreement and group differences: terminology and interdisciplinarity* (Kruskal-Wallis *H* test).

d) Interest in TEL core research areas

Main TEL core areas are *CSCL*[76], and *formal learning*, with over 90% of researchers working on it in general, i.e. at least "very little"[77]. Half of the respondents consider those areas to be part of their work even to a "great extent". Least common are *workplace learning*, *ubiquitous and mobile learning* and *digital divide in society*, with less than 10% involved in it a lot. Still, every core area represents more than 50% of researchers, who can identify with it at least to some point (see fig. 16).

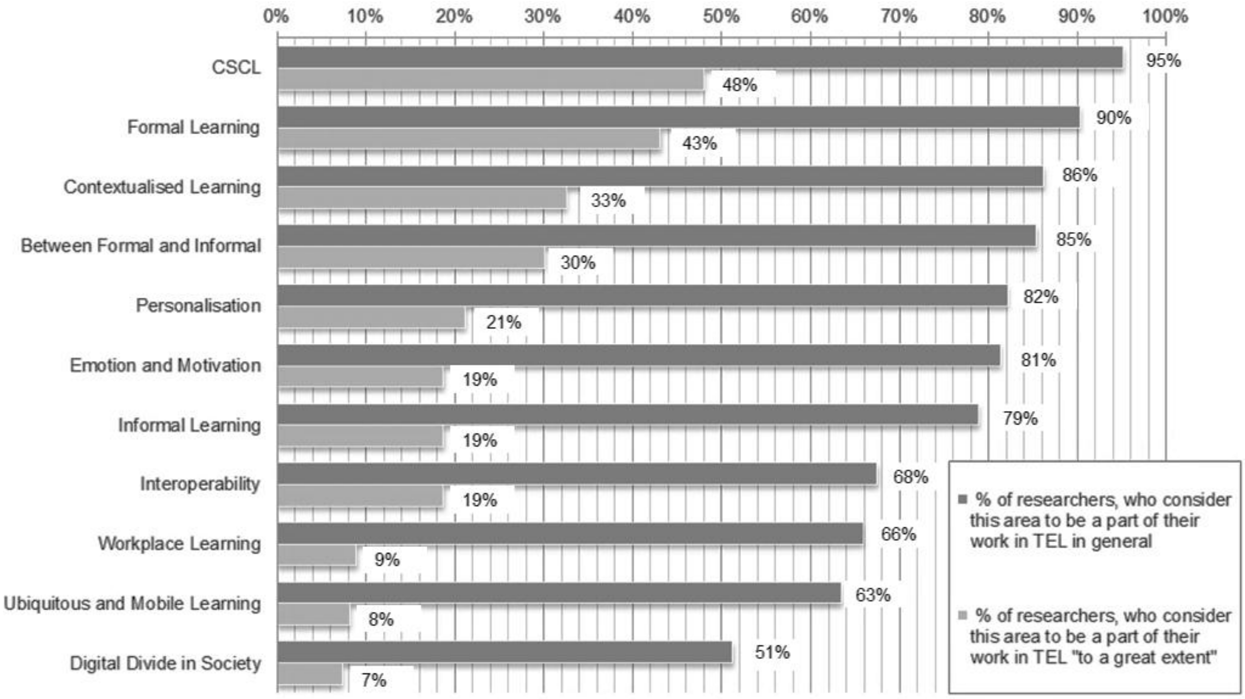

Fig. 16. "*Which of the following TEL research areas reflect your work?" (V2, N=123).*

Social science researchers are more involved in the field of *informal learning,* while computer scientists do more in the field of *interoperability*. Kruskal-Wallis tests were significant for those two areas H= 8.52 / 11.87, p = .01 / < .01.

Even though Kruskal-Wallis H tests for other areas were not significant, there are more indications for differences. Comparing only SSB and CSB researchers, the former are generally more active in core research areas. A Mann-Whitney U test between the two groups was significant for the fields *formal and informal learning*

[76] Computer supported collaborative learning (see C.4.2.1 for information on the core areas)
[77] Scaling: 0=Not at all, 1=Very little, 2=Somewhat, 3=To a great extent. All Likert-scale labels can be found in the study data (see appendix).

as well as *emotion and motivation* (U = 749 / 726, p = .04 / .02)[78]. Figure 15 visualises the disciplinary interests in a concise way, focussing only on main topics ("to a great extent").

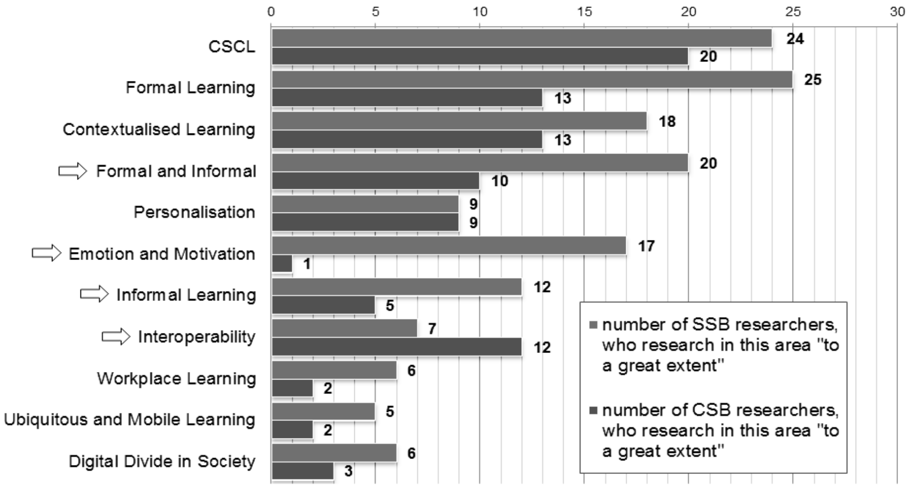

Fig. 17. *Main core research areas for TEL researchers from different disciplines.*
(V2; N =90; upper = SSB, lower = CSB[79], arrows indicate Mann-Whitney *U* significance)

In conclusion, *CSCL, formal* and *contextualised* learning, are three core areas, largely agreed on by all groups. However there are several areas, which only reflect single disciplinary branches of the community. Overall, Researchers with a background in social science agree more on the core research areas[80].

DV	Subvariables	*p*-Value	Agreement*
V2a	Computer supported collaborative learning (CSCL)	*ns*	48%
V2b	Connection between formal and informal learning experience	*ns*	30%
V2c	Contextualised learning	*ns*	33%
V2d	Emotional or motivational aspects of learning with technology	.07^{ns}	19%
V2e	Formal education through the use of technology	*ns*	43%
V2f	Informal learning settings and their motivational characteristics	.01	19%
V2g	Interoperability of tools and devices	< .01	19%
V2h	Personalisation of TEL environments	*ns*	21%
V2i	Digital divide in society	*ns*	7%
V2j	Ubiquitous and mobile technology	*ns*	8%
V2k	Workplace learning and TEL of organisations	*ns*	9%

* "To a Great Extent"

Tab. 11. *Overview of general agreement and group differences: interest in TEL core research areas* (Kruskal-Wallis *H* test).

[78] Interoperability and informal learning were again (as for the Kruskal-Wallis test) significant.
[79] MSB researchers have been left out here, as they were mostly in between the two groups.
[80] 27% average agreement ("to a great extent"), CSB / MSB researchers: 21% / 22%

6.2.2 Research Question 2: "Shared Repertoire of Practices" in the TEL Community

The second research question is about a *shared repertoire of practices* in the TEL community. This study is focussing on general research activities, methodological approaches and the underlying theoretical assumptions. Practices of media usage are not included, as they have been subject to several other TEL related studies (see Conole et al., 2010; Spada et al., 2010). Media participation is known to be higher than average in the TEL community. Practices related to the publishing of scientific knowledge are addressed in a separated chapter (C.6.2.3), as they are a special focus of the study at hand. This chapter is addressing the following concrete points:

a) Do European TEL researchers practice similar activities?
b) Do European TEL researchers use methods from multiple disciplines?
c) Are there theories that can count as cross-disciplinary in TEL?

a) Engagement in TEL activities

As expected, every participant is involved in research, because it was a precondition for taking part in the questionnaire. However 22% of researchers do it only "sometimes" or "seldom", which is an interesting result, as it raises the question, what other activities are practiced instead. Results show that these are mainly *teaching* and *coaching.* Others, as *policymaking* and *programming* are less central. Fig. 18 shows more detailed statistics on TEL work activities.

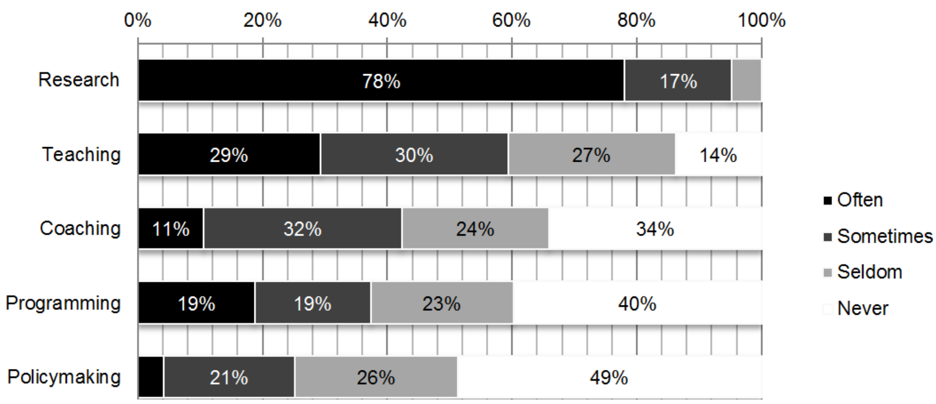

Fig. 18. "*What are your main work activities in the field of Technology Enhanced Learning?" (V1, N = 123)*

Research and teaching are shared activities across all backgrounds. Coaching shows a significant group difference. A Mann-Whitney *U* test proves the CSB researchers more unlikely to be active in coaching practices ($U = 1144, p < .01$). Almost half of the computer science group "never" coach (46%). The activity of programming is particularly interesting, as there are huge group differences to reckon, which can prove whether researchers with engineering science background are really involved with the computing discipline. 97% of CSB researchers programme, which marks a strongly significant difference, according to a Kruskal-Wallis *H* test $H= 43.10, p < .001$. A majority of SSB (57%) and MSB (61%) researchers practices policymaking at least "seldom". For CSB researchers it is only the minority (38%). A Kruskal-Wallis test was significant $H= 6.85$, p = .03. However, coaching and policymaking also correlate with age (see statistics in appendix), meaning that more experienced researchers practice those activities more often.

DV	Subvariables	*p*-Value	Agreement*
V1a	Activity: Research (researching in TEL)	*ns*	100%
V1b	Activity: Teaching (teaching students within schools and universities)	*ns*	86%
V1c	Activity: Coaching and professional training (introducing managers/teachers to TEL)	.01	66%
V1d	Activity Programming and software engineering (developing TEL tools)	< .001	60%
V1e	Activity: Policymaking (influencing policy in education and training, research, or innovation)	.03	51%
V1f	Activity: Other work for ICT/TEL industry enterprises	*ns*	51%

* At least "Seldom"

Tab. 12. *Overview of general agreement and group differences: engagement in TEL activities* (Kruskal-Wallis *H* test).

b) Usage of scientific methodologies

Almost every TEL researcher uses qualitative and quantitative empirical methods for research (see tab. 13). Also common is user-centered design and design-based research methodology[81]. Other methods used by at least 50% of researchers, are modelling & simulation, as well as socio-cognitive engineering and experimental computing methods. Rather uncommon are theoretical computing methods and

[81] For more information about the methods, which come from the social sciences, computer sciences, and TEL as an interdiscipline, see C.4.2.1.

ethnographic methodology. For the latter, many researchers (15%) haven't heard of it ("I don't know this method").

Theoretical computing as a not very applied **methodological approach of the computer sciences** shows disciplinary differences, as CSB researchers use it more often than researchers from other backgrounds (see fig. 19). Same accounts for *experimental computing* methods, where usage by computer science background persons is 14% over the average level. Kruskal-Wallis tests for both computing methods were significant H= 7.37 / 8.63, p = .03 / .01. Only *modelling and simulation* methods are used about equally among respondents from all backgrounds.

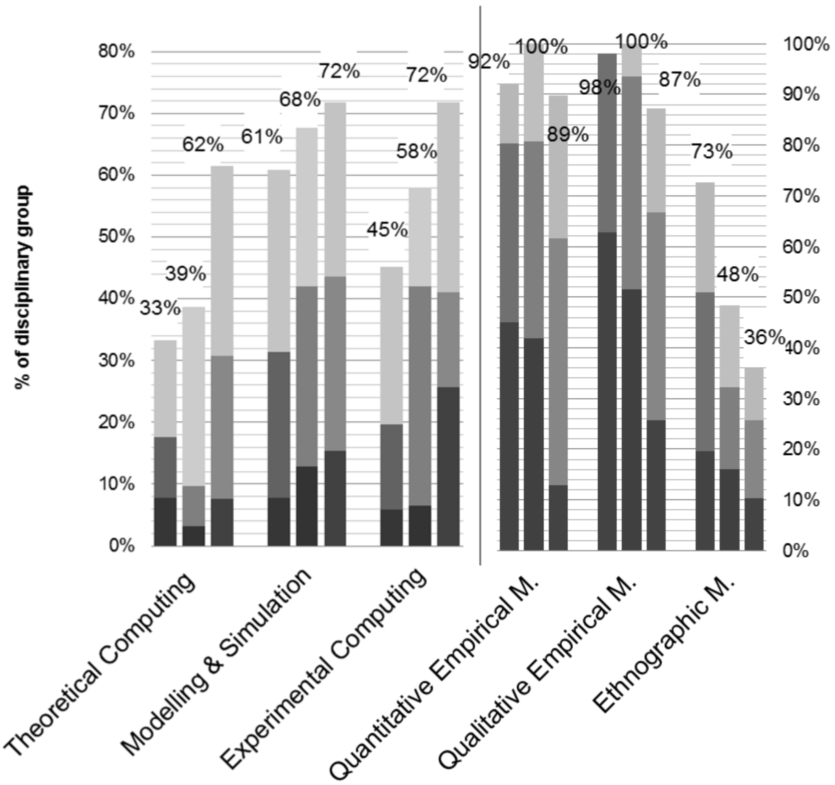

Fig. 19. *Usage of basic computer and social science methods (N=121)*
(left=SSB, middle=MSB, right=CSB, darker colour indicates higher frequency of usage)

There are also obvious differences between the groups for all of the **social science methods**, even if empirical methodology is largely used by the majority of the community. CSB researchers use less *quantitative* and *qualitative* empirical methods (see fig. 17). *Ethnographic* methods tend to be most relevant for people with social science background, as two thirds of this group use it as opposed to one third of the CSB group. All Kruskal-Wallis tests proved significant H= 11.34 / 19.29 / 10.16, p < .01 / 001 / .01.

The proposed **TEL methods** show no significant differences between the disciplinary groups (Kruskal-Wallis *H H*= 0.71 / 0.81 / 0.56, *ns*). *Design-based research*, the approach of *user-centered design* and *socio-technical engineering* are shown to be almost equally common within the community (see fig. 18).

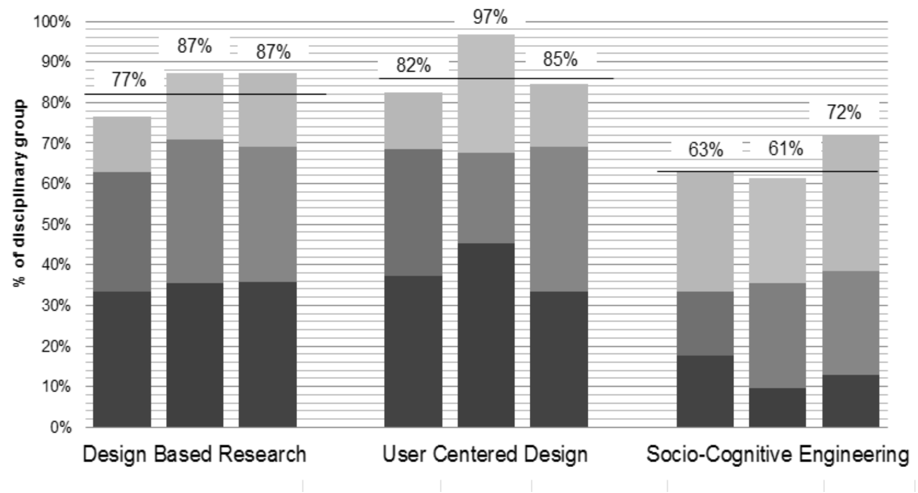

Fig. 20. *Usage of proposed TEL methods (N=121)*
(left=SSB, middle=MSB, right=CSB, darker colour indicates higher frequency of usage)

Tests along the age and institution variables showed no further particularities. Summing up, the TEL methods proved to be used across all disciplines. The same accounts for qualitative and quantitative empirical methodology.

DV	Subvariables	*p*-Value	Agreement*
V9a	Methodology: Theoretical computing methods	.03	43%
V9b	Methodology: Modelling and simulation methods	*ns*	67%
V9c	Methodology: Experimental computing methods	.01	58%
V9d	Methodology: Design (based) research methods	*ns*	83%
V9e	Methodology: User-centered design methods	*ns*	87%
V9f	Methodology: Socio-cognitive engineering methods	*ns*	64%
V9g	Methodology: Quantitative empirical methods	< .01	93%
V9h	Methodology: Qualitative empirical methods	< .001	93%
V9i	Methodology: Ethnographic methods	< .01	37%

* At least "Seldom"

Tab. 13. *Overview of general agreement and group differences: methodology* (Kruskal-Wallis *H* test).

c) Usage of Theories

Wenger's *community of practice*[82] concept is a theoretical perspective, along which most of the European TEL researchers base their inquiries. As the theory is related to the tradition of socio-cultural *constructivist learning*, not surprisingly many researchers also refer to this theoretical approach. The other learning theories like cognitivism and behaviourism are less common (see tab. 14), a fact that reflects the history of the education science in the past century. The second most cited interdisciplinary theory after CoP is Papert's *constructionism,* followed by the *actor-network theory* (ANT), which is referred to by around half of all researchers (at least "seldom"). Only a minority of TEL researchers base their research on computing theories. 50% are somehow familiar with *artificial intelligence and machine learning theory* (MLT), while *representation theory* and *theory of computing* are each only taken into account by one third of the researchers.

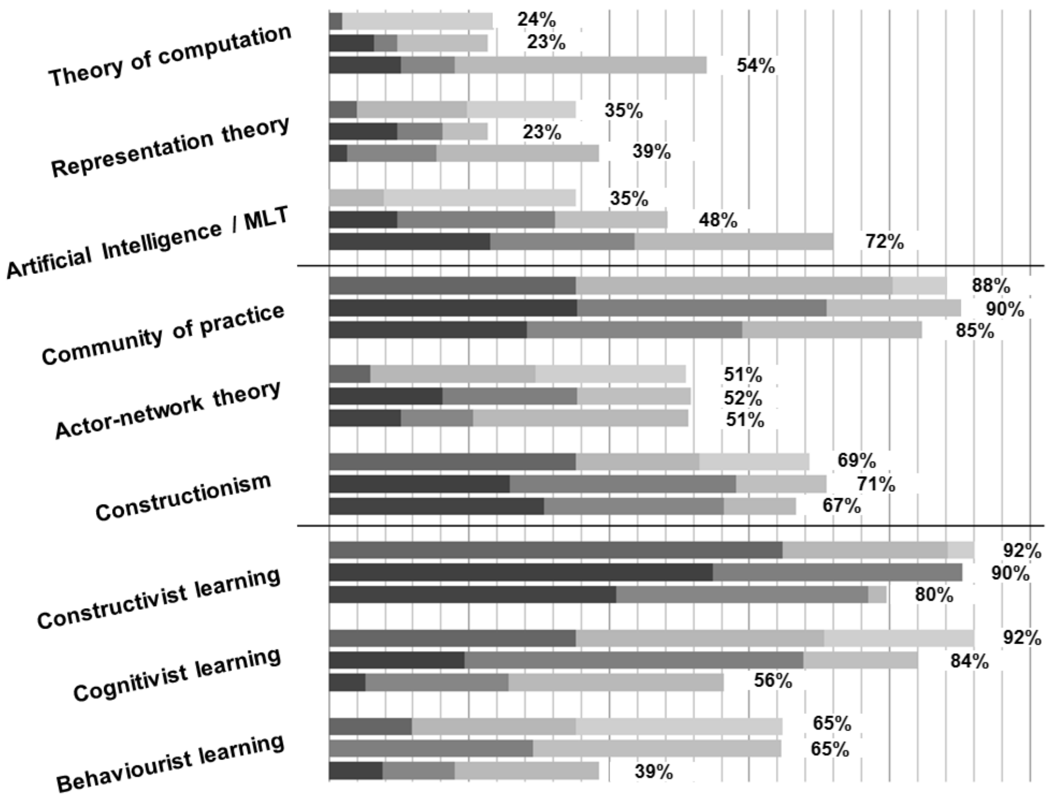

Fig. 21. *Usage of theories (V10, N=121)*
(upper=SSB, middle=MSB, lower=CSB, darker colour indicates higher frequency of usage)

[82] For more information about the theories, see C.4.2.1.

Not all researchers are familiar with the theoretical basics of computing, as in the *theory of computation*. More persons of the CSB group refer to it, a Mann-Whitney U test for this group was significant U= 1105, p < .001. In contrast, *representation theory* is referred to by all groups. The third computing theory, including both *artificial intelligence* and *MLT* is also perceived as more relevant by the computer science researchers (see fig. 19, Mann-Whitney U= 984, p < .001).

Regarding *constructivist learning theory*, strictly speaking, no significant difference between the groups could be reported by the Kruskal-Wallis test H= 5.50, p = .06. For other learning theories as *cognitivism* and *behaviourism*, significant differences between all groups were found H= 25.00 / 6.29, p < .001 / = .04. TEL computer scientists and early-career researchers (see statistics in appendix) use those theories less.

When it comes to the TEL theories, a similar picture arises as for the methodology question. Researchers from all backgrounds equally agree on the proposed theories communities of practice, ANT and constructionism.

DV	Subvariables	*p*-Value	Agreement*
V10a	Computer Science Theories: Theory of computation	<.01	33%
V10b	Computer Science Theories: Representation theory	*ns*	33%
V10c	Computer Science Theories: Artificial intelligence and machine learn. theory	<.001	50%
V10d	TEL Theories: Communities of practice (CoP)	*ns*	88%
V10e	TEL Theories: Actor-network theory (ANT)	*ns*	51%
V10f	TEL Theories: Constructionism	*ns*	68%
V10g	Learning Theories: Constructivism	.06^{ns}	87%
V10h	Learning Theories: Cognitivism	< .001	77%
V10i	Learning Theories: Behaviourism	.04	55%

* At least "Seldom"

Tab. 14. *Overview of general agreement and group differences: theory* (Kruskal-Wallis H test).

6.2.3 Research Question 3: "Open Dialogue with the Public" in the Community

In order to see, if there is an *open dialogue with the public* in the TEL community, the third research question was looking at publishing practices (see C.2.3). It addresses the following two main points:

a) Do European TEL researchers involve the (international) public in their work?
b) Do they publish their works in Open Access formats or do they rather use conventional publishing formats?

a) Audiences and Publishing Focus

When talking about publication practices, one usually thinks about the *products* of research, which generate from precedent inquiries. Nevertheless it is possible to involve the public into the actual research *process*, e.g. by sharing preliminary results and thoughts online. A majority of TEL scientists say that they let a broader public participate in their work. For publishing, target audiences are mainly researchers from one's own scientific field[83]. Only a minority addresses researchers from other scientific fields, application-orientated audiences, or interested non-professionals (statistics see tab. 15).

Group differences were found for the latter. A Mann-Whitney *U* test was significant for the CSB respondents, which means that they target non-professionals less (U= 1305, p = .02). The finding confirms former results by the German Research Foundation's study on publication practices (see tab. 14). They report that only very few engineering scientists address non-professionals, as opposed to one in six social scientists (DFG, 2005, p. 28) Audiences, who have been explicitly named here, were e.g. teachers, particularly secondary school and university teachers, students, company trainers, learning designers, policy makers and academic administration. It is surprising that no correlation was found between the discipline and the targeting of applied audiences (H= 0.29, *ns*). Results of the DFG study suggest computer scientists to be more applied (see tab. 15). In the study at hand, all researchers are about equally application-oriented. Even along the colleague discipline variable no differences have been found (Kruskal-Wallis H= 9.66, *ns*).

[83] The "scientific field" is suspected to be the discipline, which researchers identify with (see V6), so this question has to be considered with regards to previous answers.

Publication audience	DFG Open Access study (2005)			TEL interdisciplinarity survey		
	Social science	Engineer. science	Total	Social science	Engineer. science	Total
Researchers from own discipline	99%*	99%*	99%*	88%*³	97%	91%[84]
Researchers from other disciplines	55%*	41%*	48%*	43%	46%	45%
Application-oriented target groups	14%*	**39%***	18%*	37%	36%	38%
Interested non-professionals	**16%***	1%*	5%*	**37%**	15%	29%
International audience	43%*	**77 %***	78%*	57%*²	**92%***²	76%*²
* at least "predominantly" *² at least "usually" *³ no significant difference	N=235	N=225	N=1.023	N=51	N=39	N=123

Tab. 15. *Comparison with results of the DFG Open Access study (2005, pp. 28-30)*

Concerning the internationality of research, three quarters of the community address researchers outside their work country with publications at least "usually" (see tab. 16). There is a huge discrepancy between the groups, as people with a social science background seem to target international audiences less often (Mann-Whitney U= 1209, $p < .01$). Almost everyone in the CSB group has a strong international focus, as opposed to only around half of the SSB group.

DV	Subvariables	*p*-Value	Agreement*
V5c	"I involve the broader public in my research."	*ns*	65%*¹
V11a	Audience: Researchers from my own scientific field (social science/computer science, etc.)	*ns*	91%*²
V11b	Audience: Researchers from other scientific fields	*ns*	45%*²
V11c	Audience Application-orientated audiences (economy, industry, practitioners)	*ns*	38%*²
V11d	Audience: Interested non-professionals	.07 *ns*	29%*²
V12	Do you address researchers outside your work country with publications?	<.01	76%*³

*1 "Agree" and "Strongly Agree" *2 "Yes" *3 at least "Usually"

Tab. 16. *Overview of general agreement and group differences: audience and publishing focus* (Kruskal-Wallis *H* test).

The DFG study in 2005 asked exactly the same question on internationality. However, the scale for answering was less concrete, composed of "no", "to some extent"

[84] The difference to 100% could be due to some researchers being undecided about the nature of their scientific field.

and “predominantly”[85] (p. 29). The results of 2005 were able to be reproduced (tab. 15). The fact that one fifth of the engineering group only partly address an international community in the DFG study has been explained by the authors with lower values for areas such as architecture, construction, production and industrial engineering, being more nationally oriented (p. 30).

b) Open Access Publishing Practices

Before focussing on Open Access publication formats, the participants were asked how many of their works they published in a conventional way, i.e. through publishing companies with charging a fee.[86] Most work is published in the form of conference or workshop proceedings. Eight in ten researchers did publish at least once in the given timeframe, with an average of three proceedings p. a. (*M* = 2.8, *SD* = 2.6) [87], It lies over the mean of the DFG open access study (2005, p. 27), which is around two[88]. Here, journal publishing was more common among the researchers. TEL researchers only publish an average of one journal article per year (*M*: 1.3, *SD*: 1.5). Book chapters and articles are equally common in both studies, as well as monographs, which are only used by very few researchers.

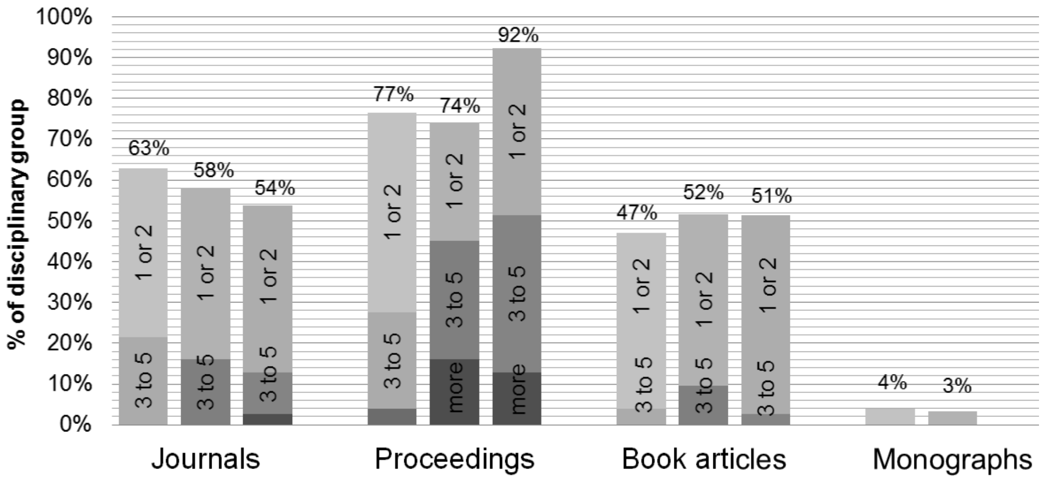

Fig. 22. *Usage of conventional publishing formats (N=121)*
(left=SSB, middle=MSB, right=CSB, darker colour indicates higher frequency of usage)

[85] Items have been translated into English.
[86] The given timeframe was 12 months, from January to February 2010. For each of the predefined formats, including journals, proceedings, book articles and monographs the number of publications had to be selected from the items “0”, “1-2”, “3-5”, “6-10” and “over 10”.
[87] Answers have been converted into numerical values, in order to calculate means and standard deviations: “1-2” ~ 1.5, “3-5” ~ 4, “6-10” ~ 8, “over 10” ~12.
[88] Question (DFG study): “In the past five years: How many of your works did you publish in a conventional way, i.e. through publishing companies with charging a fee”.

The strong focus on conference proceedings in the TEL community is unusual for the social science branch, as social scientists usually prefer journals and other formats to a greater extent. Also in the DFG study, this group (*N*=199) only publishes around one proceeding per year, as opposed to the engineering science group, who produces four proceedings in the same amount of time (p. 27). The study at hand can confirm this result. Differences have been found, as the CSB group uses this format more often than the other groups (*M*: 3.8, *SD*: 3.1). SSB researchers published only an average of 2.0 (*SD*: 1.8) and MSB researchers 3.0 (*SD:* 3.0) proceedings per year. A Mann-Whitney test[89] was significant $U= 1224$, $p = .02$.

The results on Open Access (OA) publication are harder to compare with the DFG study, as it went into more detail and differentiated between several Open Access formats, such as *OA journals*, electronic *preprints* and *postprints* (see C.2.3). Especially **openly accessible proceedings** are widespread in the TEL community. Two thirds of researchers at least once published in this format (see tab. 16), 20% thereof even three times or more, which makes up an average of 1.6 articles (*SD*: 1.8). The format seems to be less common in the DFG study (p. 45), where only a total of 17% of proceedings are published for Open Access.[90] **OA journals articles** have been written by 44% of the community in 2010, i.e. 0.9 articles per researcher (*SD*: 1.3). This is also more than indicated in the DFG study, where an average of 0.5 (*SD:* 0.5) open access journal articles had been reported (p. 44). In the study at hand, other formats were less usual, only 18% published OA book articles and 5% in open monographs.

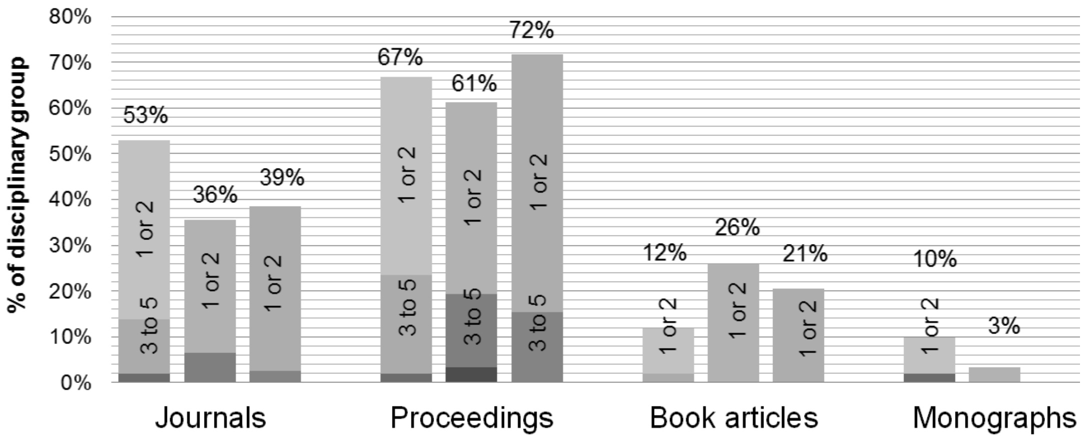

Fig. 23. *Usage of Open Access publishing formats (N=121)*
(left=SSB, middle=MSB, right=CSB, darker colour indicates higher frequency of usage)

[89] Significances have been calculated for the original, ordinal data.
[90] Comparison is difficult, as no data on the actual amount of post and preprint publications per researcher is available.

Over 50% of social scientists have also published in open journals in 2010 (see fig. 23), with an average of 1.2 articles (*SD*: 1.6). Computer scientists and multidisciplinarians published less, even though not significant (*H*= 3.96, *ns*). Surprisingly enough, results of the DFG study suggest the opposite: Social scientists publish the least in open access journals but mostly due to the contributing researchers from the humanities subdiscipline. Researchers from the engineering sciences are very active in OA journal and postprint publishing (pp. 45-46). Concerning proceedings, book articles and monographs, no differences are obvious (test statistics see appendix).

Figure 24 shows the overall usage of Open Access compared to conventional formats. Kruskal-Wallis tests report no significant differences between the disciplinary groups *H*= 1.08 / 2.210, *ns.* Computer scientists publish a bit more in the conventional formats, with a mean of 5.8 articles/papers (*SD*: 3.9).

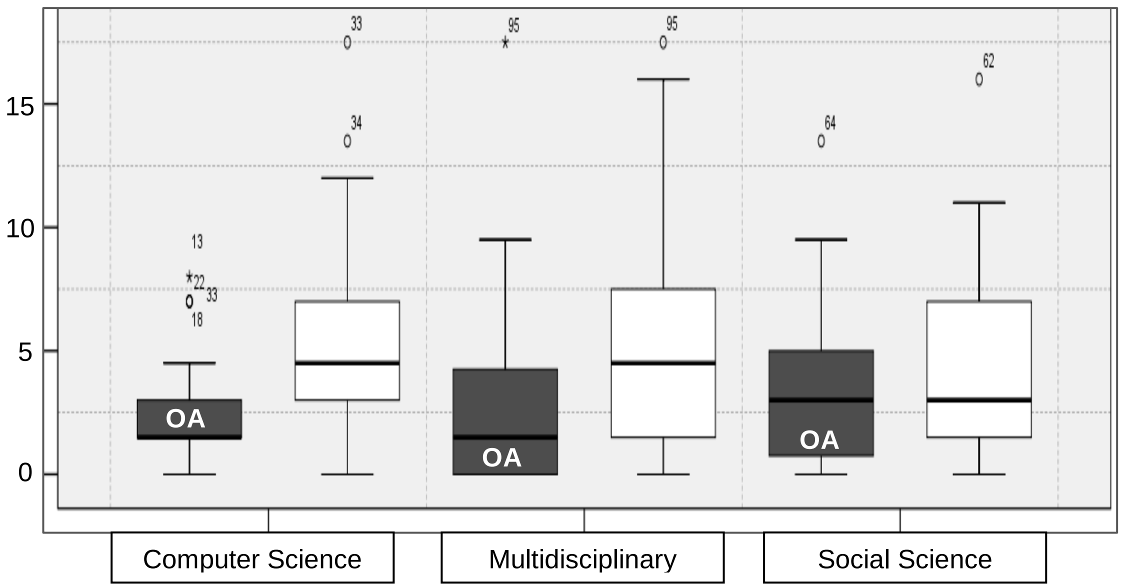

Fig. 24. *Usage of publication formats in 2010 by discipline (N=121)*
(grey=Open Access, white=conventional, Y-scale: count of publications per participant)

Open Access formats are, in general, more often used by the SSB researchers (*M*: 3.3), but with a very high deviation within the group (*SD:* 4.0). The DFG study is not fully in accordance with those results. Only for Open Access preprints in electronic archives (p. 48) social scientists gained higher values than computer scientists.

DV	Subvariables	*p*-Value	Agreement*
V13a	Conventional formats: Journal articles	*ns*	59%*
V13b	Conventional formats: Articles in workshop/conference proceedings	.03	80%*
V13c	Conventional formats: Articles in edited volumes, book chapters	*ns*	49%*
V13d	Conventional formats: Monographs	*ns*	2%*
V14a	Open Access: Journal articles	*ns*	44%*
V14b	Open Access: Articles in workshop/conference proceedings	*ns*	67%*
V14c	Open Access: Articles in edited volumes, book chapters	*ns*	18%*
V14d	Open Access: Monographs	*ns*	5%*

Tab. 17. *Overview of general agreement and group differences: OA publishing practices* (Kruskal-Wallis *H* test).

After having tested all hypotheses in consideration of the study background, a more complex analysis of the data is undertaken. Looking at multiple different variables and their clustering can give evidence, whether the three categories (SSB, CSB and MSB) are really the most appropriate way of looking at the data. Aim is to find a clustering, which can describe the data in a more differentiated, thus sophisticated way.

6.3 Survey Results: Cluster Analysis

All former variables (V1-V22) have been included into the cluster analysis, using average between-group comparison along the rescaled Person correlation. Two variables have been added: V23 indicates, whether a researcher is member of the STELLARnet project[91], which is hosting TELeurope.eu. If persons cluster along this variable, there might be some identifiable bias in the data. Furthermore, V24 shows, whether a researcher is connected on the TELeurope.eu platform[91]. This variable is retrieved by the network analysis, the results of which are going to be described in C.6.4.

A dendogram (fig. 25) shows the clusters, which resulted from using the predefined preferences. Two big clusters with a rescaled distance of around 20[92] can be identified. However, a more precise clustering is demanded, having more dimensions than the three values of the V3 study background. A cluster was accepted, if it consisted of at least N=5 cases with a maximum rescaled distance of 14. This led to eight clusters with a total of N=101 cases. All other cases were neglected, as they did not cluster well enough. Table 18-25 shows the statistics for the eight clusters, displaying some basic variables. In the following, the characteristics of each cluster are going to be explained, also providing an interpretation of the TEL subgroup.

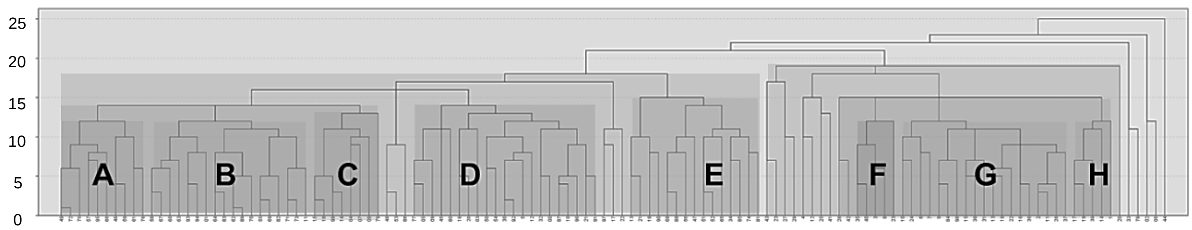

Fig. 25. *TELeurope.eu clusters dendogram (N=123, Pearson r, between-group linkage).*

a) Cluster A (10%) "The progressive social scientists"

Cluster A consists of university-based, often female researchers and PhDs, of average age (30 to 40), who studied social science, not necessarily work in social science institutions, but still mainly identity with social science. Even though they studied in only one field, they perceive their study background as interdisciplinary. They are very active in coaching, teaching, policy-making and ICT work, but less connected on the TELeurope platform. For them interdisciplinary research is

[91] 0="No", 1="Yes"
[92] Rescaled agglomerated Pearson coefficients between two cases on a scale from 0 to 25

something normal, they don't think it is hard to achieve and prefer it from working monodisciplinary. They often use systemic definitions, are familiar with theoretical, experimental computing and modelling methods, as well as TEL and social science methodology, except ethnography. Theories include especially connectivism, cognitive learning but also computing theories. Researchers in this group don't target applied audiences but are active in publishing, e.g. in open journals. Core TEL areas include everything except digital divide, mobile and workplace learning. Many different countries contribute to this cluster.

Cluster A (N = 10) *"The progressive social scientists"*							
Variable	Ø **[A]**	*SD* **[A]**	Ø[93]	**Variable** (continued)	Ø **[A]**	*SD* **[A]**	Ø
V1 TEL activity: research	0.9	*0.2*	0.9	V7 Statement 4 (preference)	**0.9**	*0.1*	0.8
V1 TEL activity: teaching	**0.7**	*0.3*	0.6	V8 Term: intervention (sys.)	**0.8**	*0.4*	0.4
V1 TEL activity: coaching	**0.6**	*0.3*	0.4	V8 Term: scenario (sys.)	**0.7**	*0.5*	0.5
V1 TEL activity: policy making	0.3	*0.3*	0.3	V9 Method: theoretical comp.	**0.5**	*0.4*	0.2
V2 Core area: formal/informal	**0.8**	*0.3*	0.6	V9 Method: experiment. comp.	**0.5**	*0.3*	0.3
V2 Core area: context. learning	**0.9**	*0.2*	0.6	V9 Method: UCD	**0.7**	*0.4*	0.6
V2 Core area: emotion/motivation	**0.7**	*0.3*	0.5	V10 Representation theory	**0.3**	*0.4*	0.2
V2 Core area: formal learning	**0.9**	*0.2*	0.7	V10 Theory AI, ML	0.3	*0.2*	0.3
V3 Background: social science	**1.0**	*0.0*	0.4	V10 Theory constructionism	**0.8**	*0.4*	0.5
V4 Study interdisciplinary (4c)	**0.6**	*0.4*	0.5	V14 Publication: open journals	**0.3**	*0.2*	0.2
V4 Study interdisciplinary (4d)	**0.5**	*0.4*	0.4	V16 Position: student	0.4	*0.5*	0.2
V6 Identity: social science	**1.0**	*0.0*	0.5	V21 Gender (0=f; 1=m)	0.1	*0.3*	0.5
V7 Statement 1(intellectual value)	1.0	*0.1*	0.9	V22 Project membership	0.2	*0.4*	0.6
V7 Statement 2 (publish hard)	0.4	*0.3*	0.5	V23 Platform degree	0.3	*0.5*	0.7

Tab 18-25. *Lists of selected cluster characteristics [94].*

b) Cluster B (18%) "Traditional TEL social scientists"

Young, university-based researchers, who studied social science and work in social science institutions, make up the second cluster. TEL activities do not include programming, and teaching only rarely. They do not perceive their study background as very interdisciplinary, same goes for their current work. For them, interdisciplinary research is hard to achieve and publish. Their preferred terminology and methodology, not surprisingly, comes from the social sciences. However it includes

[93] Average mean value for all participants (N=123)
[94] Bold values: higher means than average for all respondents, Grey values: lower means than average for all respondents. For complete statistics, see appendix.

design based research and a bit of socio-technical engineering. They are rooted in cognitivist learning theory and e.g. don't refer to representation theory at all. People in this group publish less in journals, which may be related to their relatively low age. The participation in TEL areas is rather low, but mostly in the fields of formal, sometimes informal, learning and CSCL. Five of the 18 members of this cluster come from Germany.

Cluster B (N = 18) *"Traditional social scientists"*							
Variable	Ø **[B]**	*SD* **[B]**	Ø	**Variable** (continued)	Ø **[B]**	*SD* **[B]**	Ø
V1 TEL activity: research	**1.0**	*0.1*	0.9	V8 Term: evaluation (social)	**0.6**	*0.5*	0.2
V1 TEL activity: teaching	0.5	*0.3*	0.6	V8 Term: scenario (sys.)	**0.6**	*0.5*	0.5
V1 TEL activity: programming	0.1	*0.2*	0.4	V9 Method: UCD	0.5	*0.4*	0.6
V2 Core area: context. learning	0.4	*0.3*	0.6	V11 Audience: other discipline	0.3	*0.5*	0.4
V2 Core area: formal learning	0.7	*0.4*	0.7	V11 Audience: applied	0.3	*0.5*	0.4
V2 Core area: informal learning	0.5	*0.3*	0.5	V12 Audience: international	0.6	*0.3*	0.7
V3 Background: social science	**0.9**	*0.3*	0.4	V13 Publication: conv. journals	0.2	*0.2*	0.3
V4 Study interdisciplinary (4c)	0.4	*0.4*	0.5	V14 Publication: open journals	0.1	*0.1*	0.2
V5 Work interdisciplinary (5a)	0.5	*0.4*	0.7	V15 Workplace: university	**1.0**	*0.0*	0.8
V6 Identity: social science	**1.0**	*0.0*	0.5	V16 Position: student	**0.3**	*0.5*	0.2
V7 Statement 2 (publish hard)	**0.6**	*0.2*	0.5	V17 Colleague discipline SSB	**0.9**	*0.2*	0.4
V7 Statement 3 (achieve hard)	**0.8**	*0.2*	0.6	V19 Age group	0.3	*0.4*	0.5
V7 Statement 4 (preference)	0.7	*0.3*	0.8	V22 Project membership	0.3	*0.5*	0.6
V8 Term: intervention (social)	**0.8**	*0.4*	0.4	V23 Platform degree	0.7	*0.5*	0.7

c) Cluster C (8%) "Pragmatic multidisciplinarians"

The third cluster includes experienced, university-based researchers with social science, as well as computer science background, who identify more with the social sciences as they work in corresponding institutions. Either they studied in one multidisciplinary study programme or several unconnected programmes from different fields. Study background is in general perceived as interdisciplinary. However, they don't necessarily see TEL as an integrative real academic interdiscipline and agree less on the value of interdisciplinary research. Also, they see it as rather hard to achieve and publish. Concerning their activities, they sometimes program, prefer systemic definitions and are very familiar with Design based research. Besides, they are conservatively rooted in empirical methodology with a slight overhang on qualitative aspects. Theory wise, from the given selection, there is a quite narrow focus on community of practice, everything else is below average. Researchers in this group publish less often in open formats, but through conventional proceedings and journals, focussing on an academic audience in social science, which is more international than for other social science clusters. Core TEL areas are few, but mostly formal and mobile learning. This cluster is connected on TELeurope at an average level and members come from a lot of different countries.

Cluster C (N = 8) *"Pragmatic Multidisciplinarians"*							
Variable	∅ **[C]**	*SD* **[C]**	∅	**Variable** (continued)	∅ **[C]**	*SD* **[C]**	∅
V1 TEL activity: programming	0.3	*0.2*	0.4	V8 Term: intervention (sys.)	**0.9**	*0.4*	0.4
V2 Core area: formal learning	**0.8**	*0.3*	0.7	V8 Term: evaluation (sys.)	**0.9**	*0.4*	0.6
V2 Core area: mobile learning	**0.4**	*0.4*	0.3	V9 Method: DBR	**0.8**	*0.2*	0.6
V3 Background: Multidisciplinary	**0.9**	*0.4*	0.3	V10 Theory: CoP	0.6	*0.2*	0.6
V4 Study interdisciplinary (4c)	**0.7**	*0.3*	0.5	V11 Audience: applied	0.0	*0.0*	0.4
V4 Study interdisciplinary (4d)	**0.5**	*0.4*	0.4	V12 Audience: international	**0.8**	*0.3*	0.7
V6 Identity: social science	**0.9**	*0.4*	0.5	V13 Publication: conv. proceed	**0.6**	*0.2*	0.4
V7 Statement 1 (intellectual value)	0.8	*0.2*	0.9	V14 Publication: open journals	0.1	*0.2*	0.2
V7 Statement 2 (publish hard)	**0.6**	*0.2*	0.5	V14 Publication: open proceed	0.2	*0.2*	0.3
V7 Statement 3 (achieve hard)	**0.7**	*0.2*	0.6	V17 Colleague discipline SSB	**0.9**	*0.4*	0.4
V7 Statement 5 (TEL interdisc.)	0.7	*0.2*	0.9	V19 Age group	**0.6**	*0.3*	0.5

d) Cluster D (21%) "Established TEL Interdisciplinarians"

The largest cluster (21%) consists of TEL research associates and lecturers with a mixed or multidisciplinary study background, who work in interdisciplinary university institutions. They are involved in policymaking, know about programming and see themselves as interdisciplinarians. From their view, TEL is an academic interdiscipline. They prefer systemic terminology and methodological approaches like Design Based Research, User Centered Design or sometimes Socio-Technical Engineering. Trained in computer science as well as social science methods, they also refer to theories of both fields. However, with "communities of practice" being most famous, learning approaches other than constructivism are uncommon. Researchers of this group push the boundaries of university, also targeting applied audiences, non-professionals, while actively publishing in both conventional and open formats. Core TEL areas include formal and informal learning, workplace learning, personalised, as well as contextualised learning. This cluster is averagely well connected on the platform. Main contributing country is the United Kingdom with six out of 21 researchers.

Cluster D (N = 21) *"Established TEL Interdisciplinarians"*							
Variable	Ø **[D]**	*SD* **[D]**	Ø	**Variable** (continued)	Ø **[D]**	*SD* **[D]**	Ø
V1 TEL activity: programming	0.4	*0.4*	0.4	V8 Term: scenario (sys.)	**0.9**	*0.4*	0.5
V1 TEL activity: policymaking	**0.4**	*0.3*	0.3	V9 Method: UCD	**0.8**	*0.2*	0.6
V2 Core area: formal / informal	**0.7**	*0.2*	0.6	V9 Method: STE	**0.8**	*0.2*	0.6
V2 Core area: context. learning	**0.9**	*0.2*	0.6	V10 Theory: AI / ML	0.3	*0.4*	0.3
V2 Core area: personalisation	**0.7**	*0.3*	0.5	V10 Theory: CoP	**0.8**	*0.3*	0.6
V2 Core area: workplace learning	**0.6**	*0.3*	0.4	V10 Theory: constructivism	**0.9**	*0.2*	0.8
V3 Background: multidisciplinary	**0.4**	*0.5*	0.3	V11 Audience: applied	**0.7**	*0.5*	0.4
V4 Interdisciplinary study (4d)	**0.5**	*0.4*	0.4	V11 Audience: non-profession	**0.6**	*0.5*	0.3
V5 Interdisciplinary work (5d)	**0.9**	*0.1*	0.7	V14 Publication: conv. proceed	**0.5**	*0.3*	0.4
V6 Identity: multidisciplinary	**0.3**	*0.5*	0.1	V14 Publication: open journal	**0.3**	*0.2*	0.2
V8 Term: intervention (sys.)	**0.7**	*0.5*	0.4	V17 Position: associate	**0.5**	*0.5*	0.2
V8 Term: evaluation (sys.)	**1.0**	*0.2*	0.6	V17 Colleague discipline MSB	**0.7**	*0.5*	0.3

e) Cluster E (15%) "Application-oriented TEL practitioners"

Experienced, school- or company-based TEL teachers and researchers with a largely social scientific background and identity, form the fifth cluster. They are involved in policymaking and practice less research than others. Even though they prefer social terminology and have no relation to computer science and programming whatsoever, modelling methods are quite common. In addition, their methods are more qualitative with a theoretical stance rooted in constructivism. They don't see interdisciplinarity as something hard to achieve or publish. For them it's just normal. Not surprisingly, they target applied audiences and non-professionals more than average, and publish rather in open than in conventional formats. Core TEL areas are workplace learning, formal and informal learning, digital divide, as well as emotional and motivational aspects of learning. The cluster is quite unconnected on TELeurope, with the main contributing country being the UK (4 of 15).

Cluster E (N = 15) *"Application-oriented TEL practitioners"*							
Variable	Ø **[E]**	*SD* **[E]**	Ø	**Variable** (continued)	Ø **[E]**	*SD* **[E]**	Ø
V1 TEL activity: research	0.8	*0.3*	0.9	V8 Term: intervention (social)	**0.9**	*0.3*	0.4
V1 TEL activity: programming	0.2	*0.3*	0.4	V8 Term: scenario (social)	**0.9**	*0.3*	0.3
V1 TEL activity: policymaking	**0.5**	*0.3*	0.3	V9 Method: Modelling	0.4	*0.3*	0.4
V2 Core area: formal / informal	**0.8**	*0.3*	0.6	V10 Theory: constructivism	0.8	*0.2*	0.8
V2 Core area: emotion / motivation	**0.8**	*0.2*	0.5	V11 Audience: applied	**0.5**	*0.5*	0.4
V2 Core area: digital divide	**0.6**	*0.4*	0.3	V12 Audience: non-profession	**0.6**	*0.5*	0.3

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V2 Core area: workplace learning	**0.5**	*0.3*	0.4	V14 Publication: open journals	**0.3**	*0.3*	0.2
V3 Background: social science	**0.7**	*0.5*	0.4	V14 Publication: open proceed	**0.4**	*0.3*	0.3
V6 Identity: social science	**0.9**	*0.3*	0.5	V15 Workplace: university	0.3	*0.5*	0.8
V7 Statement 2 (publish hard)	0.5	*0.3*	0.5	V17 Colleague discipline SSB	**0.9**	*0.4*	0.4
V7 Statement 3 (achieve hard)	0.5	*0.3*	0.6	V19 Age group	**0.8**	*0.4*	0.5

f) Cluster F (5%) "The established, interdisciplinary TEL computer science elite"

Cluster F is made of experienced, often male university-based professors and research associates with a computer science background. They prefer working interdisciplinary from working in a single discipline and are involved in many EU projects and TEL policymaking. They often don't identify anymore with their computer science study background but with interdisciplinarity, as they moved towards a more social science oriented and field-crossing methodology. They are familiar with most kinds of theories and methods, also ethnography and socio-technical engineering, but prefer qualitative methodology to quantitative. Their terminology has shifted from computing to more people-oriented terms, rather than systemic terms. They publish more than others and target other disciplines as well as the broader, international public a lot. Core research area: CSCL, formal learning and interoperability. The cluster is very connected on TELeurope and consists of researchers from Spain (2), Norway (2) and Romania (1).

Cluster F (N = 5) *"The established, interdisciplinary TEL computer science elite"*							
Variable	Ø **[F]**	*SD* **[F]**	Ø	**Variable** (continued)	Ø **[F]**	*SD* **[F]**	Ø
V1 TEL activity: policymaking	0.3	*0.2*	0.3	V9 Method: STE	**0.7**	*0.3*	0.4
V2 Core area: CSCL	**0.9**	*0.2*	0.8	V9 Method: quantitative	0.4	*0.1*	0.7
V2 Core area: formal learning	**0.8**	*0.3*	0.7	V9 Method: qualitative	**0.9**	*0.1*	0.8
V2 Core area: interoperability	**0.7**	*0.3*	0.4	V9 Method: ethnography	**0.6**	*0.4*	0.4
V3 Background: computer science	**1.0**	*0.0*	0.3	V11 Audience: other discipline	**1.0**	*0.0*	0.4
V5 Interdisciplinary work (5e)	**0.8**	*0.1*	0.6	V12 Audience: international	**1.0**	*0.1*	0.7
V6 Identity: multidisciplinary	**0.4**	*0.5*	0.1	V16 Position: professor	**0.4**	*0.5*	0.2
V7 Statement 4 (preference)	**0.9**	*0.2*	0.8	V16 Position: associate	**0.4**	*0.5*	0.2
V7 Statement 5 (TEL interdisc.)	**1.0**	*0.1*	0.9	V19 Age group	0.6	*0.4*	0.5
V8 Term: evaluation (social)	**0.4**	*0.5*	0.2	V21 Gender	**0.8**	*0.4*	0.5
V8 Term: scenario (social)	**1.0**	*0.0*	0.3	V22 Project	**1.0**	*0.0*	0.6

g) *Cluster G (19%) "Young, progressive TEL computer scientists"*

The next cluster (19%) contains young, university-based researchers with a computer science background, who are well connected on TELeurope. For them studying computer science meant studying an "interdiscipline". They consider themselves as interdisciplinarians, who clearly prefer a systemic, discipline-bridging terminology and target applied audiences. Compared to other computer scientists they use more quantitative empirical methodology. However, they are in general not very used to theories such as e.g. constructivism, show less interest in TEL core areas, publish seldom in journals and open formats, and don't do coaching and policymaking.. Core research areas are personalisation and interoperability. Cluster G is very connected on TELeurope. 5 of the 19 members come from Spain, 3 from the United Kingdom.

Cluster G (N =19) *"Young, progressive TEL computer scientists"*							
Variable	∅ **[G]**	*SD* **[G]**	∅	**Variable** (continued)	∅ **[G]**	*SD* **[G]**	∅
V1 TEL activity: coaching	0.2	*0.2*	0.4	V8 Term: evaluation (sys.)	**0.9**	*0.2*	0.6
V1 TEL activity: programming	**0.7**	*0.3*	0.4	V8 Term: scenario (sys.)	**0.8**	*0.4*	0.5
V1 TEL activity: policymaking	0.1	*0.3*	0.3	V9 Method: STE	**0.5**	*0.4*	0.4
V2 Core area: formal / informal	0.4	*0.4*	0.6	V9 Method: quantitative	0.6[95]	*0.2*	0.7
V2 Core area: interoperability	**0.6**	*0.4*	0.4	V10 Theory: constructivism	0.6	*0.4*	0.8
V2 Core area: personalisation	**0.6**	*0.4*	0.5	V12 Audience: applied	0.4	*0.5*	0.4
V3 Background: computer science	**0.8**	*0.4*	0.3	V13 Publication: conv. journal	0.2	*0.3*	0.3
V5 Interdisciplinary work (5d)	**0.8**	*0.2*	0.7	V14 Publication: open journal	0.1	*0.2*	0.2
V6 Identity: computer science	**0.9**	*0.2*	0.3	V17 Colleague discipline CSB	**0.9**	*0.3*	0.3
V7 Statement 5 (TEL interdisc.)	**1.0**	*0.1*	0.9	V19 Age group	0.3	*0.4*	0.5

h) *Cluster H (5%) "Conservative but broadly interested young computer scientists"*

Cluster H (5%) is made of young, often female, university-based research assistants with a computer science background, who do not participate in European TEL projects. They don't see themselves as interdisciplinarians, as they choose to use a technology oriented terminology and do not address the public or applied audiences. They do not always see interdisciplinarity as something worth striving for. Also, for them TEL is not necessarily an interdiscipline, as they use mainly computing methods and user-centered design. However, they are very active with publishing internationally in journals and with doing teaching and ICT work. They

[95] Highest value of all CSB clusters

have many and broad interests, which also involve learning theories as constructionism, cognitive and machine learning theory. Characteristic core research areas are especially formal learning, interoperability and personalisation. The cluster is less connected on TELeurope, three of contributing researchers come from south-eastern European countries (Serbia, Croatia, Greece).

Cluster H (N = 5) *"Conservative but broadly interested young computer scientists"*							
Variable	Ø **[H]**	*SD* **[H]**	Ø	**Variable** (continued)	Ø **[H]**	*SD* **[H]**	Ø
V1 TEL activity: teaching	**0.8**	*0.3*	0.6	V9 Method: experiment. comp.	**0.6**	*0.3*	0.3
V1 TEL activity: ICT work	**0.3**	*0.1*	0.2	V9 Method: UCD	**0.8**	*0.2*	0.6
V2 Core area: formal learning	0.7	*0.3*	0.7	V10 Theory: AI / ML	**0.6**	*0.4*	0.3
V2 Core area: interoperability	**0.7**	*0.4*	0.4	V10 Theory: constructionism	**1.0**	*0.0*	0.5
V2 Core area: personalisation	**0.8**	*0.2*	0.5	V10 Theory: cognitivism	0.5	*0.3*	0.5
V3 Background: computer science	**1.0**	*0.0*	0.3	V11 Audience: applied	0.0	*0.0*	0.4
V4 Interdisciplinary study (4d)	0.1	*0.1*	0.4	V12 Audience: international	**0.9**	*0.1*	0.7
V5 Interdisciplinary work (5a)	0.6	*0.4*	0.7	V13 Publication: conv. journal	**0.4**	*0.1*	0.3
V5 Interdisciplinary work (5e)	0.4	*0.2*	0.6	V14 Publication: open journal	**0.3**	*0.1*	0.2
V7 Statement 4 (preference)	0.7	*0.3*	0.8	V16 Position: Assistant	**1.0**	*0.0*	0.2
V7 Statement 4 (TEL interdisc.)	0.7	*0.1*	0.9	V19 Age group	0.2	*0.3*	0.5
V8 Term: evaluation (tech.)	**0.6**	*0.5*	0.1	V21 Gender	0.4	*0.5*	0.5
V8 Term: scenario (tech.)	**0.6**	*0.5*	0.1	V22 Project	0.0	*0.0*	0.6

i) *Consolidation: Cluster Grouping along Selected Variables*

The cluster analysis provided valuable insights into the structure of the TELeurope community. Even if the reliability of the clusters or the significance of differences is debatable, the participants could be grouped in a clearer way. This allows for a better differentiation between disciplinary branches in TEL, looking at all surveyed variables and not only the study background. To sum up the results and visualise the clusters two new comprehensive variables have been calculated, namely *V25 TEL participation* and *V26 disciplinary orientation*.

TEL participation refers to all variables, which indicate that the respondent is actively participating in TEL research. It sums up the score of activities (V1), the involvement in core research areas (V2), the general use of and knowledge about methods (V9), as well as theories (V10), the targeting of many audiences (V11), the publication score (V13/14), project participation (V22) and TELeurope platform connections (V23)[96]. *Disciplinary orientation* takes into account all variables, which are related to the concept of a strong, integrative interdisciplinarity. This includes having a study background in several disciplines (V3), perceiving one's own studies (V4c/d) and work (V5a/d/e) as very interdisciplinary, having a positive attitude towards interdisciplinarity (V7a/d/e), using discipline-bridging terminology (V8b/e/h), methodology (V9b/e/h) and theory (V10b/e/h), targeting audiences other than one's own (V11b/c/d), publishing open access (V14), and working together with multidisciplinary colleagues (V17c).

The new variables have been calculated by summing up the rescaled (0-1) mean values of the corresponding variables. In doing so, every variable is equally[97] taken into consideration. However, they can only provide an indication of a person's "participation" or "orientation", useful to compare and rank the clusters. Fig. shows the clusters, grouped by the two new variables.

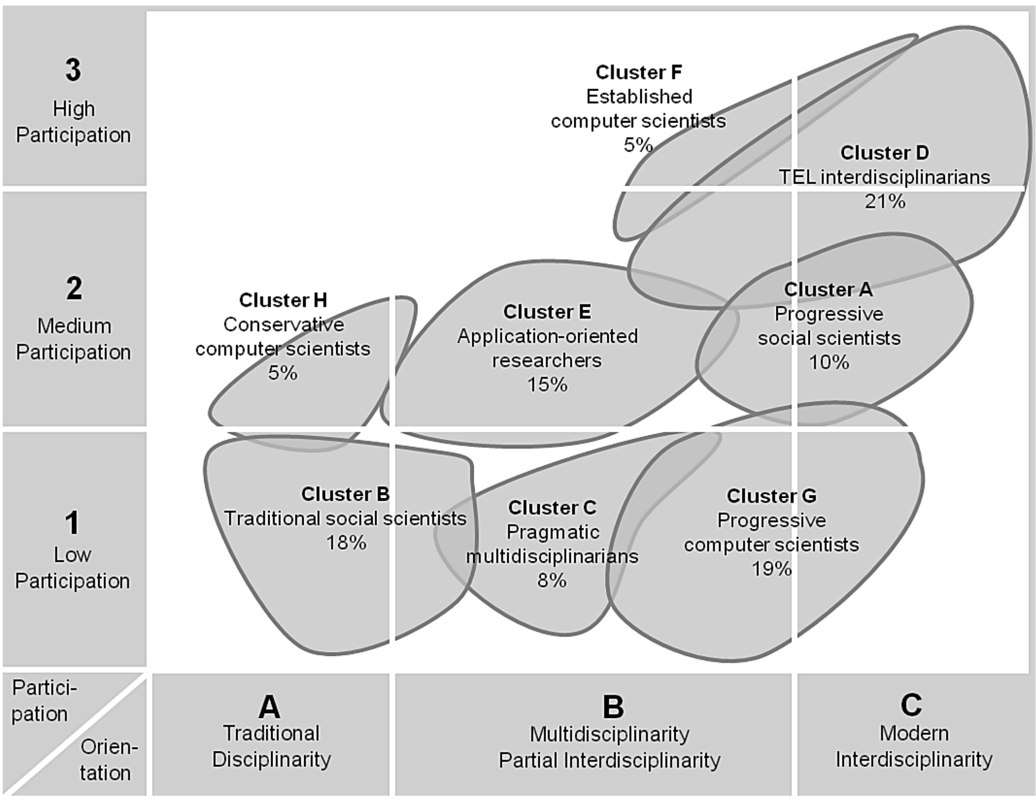


Fig 26. *Clusters of the European TEL community.*

[96] See network analysis C.6.4

[97] The difference in subvariables accounts for the fact that not every variable is considered to the same extent. Even if average values for each variable are calculated, the general validity with regards to really representing "participation" or "orientation" is unlikely to improve much.

As it is shown in the figure, cluster D has the highest values for participation in TEL research (26.3[98]) and disciplinary orientation (17.5). It is then followed by cluster F (25.5 | 13.8). Cluster A and G show only low or medium participation, but a high interdisciplinarity (A: 23.3 | 13.3, G: 19.8 | 12.9). In the middle lies cluster E with both medium participation and orientation values (22.1 | 12.5). The clusters H and C have either traditional orientation (H: 22.1 | 10.7), or low participation (C:18.2 | 12.5). Overall, the lowest values are found for cluster B (18.1 | 11.2).

6.4 Results: Social Network Analysis

In order to answer the fourth research question on whether researchers are connected to each other in *mutual engagement*, network analysis is conducted. The collective data has been gathered from the platform database. It is process-produced and therefore non-reactive data about digital behavioural traces. "Non-reactive" in this respect means it has not been influenced by any measuring instrument (Diekmann, 1995, p. 627), as opposed to survey data.

6.4.1 Research Question 4: "Mutual Engagement in Relationships" in the Community

Before going into details with network analysis, some basic statistics are going to be explained, in order to answer the fourth research question. 69% of the researchers on TELeurope, who participated in the survey, are connected to others[99]. Thereof, 26% have one to five connections, 25% have six to twenty, 14% have twenty-one to fifty and 4% over 50 connections[100], with a maximum count of 138. Doing the Kruskal-Wallis *H* test for the five different categories reveals significant differences along the background variable (H= 9.98, p < .01), as it can be seen in fig. 27. CSB researchers are more connected on TELeurope.eu (87%, Mann-Whitney U= 1140, p < .01), followed by multidisciplinary researchers (68%). Social scientists are least connected (57%).

[98] Sum of rescaled cluster means, including the variables mentioned on pp. 88-89.
[99] Platform statistics show that currently 482 members are connected, which is about half of the estimated 1.000 platform users. It suggests itself that survey respondents recruit from the more active part of the community. A total of 1989 interpersonal connections (undirected) exist on TEL-europe.eu.
[100] New variable calculated from network data: V23 (0="no connections", 1="1-5 connections", 2="6-20 connections", 3="21-50 connections", 4="over 50 connections"

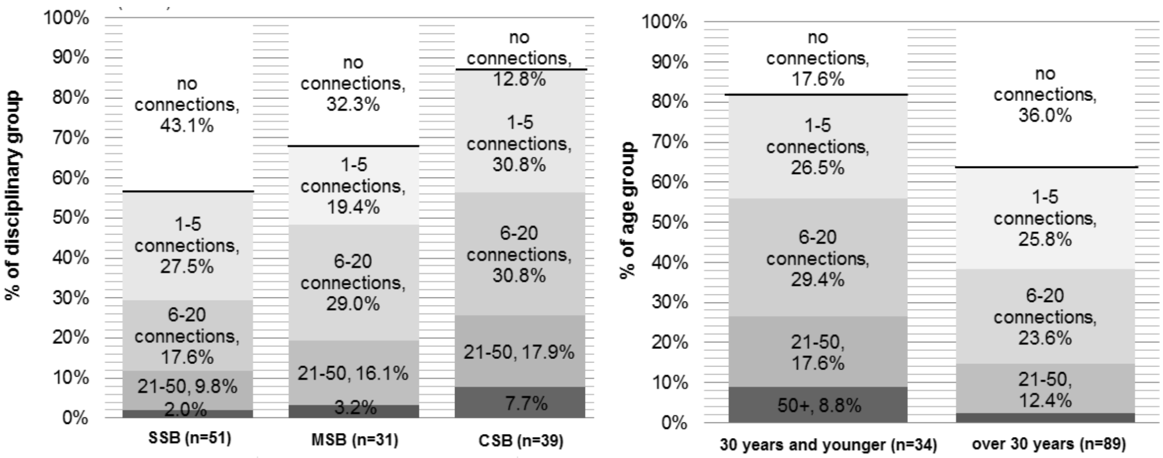


Fig. 27. *General platform participation along study background/age.*

Platform participation is higher for researchers who are 30 years and younger, as compared to those over 30 (see fig. 27). This proves significant for comparing the two groups with the Mann-Whitney test $U= 1080$, $p = .02$. So there is a difference along the age of researchers, but it seems to be less pronounced than the aforementioned discipline differences[101].

There are also indicators that suggest there is a difference in participation, regarding the country in which a researcher works. Looking at countries, the numbers become too small to state significance. All researchers from Germany are connected on TELeurope.eu, 11 out of 15 researchers from Spain, but only 12 out of 21 from UK and 5 out of 9 from the Netherlands.[102] Fig. 28 shows how the European researchers are connected to each other on TELeurope.eu and what disciplinary backgrounds are predominant for each country.

The 123 survey participants share a total of 151[103] undirected connections. A majority of countries, i.e. 22 out of 25 within Europe, is connected. Summed network statistics show that most edges are shared between the UK and Spain (n=14), as well as the UK and Germany (n=13). Even though lots of participants come from Spain and Germany, only 3 connections can be stated between those countries.

[101] The age of participants from contrasting study backgrounds is significantly different, as described in C.6.1 ($H= 10.53$, $p < .01$),

[102] This is likely to be related to the age, as the amount of early career researchers on TELeurope.eu from those two countries is above the average of 28% (Germany: 7 out of 14, Spain: 6 out of 15)

[103] All reported edges from this point on are thought as undirected

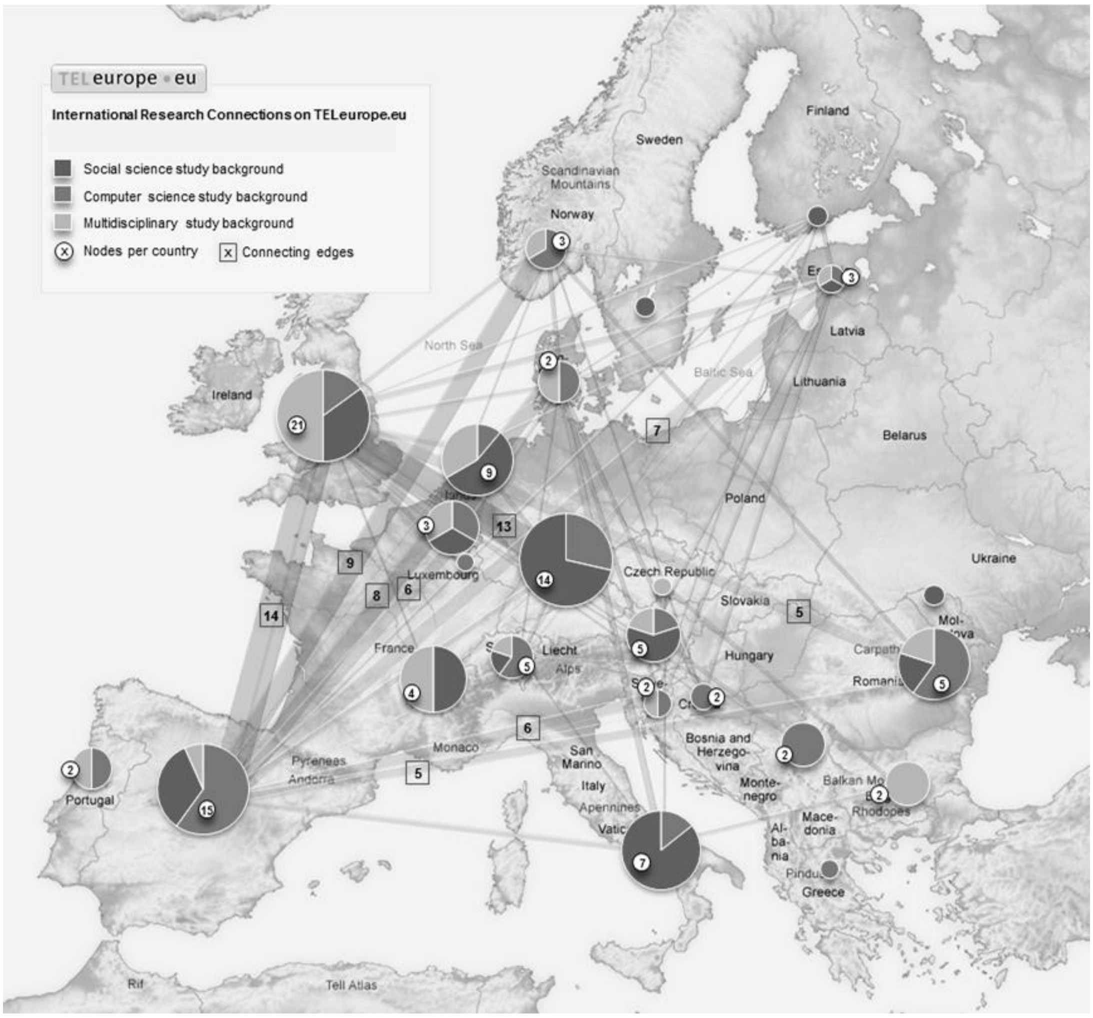


Fig. 28. *Connections between European countries on TELeurope.eu (N=123, n=151)* [104].

6.4.2 Network Analysis of Cluster Connections

The degree of connectedness is very different for the clusters identified in C.6.3. The *"progressive computer scientists"* of cluster G are most connected, with a degree level $dc_{(G)}$ of 3.3[105]. High values are present for any measure of centrality. Even though general research participation is lower than in other clusters, the contributing researchers are active networkers and connect with all clusters.

[104] N=Nodes, n=edges (undirected). Note: figures are not meant to representative for the whole field of TEL related research in Europe, but only for the TELeurope platform.

[105] Average centrality values for the cluster nodes. *dc=degree centrality, bc=betweenness centrality, cc= closeness centrality* (n=482). Darker nodes in fig. 29-36 indicate higher centrality values. The centrality algorithm as described by Brandes (2001) has been used.

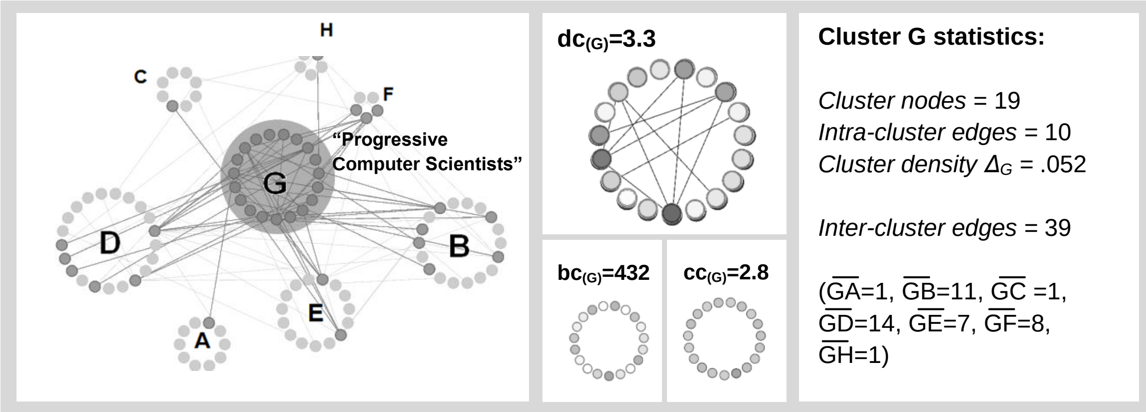
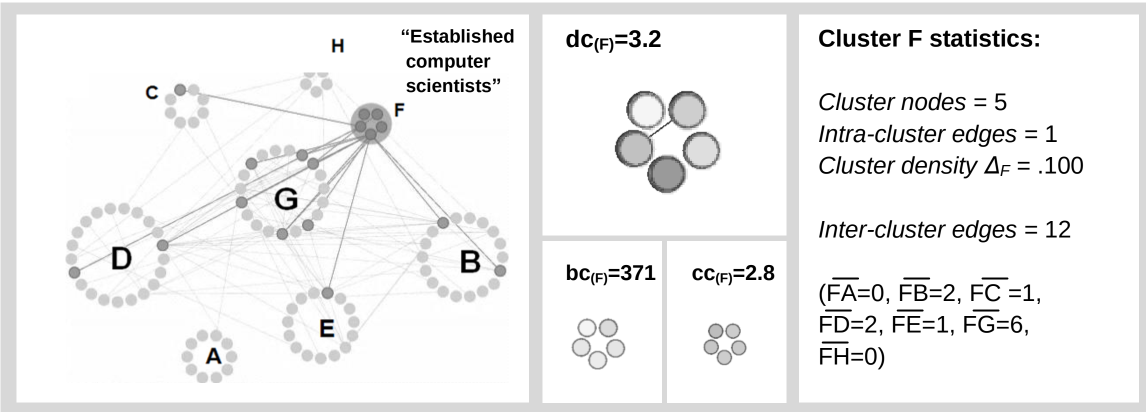
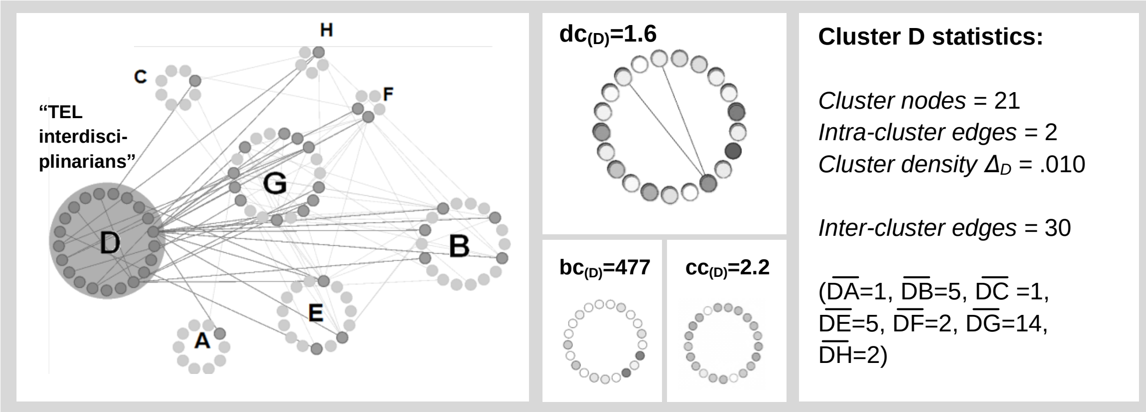


Fig. 29-36. *Cluster network statistics.*

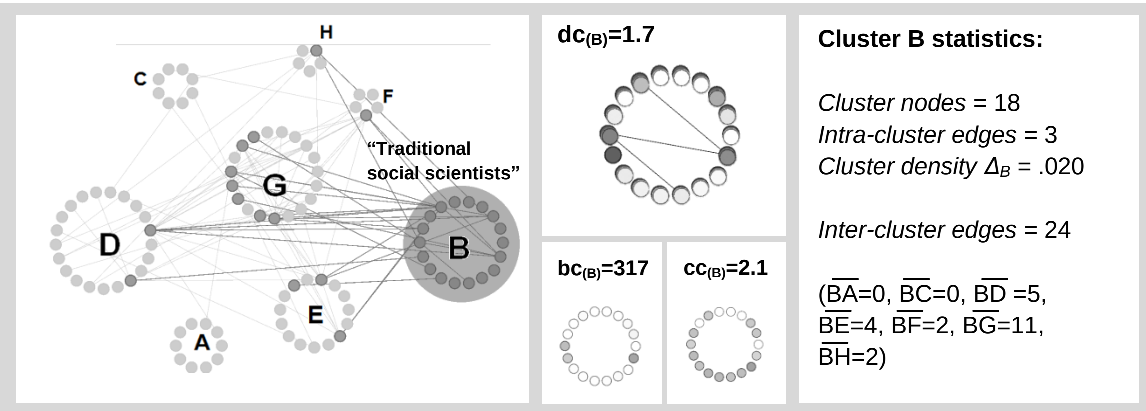
Another computer science cluster, the *"established computer scientists"* is the second most active one on TELeurope, despite the relatively high age. Only one cluster (H) does not have connections with this group of researchers. However they are mainly connected to the aforementioned computer science cluster G (n=6).



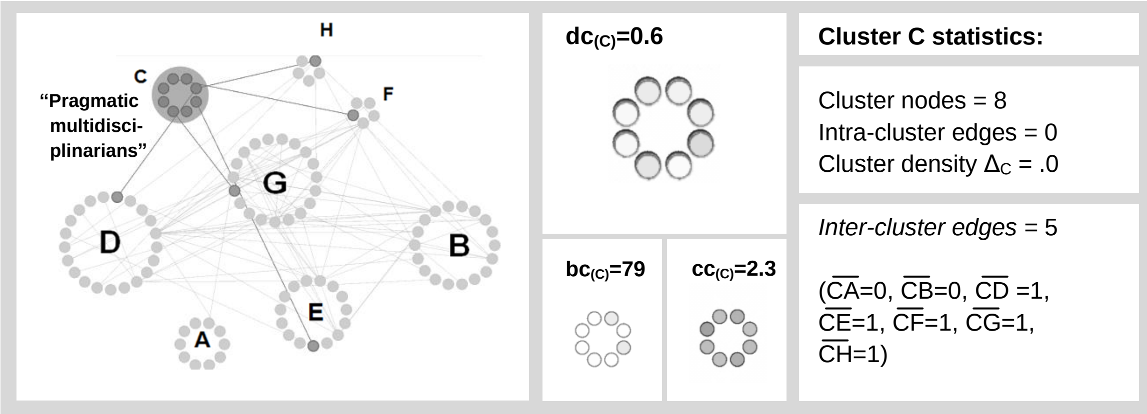
The strongly participatory *"TEL interdisciplinarians"* (Cluster D) stand out, as they have the highest betweenness centrality value. It is indicating that many others are dependent on this group, in order to reach indirect contacts. Even though it does not have a lot of direct ($dc_{(D)}$=1.6) and indirect ($cc_{(D)}$=2.2) connections, cluster D is connected to all other clusters. TEL interdisciplinarians are not very connected to themselves. Instead, lots of connections are shared especially with the "applied researchers" (n=5), the "progressive computer scientists" (n=6) and the young, "traditional social scientists" (n=5).



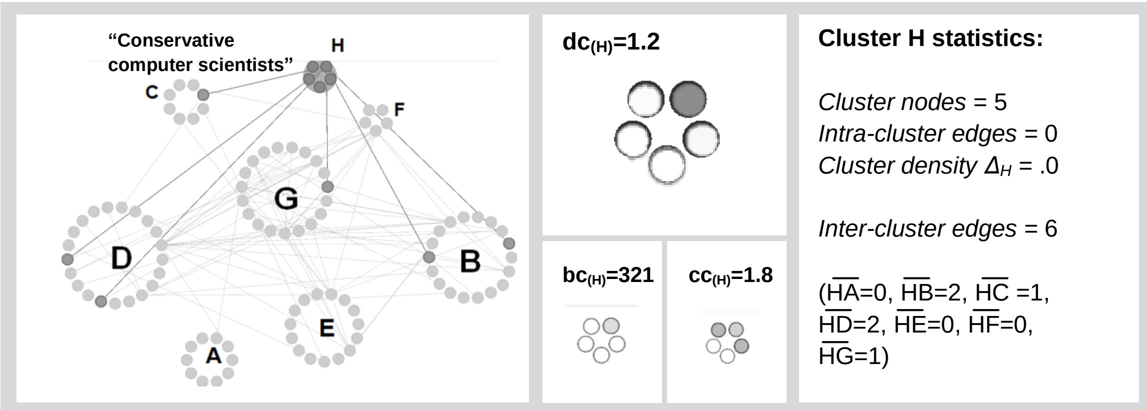
Researchers in cluster B are neither very interdisciplinary oriented, nor actively participating in TEL. Still, the *“traditional social scientists”* are relatively well connected on TELeurope. They share only a few internal connections and less external connections with multidisciplinarians than others, but are often interacting with the computing researchers in cluster G. Surprisingly they are not at all connected to the progressive social scientists in cluster A.



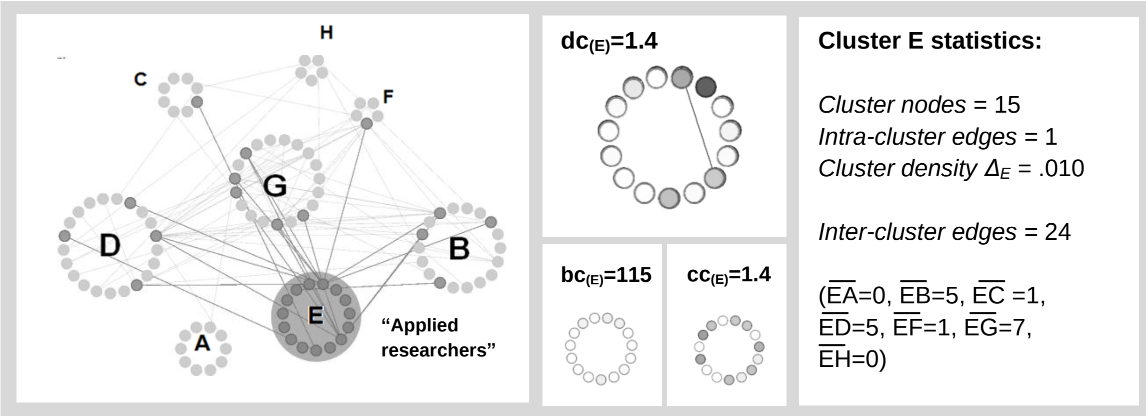
The *“pragmatic multidisciplinarians”* (cluster C) show a very high closeness centrality ($cc_{(C)}$=2.3), compared to a low degree ($dc_{(C)}$=0.6) and betweenness centrality ($bc_{(C)}$=79). They are not connected to each other, but connect a lot of clusters. For that reason, they have a high effectiveness within the network. This accounts more for the computer science clusters and clusters with persons from interdisciplinary background. There are no friendship relations to persons from the social sciences. An exception is the “application-oriented” cluster (n=1) of researchers in schools and companies, who also originally come from a social science background.



Another group of nodes with a high betweenness centrality ($bc_{(H)}$=321) are the *“conservative computer scientists”* of cluster H. They are connected with many clusters, like the TEL interdisciplinarians (n=2), the “traditional social scientists” (n=2), the “established computer scientists” and the “pragmatic multidisciplinarians”. All friendships are hold by only one researcher; the others are unconnected on TEL-europe.eu.

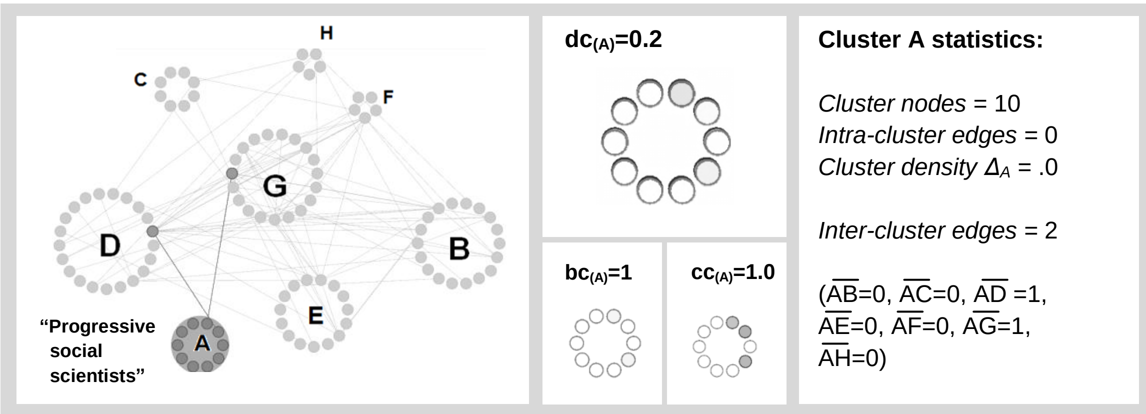


The *“application-oriented researchers”* (cluster E) are less central in the TELeurope network. Only a few nodes are well connected. They are in particular friends with researchers from the bigger clusters, i.e. the “progressive computer scientists” (n=7), the “traditional social scientists” and the “interdisciplinarians” (both n=5).



The *“application-oriented researchers”* (cluster E) are less central in the TELeurope network. Only a few nodes are well connected. They are in particular friends with researchers from the bigger clusters, i.e. the “progressive computer scientists” (n=7), the “traditional social scientists” and the “interdisciplinarians” (both n=5).

Persons with a very interdisciplinary attitude and a high participation in TEL research and related activities belong to the *“progressive social scientists”* in cluster A. Their activity in interdisciplinary research doesn’t reflect on the TELeurope platform, as they are rather isolated. Only one of the contributing 10 nodes is connected to other cluster. It lies at hand for this cluster that the social scientists play a less active role in the European TEL network.



VII. STUDY DISCUSSION

Firstly, results of the different instruments, i.e. survey, cluster analysis and social network analysis are going to be discussed. Secondly, the four research questions are going to be addressed, debating the strength of a "technology-enhanced learning community of practice". Thirdly, a general critical acclaim on study design and methodology is conducted.

7.1 Discussion of Survey Results

Some of the survey results deserve interpretation, as their meaning can only be fully understood, when taking history and other specifics of the disciplines into account. In the following a selection of debatable results is going to be presented.

a) Gender and Disciplinary Background

Chapter 6.1 reports that computer scientists are more often male than their social science colleagues. The huge difference is backed up by the nature of the field of computing. A study by Kozen and Zweben (1998) revealed that only 15-20% of undergraduate computer science students at leading U.S. departments are female. Even if due to efforts of increasing this numbers (see e.g. Margolis and Fisher, 2002) might have led to a higher percentage by 2011, one can still assume that more men than women engage in computing. In contrast, for fields like education and the social sciences, the opposite is the case, as shown by the 2010 US survey of earned doctorates (SED). For example, the amount of female researchers, who have been awarded with a doctorate in education, lies around 70% (National Science Foundation, 2010).

b) Age and Multidisciplinarity

The results suggest that researchers with a multidisciplinary background tend to be older. A simple explanation for this difference might be that older researchers are more likely to have studied more than one full-or-part-time programme. Also, the Bologna process, starting in 1999, evoked some changes in Europe. The new study modularisation and the introduction of three-year bachelor and two-year master programmes lead students to leave university earlier than before in some countries, e.g. Germany (HfWU, 2005).

c) Country Representation

The perception that the United Kingdom is overrepresented on TELeurope.eu can be explained by the special role that technology-enhanced learning has on the island. In UK the Teaching and Learning Research Programme funds eight large projects in the TEL field across the UK (TLRP, 2009). Also, the familiarity with the English language and the fact, that the TELeurope.eu platform is hosted in England might play a role for the predominance.

Also, some researchers from outside Europe participated in the survey. As platform registration is open to anyone, also Non-Europeans are registered on TELeurope.eu. Those may either be interested in European TEL research, or may have been working in Europe before leaving for a time abroad.

d) TEL Core Areas and Identification

The core areas have proven to work well, as many researchers across the groups agreed with them. The results of the STELLAR Delphi study (see descriptions in C.4.2.1) therefore can be confirmed by this study. Researchers also largely agree upon the value of interdisciplinarity. Nevertheless, there is indication in the data that people with a background in social science do not only quantitatively dominate TEL in Europe (see C.6.1). They are also more reflected in core research areas and most researchers identify with social science. A less integrated expert minority of computer science researchers seems to be present, who view their training as less interdisciplinary. They choose to use a technology-focused terminology, whereas for the other disciplines a learner focussed language was usually the case.

It is also not very surprising that MSB researchers agreed more, that they studied “several” study programmes. To a large degree this is what makes them “multidisciplinary researchers”. However not all of them agreed, which might be due to the fact, that they don’t perceive these study programmes as “unconnected”.

The rootedness of TEL researchers in terms of their identity does not necessarily mean that they are less interdisciplinary. On the contrary, an awareness and sense of one’s disciplinary stance may be the basis for negotiating in a heterogenic community. The identity-question was concretely asking for the field that people “identify with *the most*”, which may have forced respondents to make a decision for their answer.

e) Social Scientists and Statements on Interdisciplinarity

One of the questions on the interdisciplinarity of study backgrounds was unfortunately phrased ("I studied courses from neighbouring departments towards a disciplinary major, rooted in only one scientific field (e.g. in the Social Sciences).")
The additional information "e.g. in the Social Sciences" for could have primed respondents with a social science background to agree more often. If it had been known that the chosen phrasing would lead to misunderstandings, a more precise one would have been chosen.

f) TEL Practices between the Disciplines

Some activities like programming, coaching and policymaking are, according to the results, only relevant for parts of the TEL community. In general, the background determines the use of methodology and the citation of theories for TEL research, as can be seen for the theories and methods, derived from the traditional disciplines. Computer scientists use way more social science methodology than the other way round. Nevertheless, a shared repertoire of TEL practices could be confirmed, as all methods identified by previous qualitative TEL studies did not show any differences across the disciplinary groups. Therefore design-based research, user centered design and socio-technical engineering can be considered as "TEL methods", though the latter is only used frequently by one third of the community. Community of practice is in this respect a "TEL theory". Others like constructionism and actor-network theory are less common. Only a minority of European TEL researchers use methods and especially theories from multiple disciplines. When the amount of usage is taken into account, empirical research, i.e. quantitative and qualitative methods, are a shared practice within technology-enhanced learning,. Theory-wise, constructivist learning theory is the ground on which a vast majority of TEL researchers base their assumptions. Again, as for the first research question, the TEL community has proven to be very heterogeneous, but still with some common practice.

g) "Representation Theory" and the Social Sciences

The selected theories and methods can only detect tendencies, as the lists were far from complete. For the computer science "representation theory" it is interesting that many social scientists state to cite this theory. Even though concrete descriptions had been provided, it is possible that it has been mistaken for Moscovici's *social representations theory* (see e.g. Moscovici, 1984). This could explain the indifference between the groups for this item.

h) Open Access Publishing

The results suggest that TEL researchers embrace an open dialogue with a broader public, because persons across all backgrounds address application-oriented audiences a lot, use open publication formats often and involve the public in the research process. This overall tendency might be because TEL researchers are more oriented towards non-research stakeholders, involved in education.

The fact that many researchers involve the public in their research suggests a strong commitment to openness. However, there are gaps along the disciplinary backgrounds, as computer scientists involve non-professionals less and use less open journals. The former could be due to the nature of computer science publications, which are often written in a more technical-oriented language and therefore less comprehensible for non-experts. The computer science branch of TEL is on the contrary more internationally focussed and publishes more in numbers. A manifest explanation for the lack of internationality in the social sciences is that the field is more connected to the social context and language of the country where the research is conducted.

7.2 Discussion of Cluster Analysis

Only one fifth of the network belongs to the cluster of modern "interdisciplinarians", who meet all applied criteria for being interdisciplinary to a large extent. In short, these criteria involve the following:

- Training in different disciplines
- Interest in many TEL core areas
- Co-working with multidisciplinary colleagues
- A positive attitude towards interdisciplinarity
- Publishing also for audiences outside university
  (applied audiences, non-professionals)
- Publishing OA and with an international focus
- Preference for a terminology that integrates aspects of
  learning and technology
- Knowledge of Computing and Social Sciences Methods and Theories
- Cross-disciplinary connections to other researchers on TELeurope.eu

Researchers meeting there criteria push TEL towards becoming an integrated discipline with its own standards of validity, and shared epistemological practices. As this group is doing quite well, it is worth to focus on the more traditional disciplinary fragments of the TEL community. There is a big cluster of young "traditional social scientists" on TEL, which members are quite well connected across the disciplines. However, their participation in TEL research is rather low and they are rooted in the technology-oriented social sciences. In contrast, young computer science researchers are not only highly connected on TELeurope but also very interdisciplinary in their practices, using also empirical methods and referring to constructivist learning theories. One out of six TEL researchers belongs to a cluster of applied researchers. This cluster is not very well connected, which may be related to the fact that most persons in this cluster do not work in universities, and belong to a higher age group.

7.3 Discussion of Social Network Analysis

The results of the network analysis showed that younger researchers are more active on TELeurope.eu. It is reasonable, that platform participation differs by age, as social networking platform are especially used by the younger generation (Boyd, 2008). Also the motivation for networking might be higher for early-career researchers below 30, as they often still need to find their place in the academic landscape.

The fact that someone is connected to another person through a friendship relation on TELeurope.eu does not necessarily indicate that they really are friends. Approving the digital friendship could be the only interaction they had in ten years, it is not sure to say whether those two also know each other "in person". However, several studies on social networking suggest that those connections represent an extension of "real" friendships, and the number of connections often correlates with high self-esteem and social capital of the users (Ellison, Steinfield, & Lampe, 2007, Bargh, & McKenna, 2004). Researchers, who are not connected on TELeurope, could still know themselves from projects or events, so the validity of measuring only platform connections is limited, but indicative.

The identified clusters are not necessarily connected on TELeurope. This is actually only the case for the "progressive computer science" cluster. Also, a high value in TEL research participation does not correlate with a high degree of connectivity on the platform. Younger researchers and in particular researchers, who come from the computing discipline (see fig. 37) are more active in the European technology-enhanced learning network. It is not indicated that researchers are more connected with persons from the same disciplinary background. So there are some "mutual relationships" across the disciplines. Especially the younger TEL generation (under 30) is connected with each other, regardless of the discipline. Regarding the work countries, researchers from Spain and the UK are connected to lots of different European countries. Germany's connections in the technology-enhanced learning community are very much focussed on the United Kingdom.

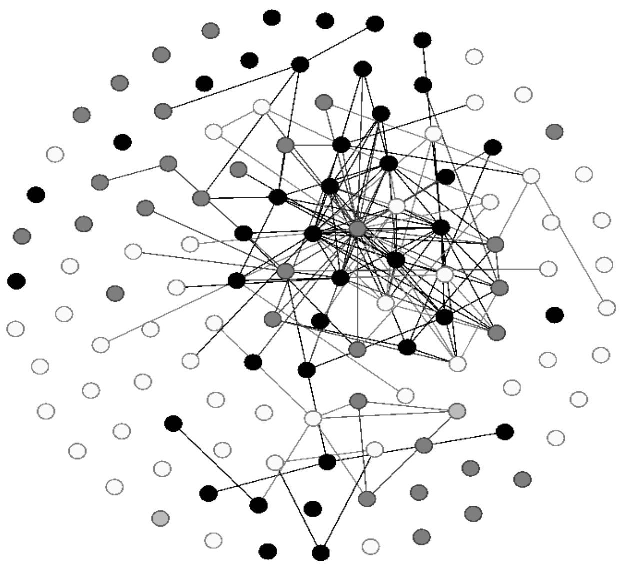


Fig. 37. *Network of survey participants on TELeurope.eu.*
(N=123, n=151, black=CSB, white=SSB, grey=MSB, Algorithm: Fruchterman Reingold)

7.4 Reference to the Research Questions

Recapitulating the research questions, they address whether there is a *sense of joint enterprise*, a *shared repertoire* of TEL research practices, an *open dialogue* with a broader public and *mutual engagement* in relationships on the network. First every question is going to be answered separately, before a conclusion on TEL as an epistemic community of practice can be approached.

Concerning the sense of *joint enterprise*, there is a wide agreement on core TEL research areas and on the general value and existence of interdisciplinary research. However, this "sense" is less present, when researchers are asked to judge the interdisciplinarity of their study background, as computer scientists often feel that their studies were rather monodisciplinary. People who have been trained in both disciplines are more likely to consider their current work in TEL as interdisciplinary. TEL researchers often seem to speak a different language and to define terms in a way that correlates with their background. Also, the study discipline is often a factor for identification, as only few researchers identify with a discipline other than the one they studied.

For a *shared repertoire* of practices, differences were present across the disciplines. E.g. coaching, and policymaking are more the realm for TEL social scientist and multidisciplinarians, and computer science theories and methods are usually exclusively used by those with a computing background. However, there are indications that a repertoire does exist. It consists of methods such as design-based research, user centered design, socio-technical engineering and qualitative, as well as quantitative empirical methods. Common theories include Wenger's community of practice theory, constructivist learning theory, Papert's constructionism and actor-network theory.

An *open dialogue* with a broader public is present in the TEL community, especially when comparing it with the results of other open access studies (SOAP, 2011; DFG, 2005). The traditional disciplinary difference that the computer sciences publish generally more, target more international, more application-oriented, and less non-professional audiences, was visible but not as pronounced as it could have been expected.

For the investigated context, the TELeurope network, *mutual engagement* in relationships across the network was more the case for computer science researchers, even though their numbers are underrepresented in the TEL sample. However, they are not only connected to each other, but also to a lot of different clusters with persons from contrasting disciplines.

Summing it all up, it seems that TEL is indeed, - as one interviewee in the study of Conole et al. (2010) suggested - "historically dominated by the social scientists". Those are traditionally rooted in their methodology and more often in the age group and position to influence TEL policy. However, this group of social scientists often clusters with multidisciplinarians, who received training in both disciplines and also highly participatory "interdisciplinarians". Nevertheless, a large cluster of early-career researchers, who have studied computer science, is very active in networking and shows modern and interdisciplinary features. This cluster often has knowledge of social science and engineering science methods. For the future of TEL, it is to hope that these researchers gain more power and help to shape an emerging technology-enhanced learning interdiscipline.

7.5 Critical Acclaim on Study Design and Methodology

The critical discussion of this thesis is going to address the three basic phases of the research process, following Diekmann (2010). These are the *planning* of investigation, *data collection*, and *data analysis*.

As for the *planning* and the choice of methods a combined quantitative approach on measuring interdisciplinarity has been taken. There is no prior experience with combining survey, cluster analysis and network analysis to the author's knowledge. Chapter 5 named reasons for combining the three, namely to take a look at disciplinary differences, as well as interdisciplinary variety and integration in the TEL network. Still, the combination means that if there are flaws in the first step they are likely to influence the reliability of further investigation in cluster and network analysis.

For the *collection* of data on interdisciplinarity, a survey and the process generated network data have some shortcomings. First of all, the construction of the survey was heavily relying on findings of previous TEL studies. Especially the terminology, theories and methods had to be chosen with respective to qualitative studies, who only involved few participants. Parts of the survey were trying to reproduce qualitative findings on a quantitative scale. Information had to be reduced therefore, in order to keep the survey manageable. The disciplinary background has only been measured in four broad categories (Life/Nature/Social /Engineering Science), only three terms have been tested on their definitions, only nine theories and respectively methods were proposed. They had been chosen in the hope that they are the most common of its kind in the field, but one can't be sure about this. A backchannel comment field, however, did not show any indication that respondents missed some important theories or methods. Still, a general remark on the validity of the study has to be made. This criticism addresses the collection of both survey and network data. It is not necessarily the case that "interdisciplinarity" is measured by the instruments, as it could results in other forms, for example:

- A person can be close friends with another person, but not be connected on TELeurope, because of infrequent use of the platform or the lack of a "need" to connect there. Then "TELeurope connection" as a measure for interdisciplinarity will not work.
- A person can publish a lot together with scientists from different disciplines and still feel that their work is rather monodisciplinary, or at least not interdisciplinary enough. The self-perception of the respondent then would differ from how we the author would have judged the person's behaviour.

- A person from the social sciences can talk with a computer scientist everyday about the most complex computing methods and programming languages, without using them personally (however if the person works in a social science institution, it is unlikely that this actually happens).

All these examples involve the existence of an interdisciplinarity, which has not been measured. Naturally, also the opposite is imaginable, when an indication for interdisciplinarity is believed, where there is none. All questions on positive opinions on interdisciplinarity for example do not have to mean an actual interdisciplinarity of epistemic practices.

For the step of *data analysis* it can be discussed, if it is appropriate to limit the four research questions to the survey and very basic network statistics. As the author was especially familiar with testing hypotheses for bivariate correlations, focus has been put on those. The exploratory cluster and network analyses however remain disconnected from the research questions. Another point to be discussed is the so to speak “all-or-one” approach taken by this thesis. This refers to the fact that the independent variable, chosen for the bivariate analysis, always was the study background (and sometimes the age group). Other variables, like the “colleague discipline”, which indicates in what kind of institution people work, have not been considered.[106] For the multivariate analysis all variables have been included into the clustering. Usually it is not recommended to cluster along a huge number of variables (see Hastie et al., 2009). In this study this recommendation was neglected, as all of those variables contributed to the concept of interdisciplinarity and therefore were considered as relevant for the clustering. Moreover the algorithms for clustering and network analysis sometimes have been chosen rather subjectively, according to the (perceived) best way of visualising results. Several algorithms have been tested, but it is not sure to say that finally the most valid has been selected. For the network analysis only few variables have been taken into account as node attributes. To be precise, these were the “location”, “study background”, and “cluster membership”. To limit the effort only those selected few have been analysed for clustering, even though it also could be that e.g. persons who practice the same method, are connected on the platform.

[106] Note: several calculations have been made using different independent variables. Nevertheless, not all of them have been reported, as results were not significant.

VIII. CONCLUSIONS AND FUTURE OUTLOOK

8.1 Main Findings

To sum up the findings of this thesis in short words, TEL is hardly one integrated discipline. Still, practices are too different within the community. Overall, a few basic tendencies can be reported:

- High participation in TEL research is held by a cluster of interdisciplinarians, age 30-40, and a small cluster of established computer science researchers. First of all it is worth noting that both of these clusters are well connected on TELeurope.eu (also across disciplines=, even though they do not consist of many early career researchers. Characteristics of these groups are training in different disciplines; Interest in many TEL core areas; Co-working with multidisciplinary colleagues; a positive attitude towards interdisciplinarity; publishing also for audiences outside university; publishing OA and with an international focus; preference for a terminology that integrates aspects of learning and technology; knowledge of computing and social sciences methods and theories
- Younger researchers are more connected on the European TEL network. This can mostly be explained by the fact that networking is especially important for career building and therefore more relevant for younger researchers. Also there might be a higher affinity to social networking platforms, for already mentioned reasons.
- Computer Scientists are more connected on the European TEL network. Being a computer scientist correlates with younger age in the sample of this study. Beyond that, an international focus is more apparent for the computer scientists (see e.g. DFG, 2005) as social scientists naturally tend to be rooted in the social context of their investigation.
- Early career computer science researchers are more interdisciplinary than early career social science researchers. The two youngest clusters both show only a low participation in TEL research, which is natural, as they yet have to grow into the research community. Still, it is much more likely for a computing researcher to also use empirical methodology than it is for a social science researcher to use computing methods. These criteria might seem strict, but concerning the focus of epistemic integration, which lies at the heart of this study, this conclusion must be made.

8.2 Recommendations and Outlook

One mechanism to promote interdisciplinarity is, according to Augsburg and Henry (2009, pp. 238-239) to support "self-consciousness about interdisciplinarity and integration". It is only, when the need to establish a TEL discipline is shared by all stakeholders, that it can become a reality. This implies to not only be interdisciplinary as an individual, but also care about the interdisciplinarity of others and to engage in initiatives, which seek to establish epistemic standards for the field. The TEL social scientists already seem to be very active in policy making, as it is suggested by the results of the study at hand. Therefore it can be useful to establish a *dialogue between the early career computer scientists and established policymakers*, who are unconnected on TELeurope. Also the general *value of networking* could be promoted more, as many (especially social science) researchers remain relatively unconnected on TELeurope, even though they are actively participating in the field of TEL. As many researchers work in institutions together with colleagues from the same discipline, it should be a political aim to create more *interdisciplinary institutions*, where researchers from both disciplines work together on problems. Looking at interdisciplinary connections between countries, relatively few computer science researchers from Germany and England contribute to TEL. *Recruiting more researchers from the computing disciplines* can be a recommendation in those two countries. Also, the connections between Germany and other European countries than UK are quite few. Fostering European TEL therefore needs to *better integrate German researchers* with those from other countries. Also France doesn't have many of researchers registered on TELeurope. The TEL community should focus on *getting more French researchers involved* in European TEL research. Moreover, many *central-eastern European* countries as e.g. Poland, Slovakia and the Czech Republic are yet underrepresented. Future research project should try to include more research institutions from those countries.

This thesis hopes to trigger more research on difference, diversity and integration in the TEL community. The approach taken here was relatively universal, including publishing, theories, methods, terminology et al. Future studies can be more precise in their focus, taking single aspects into account. Expert interviews could e.g. identify features of TEL methods that cross the disciplines. From a practical perspective, also patterns and scenarios are imaginable, which describe how to address and methodologically approach problems in the field. In order to capture dynamics of the technology-enhanced learning network, it would be interesting to repeat the study in one or two years, using the same methodology. The approach could also be applied to other networks, where email addresses and connection data is available. For example, many papers in the field usually include mail addresses of the authors. These could be used to repeat the study in a context, where connections might be more meaningful than on the TELeurope platform. In a time where one has 500 friends on Linked In and Facebook, the meaning and strength of a single connection can be questioned. Writing a paper together therefore indicates a more profound collaboration, as it takes effort. These connections are surely worth taking a closer – maybe qualitative – look at.

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XII. LIST OF ABBREVIATIONS

abbr.	abbreviated
approx.	approximately
B.A.	Bachelor of Arts
bc	betweenness centrality
B.Sc.	Bachelor of Sciences
C	chapter
cc	closeness centrality
cf.	confer (compare)
cit.	cited
CSB	computer science study background
dc	degree centrality
DV	dependent variable
i.e.	id est (that is)
ed(s).	editor(s)
et al.	et alii (and others)
e.g.	for example
etc.	et cetera (and more)
Fig.	figure
H	Kruskal-Wallis *H* test value
ICT	information and communication technologies
ID	interdisciplinarity
IV	independent variable
M	mean value
M.A.	Master of Arts
M.Sc.	Master of Sciences
MSB	multidisciplinary study background
N	N value (amount of cases / actors)
n	n value (amount of edges)
p.	page
p	probability value
p. a.	per annum (per year)
PhD	Doctor of Philosophy
SD	standard deviation value
SME	small and medium enterprises
SSB	social science study background
Tab.	table
TEL	Technology-Enhanced Learning
TLRP	Teaching and Learning Research Programme
U	Mann-Whitney *U* test value
UK	United Kingdom
viz.	videlicet (as follows)
vs.	versus
[ ]	author's note
~	is equivalent to
%	percent

XIII. APPENDIX

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Cluster Data XSLX File	49 KB	Microsoft Office Excel Worksheet
Master's Thesis	4,605 KB	Adobe Acrobat Document
Network Data GDF File.gdf	154 KB	GDF-Datei
Network Data GEFX File	822 KB	GEXF Graph File
Network Data Gephi File	113 KB	Gephi Project File
Network Data GRAPHML File.graphml	566 KB	GRAPHML-Datei
Questionnaire - Final Version	720 KB	Adobe Acrobat Document
Questionnaire - Pretest Version	259 KB	Adobe Acrobat Document
Survey Data CSV File (Values)	29 KB	Microsoft Office Excel Comma Separated Values File
Survey Data CSV File	102 KB	Microsoft Office Excel Comma Separated Values File
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Survey Data XLS File	201 KB	Microsoft Office Excel 97-2003 Worksheet
Survey Data XLSX File	58 KB	Microsoft Office Excel Worksheet

A) Survey Questionnaire (Final Version)

Questionnaire on Interdisciplinarity and Research Identity in Technology Enhanced Learning

Dear TELeurope.eu member,

The domain of Technology Enhanced Learning (TEL) is, by definition, an interdisciplinary research field. However, true interdisciplinarity in science is rare, as disciplinary boundaries tend to determine the research that is being undertaken. Several studies in the past years have examined the quality and specific characteristics of interdisciplinary TEL research. This study aims at testing some of the raised assumptions on a broader, quantitative scale.

About the author: My name is Philip Meyer. For my M.A. at the University of Augsburg I am doing a study on research culture and interdisciplinarity in the field of technology enhanced learning. At the moment I am located at KMi, The Open University, UK. For any questions concerning the content or results of this study, please contact me (0044 / 7594806487, e-mail: p.meyer@open.ac.uk).

Disciplinary Thinking (Cartoon source: bhs-runyan.wikispaces.com)

If you have any whatsoever connection to research in the field of TEL, this questionnaire is just for you. It takes only about **10-12 minutes.** All data that you provide will be used for research purposes only and remains confidential and private. This research is supported by the STELLARnet network of excellence. Thank you for your cooperation.

Supported by STELLARNET

0% 100%

TEL Basics

At first, please provide some basic information about your relation to the field of Technology Enhanced Learning.

*** What are your main work activities in the field of Technology Enhanced Learning?**

	Often	Sometimes	Seldom	Never
Research (researching in TEL)	○	○	○	○
Teaching (teaching students within schools and universities)	○	○	○	○
Coaching and professional training (introducing managers/teachers to TEL)	○	○	○	○
Programming and software engineering (developing TEL tools)	○	○	○	○
Policymaking (influencing policy in education and training, research, or innovation)	○	○	○	○
Other work for ICT/TEL industry enterprises	○	○	○	○

*** Which of the following TEL research areas reflect your work?**

	To a Great Extent	Somewhat	Very Little	Not at All	I don't know
Computer supported collaborative learning (CSCL)	○	○	○	○	○
Connection between formal and informal learning experiences	○	○	○	○	○
Contextualised learning	○	○	○	○	○
Emotional or motivational aspects of learning with technology	○	○	○	○	○
Formal education through the use of technology	○	○	○	○	○
Informal learning settings and their motivational characteristics	○	○	○	○	○
Interoperability of tools and devices	○	○	○	○	○
Personalisation of TEL environments	○	○	○	○	○
Digital divide in society	○	○	○	○	○
Ubiquitous and mobile technology	○	○	○	○	○
Workplace learning and TEL of organisations	○	○	○	○	○

0% 100%

TEL Interdisciplinarity

Please tell a few things about your background and your attitude towards interdisciplinarity.

*** In which scientific fields have you been studying (for Bachelor/Master/PhD)?**
(Note: You can check several. If you are not sure which field(s) your study programme belongs to, look it up here)

- [ ] Humanities and Social Sciences (incl. Education, Psychology, Economics, etc.)
- [ ] Life Sciences (incl. Biology, Medicine, Neurosciences, etc.)
- [ ] Natural Sciences (incl. Chemistry, Physics, Mathematics, Geography, etc.)
- [ ] Engineering Sciences (incl. Computer Science, Materials Science, Mechanics, etc.)
- [ ] Other: ______

*** Would you consider your study background as "interdisciplinary"?** *Please answer for different definitions of interdisciplinarity.*

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
I studied courses from neighbouring departments towards a disciplinary major, rooted in only one scientific field (e.g. in the Social Sciences)	○	○	○	○	○
I studied several unconnected study programmes from different scientific fields (e.g. Humanities & Engineering Sciences).	○	○	○	○	○
I studied courses focused on topics from different scientific fields in one study programme.	○	○	○	○	○
I studied in an academic "interdiscipline" (e.g. biomedical engineering), that methodologically and epistemogically integrates different scientific fields.	○	○	○	○	○

*** Would you consider your current work as "interdisciplinary"?** *Please answer for different definitions of interdisciplinarity.*

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
I work in an academic "interdiscipline" (e.g. biomedical engineering) that integrates different scientific fields.	○	○	○	○	○
I interact with neighbour disciplines in my research.	○	○	○	○	○
I involve the broader public in my research.	○	○	○	○	○
I involve specialists from different scientific fields (e.g. Humanities & Engineering Sciences) in my research.	○	○	○	○	○
I bridge different scientific fields (e.g. Humanities & Engineering Sciences) in the research practices and methods I use.	○	○	○	○	○

* **On the whole, which scientific field do you identify with the most?**
Choose one of the following answers

Please choose...

Options:

- Humanities and Social Sciences (incl. Education, Psychology, Economics, etc.)
- Life Sciences (incl. Biology, Medicine, Neurosciences, etc.)
- Natural Sciences (incl. Chemistry, Physics, Mathematics, Geography, etc.)
- Engineering Sciences (incl. Computer Science, Materials Science, Mechanics, etc.)
- I can not say (Multidisciplinary Identity)

* **What is your opinion on the following statements about interdisciplinarity?**
(Note: Interdisciplinary research here defined as: "Strong and integrative collaboration of researchers from different scientific fields working on a common research aim.")

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Interdisciplinary research pushes researchers intellectually.	◯	◯	◯	◯	◯
Interdisciplinary research is hard to publish.	◯	◯	◯	◯	◯
Interdisciplinary research is hard to achieve.	◯	◯	◯	◯	◯
I prefer working interdisciplinary to working in a single discipline.	◯	◯	◯	◯	◯
TEL is an academic "interdiscipline" that bridges different scientific fields.	◯	◯	◯	◯	◯

0% 100%

TEL Terminology

! Congratulation, you are about to complete the first 50% of the survey !

Now it gets a little tricky. Please tell how you use the following terms that are often relevant to TEL research.
There are no right or wrong answers. Please finish the following sentences by ticking the option that best reflects your gut feeling.

* *"When I use the term* **"intervention"**, *it is usually about ...*

- ... *changing people"* (e.g. change in teaching and learning which is implemented in the classroom).
- ... *changing technology"* (e.g. user intervention, user input to a device in Human-Computer Interaction).
- ... *changing systems"* (e.g. activity to improve the performance of a socio-technical system).

- None of them

* *"When I use the term* **"evaluation"**, *it is usually about ...*

- ... *evaluating systems"* (e.g. the usability of a system involving people and technology).
- ... *evaluating technology"* (e.g. the performance of hardware and software).
- ... *evaluating people"* (e.g. the performance of teachers or learners).

- None of them

* *"When I use the term* **"scenario"**, *it is usually about ...*

- ... *describing Human-Computer interactions"* (e.g. narratives and interactions in a system involving people and technology).
- ... *describing steps or actions between people"* (e.g. role plays, team work, teaching strategies).
- ... *describing technology interactions"* (e.g. use cases with abstract actors, such as external software or manual processes).

- None of them

0% 100%

TEL Methodology

Please give information on the methodology that you use for TEL research.

*** Which of the following methods do you use in your research?**
Move the mouse over the questionmarks to display method descriptions.

	Often	Sometimes	Seldom	Never	I don't know
Theoretical computing methods [?]	○	○	○	○	○
Modelling and simulation methods [?]	○	○	○	○	○
Experimental computing methods [?]	○	○	○	○	○
Design (based) research methods [?]	○	○	○	○	○
User-centered design methods [?]	○	○	○	○	○
Socio-cognitive engineering methods [?]	○	○	○	○	○
Quantitative empirical methods [?]	○	○	○	○	○
Qualitative empirical methods [?]	○	○	○	○	○
Ethnographic methods [?]	○	○	○	○	○

*** On which of the following theoretical perspectives do you base your research?**
Move the mouse over the questionmarks to display theory descriptions.

	Often	Sometimes	Seldom	Never	I don't know
Theory of computation [?]	○	○	○	○	○
Representation theory [?]	○	○	○	○	○
Artificial intelligence and machine learning theory [?]	○	○	○	○	○
Communities of practice [?]	○	○	○	○	○
Actor-network theory [?]	○	○	○	○	○
Constructionism [?]	○	○	○	○	○
Constructivist learning theory [?]	○	○	○	○	○
Cognitivist learning theory [?]	○	○	○	○	○
Behaviorist learning theory [?]	○	○	○	○	○

(For question mark descriptions, see appendix C)

0% 100%

TEL Publishing Practices

It's almost done! Please give some information on your research publishing practices.

* **What audiences do you typically address with your publications?**
Check any that apply

- [ ] Researchers from my own scientific field (social science/computer science, etc.)
- [ ] Researchers from other scientific fields
- [ ] Application-orientated audiences (economy, industry, practitioners)
- [ ] Interested non-professionals
- [ ] Other audience: ______

* **Do you address researchers outside your work country with your publications?**
Choose one of the following answers

Please choose...

Options: Always, Usually, About Half the Time, Seldom, Never

* **In 2010, how many of your works did you publish in a conventional way (through publishing companies with charging a fee)**

	0	1 - 2	3 - 5	6 - 10	Over 10
Journal articles	○	○	○	○	○
Articles in workshop/conference proceedings	○	○	○	○	○
Articles in edited volumes, book chapters	○	○	○	○	○
Monographs	○	○	○	○	○

* **In 2010, how many of your works did you <u>also</u> publish for open access on the web (preprint as well as postprint)?**

	0	1 - 2	3 - 5	6 - 10	Over 10
Journal articles	○	○	○	○	○
Articles in workshop/conference proceedings	○	○	○	○	○
Articles in edited volumes, book chapters	○	○	○	○	○
Monographs	○	○	○	○	○

0% 100%

Personal Information

Finally, please provide some information about your person.

* **What kind of workplace have you mainly been working in for the past 12 months?**
(Note: If you have been working in more than one place, please consider the one where you spent most of your time)
Choose one of the following answers

- University or tertiary college/school (public/private sector)
- Primary/secondary school (public/private sector)
- Privately held company
- Non-profit organisation
- Public cooperation
- Individual enterprise
- Freelance work
- Unemployed

* **Work position:**
Check any that apply

- Professor
- Higher education teacher/lecturer
- Research associate
- Research assistant
- Research student
- Scholarship holder
- Other:

* **What academic background do most of your colleagues have?**
Choose one of the following answers

Please choose...

Options:

- Mainly Humanities and Social Sciences (incl. Education, Psychology, Economics, etc.)
- Mainly Life Sciences (incl. Biology, Medicine, Neurosciences, etc.)
- Mainly Natural Sciences (incl. Chemistry, Physics, Mathematics, Geography, etc.)
- Mainly Engineering Sciences (incl. Computer Science, Materials Science, Mechanics, etc.)
- Mixed Background
- I don't know

* **Where is the institution located?**
Choose one of the following answers

Please choose...

Options: Country list

City / town

What age group do you belong to?
Choose one of the following answers

Please choose...

Options: 30 years and younger, 31-40 years, 41-50 years, 51-60 years, 61 years and older

For how many years approx. have you been working in the field of TEL?

Only numbers may be entered in this field

Gender:

- Female
- Male

* **Final question: Do you participate or have you previously participated in any European TEL project?**

- **No**, I did not participate in any European TEL project.
- European Commission FP7 TeLearn projects
- European Commission FP6 TeLearn projects
- European Commission FP5 TeLearn projects
- eContentplus projects
- Other European TEL projects:

B) Questionnaire descriptions of Methods and Theories

METHODS

Theoretical computing methods
Includes formal methods, the application of e.g. logic calculi, formal languages, algorithms, automata theory, program semantics, type systems, algebraic data types to problems in software and hardware specification and verification.

Modeling and simulation methods
Includes e.g. probabilistic methods, descriptive simulation modeling, computational statistics, techniques for sensitivity estimation, simulation-based optimization techniques, metamodeling, goal seeking problems, "What-if" analysis techniques.

Experimental computing methods
Includes e.g. hypothesis testing, single and two-factor ANOVA, simple linear regression models, curvilinear regression and transformations, factorial experiment design, one-factor experiments, distribution fitting methods, discrete event simulation, performance modeling.

Design (based) research methods
A systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories.

User-centered design methods
Includes cooperative design, participatory design, contextual design. Methods in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design process.

Socio-cognitive engineering methods
Analysis of activity systems, including social interactions, styles and strategies of working, language and patterns of communication, to form a composite picture of human knowledge and activity that can inform system design.

Quantitative empirical methods
Systematic empirical investigation of quantitative properties and phenomena and their relationships. The objective of quantitative research is to develop and employ mathematical models, theories and/or hypotheses pertaining to phenomena.

Qualitative empirical methods
Methods that aim to gather an in-depth understanding of human behavior and the reasons that govern such behavior. The qualitative method investigates the why and how of deci-

sion making, not just what, where, when. Hence, smaller but focused samples are more often needed, rather than large samples.

Ethnographic methods
Direct, first-hand observation of frequent participation. Includes e.g. genealogical methods, chain sampling, longitudinal research.

THEORIES

Theory of computation
Includes e.g. automata theory, computability theory, algorithm theory, computational complexity theory, cryptography, quantum computing theory. The study of the theory of computation is focused on answering fundamental questions about what can be computed and what amount of resources are required to perform those computations.

Representation theory
Representation theory is a branch of mathematics that studies abstract algebraic structures by representing their elements as linear transformations of vector spaces. In essence, a representation makes an abstract algebraic object more concrete by describing its elements by matrices and the algebraic operations in terms of matrix addition and matrix multiplication.

Artificial intelligence and machine learning theory
Includes e.g. unsupervised learning, supervised learning, decision theory, computational learning theory. Artificial intelligence is the study and design of intelligent agents, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success.

Communities of practice
Theory that views learning as a social process that occurs when people who have a common interest in a subject or area collaborate over an extended period of time, sharing ideas and strategies, determine solutions, and build innovations.

Actor-network theory
Actor-Network Theory is a framework and systematic way to consider the infrastructure surrounding technological achievements. Assigns agency to both human and non-human actors (e.g. artifacts).

Constructionism
Constructionism (Seymour Papert) holds that learning can happen most effectively when people are also active in making tangible objects in the real world. In this sense, constructionism is connected with experiential learning and builds on some of the ideas of Jean Piaget.

Constructivist learning theory
Includes e.g. problem-based learning, action learning, social constructivism, cognitive apprenticeship, situated learning. Constructivism is a theory of knowledge (epistemology) that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. During infancy, it is an interaction between their experiences and their reflexes or behavior-patterns. Piaget called these systems of knowledge schemata.

Cognitivist learning theory
Includes e.g. cognitive load, information processing theory, attribution theory, instructional design theory. Cognitivism theories consider how human memory works to promote learning. Two key assumptions underlie this cognitive approach: (1) that the memory system is an active organized processor of information and (2) that prior knowledge plays an important role in learning. Cognitive theories look beyond behavior to explain brain-based learning.

Behaviorist learning theory
Includes e.g. relational frame theory, theories of applied behavior analysis, curriculum based measurement, direct instruction, social learning theory (Bandura). Behaviorism as a theory was primarily developed by B. F. Skinner. In essence, three basic assumptions are held to be true. First, learning is manifested by a change in behavior. Second, the environment shapes behavior. And third, the principles of contiguity (how close in time two events must be for a bond to be formed) and reinforcement (any means of increasing the likelihood that an event will be repeated) are central to explaining the learning process. For behaviorism, learning is the acquisition of new behavior through conditioning.

C) DFG Scientific Fields

DFG Classification of Subject Area, Review Board, Research Area and Scientific Discipline (Status: 06/2008)

Subject Area		Review Board	Research Area	Scientific Discipline
10101	Prehistory	101 Ancient Cultures	11 Humanities	1 Humanities and Social Sciences
10102	Classical Philology			
10103	Ancient History			
10104	Classical Archaeology			
10105	Egyptology and Ancient Near Eastern Studies			
10201	Medieval History	102 History		
10202	Early Modern History			
10203	Modern and Current History			
10204	History of Science			
10301	Art History	103 Fine Arts, Music, Theatre and Media Studies		
10302	Musicology			
10303	Theatre and Media Studies			
10401	General and Applied Linguistics	104 Linguistics		
10402	Individual Linguistics			
10403	Typology, Non-European Languages, Hist Linguistics			
10501	Older German Literature	105 Literary Studies		
10502	Modern German Literature			
10503	European and American Literature			
10504	General and Comparative Literature and Cultural Studies			
10601	Ethnology / European Ethnology	106 Non-European Languages and Cultures, Social and Cultural Anthropology, Jewish Studies and Religious Studies		
10602	Regional Studies, Languages and Cultures: Africa, America, Asia, Australia			
10603	Study of Religion			
10604	Islamic Studies, Arabian Studies, Semitic Studies			
10605	Jewish Studies			
10701	Protestant Theology	107 Theology		
10702	Roman Catholic Theology			
10801	History of Philosophy	108 Philosophy		
10802	Theoretical Philosophy			
10803	Practical Philosophy			
10901	General Education and Historical Perspectives	109 Education Sciences	12 Social and Behavioural Sciences	
10902	Teaching-Learning Process and Qualification Process			
10903	Socialization, Institutions and Professions			
11001	General and Physiological Psychology, Methodology and Evaluation	110 Psychology		
11002	Developmental and Educational Psychology			
11003	Social Psychology, Industrial and Organisational Psychology			
11004	Clinical Psychology, Differential Psychology and Diagnostics			
11101	Sociological Theory	111 Social Sciences		
11102	Empirical Social Research			
11103	Communication Science			
11104	Political Science			
11201	Economic Theory	112 Economics		
11202	Economic and Social Policy			
11203	Finance			
11204	Business Administration			
11205	Statistics and Econometrics			
11206	Economic and Social History			
11301	Legal and Political Philosophy, Legal History, Legal Theory	113 Jurisprudence		
11302	Private Law			
11303	Public Law			
11304	Criminal Law and Law of Criminal Procedure			
11305	Criminology			

Subject Area	Review Board	Research Area	Scientific Discipline
20101 Biochemistry 20102 Biophysics 20103 Cell Biology 20104 Structural Biology 20105 General Genetics 20106 Developmental Biology 20107 Bioinformatics and Theoretical Biology 20108 Anatomy	201 Foundations of Biology and Medicine	21 Biology	2 Life Sciences
20201 Systematic Botany and Evolution 20202 Plant Ecology and Ecosystem Research 20203 Allelobotany 20204 Plant Physiology 20205 Plant Biochemistry and Biophysics 20206 Plant Cell and Developmental Biology 20207 Plant Genetics	202 Plant Science	21 Biology	2 Life Sciences
20301 Special Zoology, Morphology 20302 Evolution, Biodiversity, Physical Anthropology 20303 Comparative Biochemistry, Animal Physiology and Ecophysiology 20304 Sensory and Behavioural Biology 20305 Animal Ecology and Ecosystem Research 20306 Animal Genetics, Cell and Developmental Biology	203 Zoology	21 Biology	2 Life Sciences
20401 Metabolism, Biochemistry and Genetics of Microorganisms 20402 Microbial Ecology and Applied Microbiology 20403 Medical Microbiology, Molecular Infection Biology 20404 Virology 20405 Immunology	204 Microbiology, Virology and Immunology	22 Medicine	2 Life Sciences
20501 Medical Biometry, Epidemiology, Medical Informatics 20502 Occupational and Social Medicine 20503 Human Genetics 20504 Physiology 20505 Nutritional Sciences 20506 Pathology and Forensic Medicine 20507 Clinical Chemistry and Pathobiochemistry 20508 Pharmacy 20509 Pharmacology and Toxicology 20510 Anaesthesiology 20511 Internal Medicine - Cardiology 20512 Internal Medicine - Angiology 20513 Internal Medicine - Pneumology 20514 Internal Medicine - Hematology, Oncology, Transfusion Medicine 20515 Internal Medicine - Gastroenterology, Metabolism 20516 Internal Medicine - Nephrology 20517 Internal Medicine - Endocrinology, Diabetology 20518 Internal Medicine - Rheumatology 20519 Pediatrics 20520 Gynaecology and Obstetrics 20521 Dermatology 20522 Urology 20523 Vascular and Visceral Surgery 20524 Cardiothoracic Surgery 20525 Orthopaedics, Traumatology 20526 Dentistry, Oral Surgery 20527 Radiology, Nuclear Medicine, Radiotherapy 20528 Biomedical Technology and Medical Physics	205 Medicine	22 Medicine	2 Life Sciences
20601 Molecular Neuroscience and Neurogenetics 20602 Cellular Neuroscience 20603 Developmental Neurobiology 20604 Systemic Neuroscience and Behaviour 20605 Comparative Neurobiology 20606 Cognitive Neuroscience and Neuroimaging 20607 Molecular Neurology 20608 Clin Neurosciences I - Neurology, Neurosurgery 20609 Biological Psychiatry 20610 Clin Neurosciences II - Psychiatry, Psychotherapy 20611 Clin Neurosciences III - Ophthalmology 20612 Clin Neurosciences IV - Otolaryngology	206 Neurosciences	22 Medicine	2 Life Sciences
20701 Soil Sciences 20702 Plant Cultivation 20703 Plant Nutrition 20704 Ecology of Agricultural Landscapes 20705 Plant Breeding 20706 Phytomedicine 20707 Agricultural and Food Process Engineering 20708 Agricultural Economics and Sociology 20709 Inventory Control and Use of Forest Resources 20710 Basic Forest Research 20711 Animal Breeding, Maintenance and Hygiene 20712 Animal Nutrition and Nutrition Physiology 20713 Foundations of Veterinary Medicine 20714 Foundations of Pathogenesis, Diagnostics, Therapy 20715 Clinical Veterinary Medicine	207 Agriculture, Forestry, Horticulture and Veterinary Medicine	23 Agriculture, Forestry, Horticulture and Veterinary Medicine	2 Life Sciences

Subject Area	Review Board	Research Area	Scientific Discipline
30101 Inorganic Molecular Chemistry 30102 Organic Molecular Chemistry	301 Molecular Chemistry	31 Chemistry	3 Natural Sciences
30201 Solid State and Surface Chemistry, Material Synthesis 30202 Physical Chemistry of Solids and Surfaces 30203 Theory and Modelling	302 Chemical Solid State Research		
30301 Physical Chemistry of Molecules and Liquids 30302 General Theoretical Chemistry	303 Physical and Theoretical Chemistry		
30401 Analytical Chemistry, Method Development (Chemistry)	304 Analytical Chemistry, Method Development (Chemistry)		
30501 Biological and Biomimetic Chemistry 30502 Food Chemistry	305 Biological Chemistry and Food Chemistry		
30601 Polymer Chemistry 30602 Polymer Physics 30603 Polymer Materials	306 Polymer Research		
30701 Experimental Condensed Matter Physics 30702 Theoretical Condensed Matter Physics	307 Condensed Matter Physics	32 Physics	
30801 Optics, Quantum Optics, Atoms, Molecules, Plasmas	308 Optics, Quantum Optics and Physics of Atoms, Molecules and Plasmas		
30901 Particles, Nuclei and Fields	309 Particles, Nuclei and Fields		
31001 Statistical Physics and Nonlinear Dynamics	310 Statistical Physics and Nonlinear Dynamics		
31101 Astrophysics and Astronomy	311 Astrophysics and Astronomy		
31201 Mathematics	312 Mathematics	33 Mathematics	
31301 Atmospheric Science 31302 Oceanography	313 Atmospheric Science and Oceanography	34 Geosciences (including Geography)	
31401 Geology and Paleontology	314 Geology and Palaeontology		
31501 Geophysics, Geodesy, Remote Sensing, Geoinformatics	315 Geophysics and Geodesy		
31601 Geochemistry, Mineralogy and Crystallography	316 Geochemistry, Mineralogy and Crystallography		
31701 Physical Geography 31702 Human Geography	317 Geography		
31801 Water Research	318 Water Research		

Subject Area		Review Board	Research Area	Scientific Discipline
40101	Metal-Cutting Manufacturing Engineering	401 Production Technology	41 Mechanical and Industrial Engineering	4 Engineering Sciences
40102	Primary Shaping and Reshaping Technology			
40103	Micro-, Precision, Mounting, Joining, Sep Techn			
40104	Plastics Engineering			
40105	Prod Automation, Factory Operation, Operations Mgt			
40201	Construction, Machine Elements	402 Mechanics and Constructive Mechanical Engineering		
40202	Mechanics			
40203	Lightweight Construction, Textile Technology			
40204	Acoustics			
40301	Chemical and Thermal Process Engineering	403 Process Engineering, Technical Chemistry	42 Thermal Engineering/ Process Engineering	
40302	Technical Chemistry			
40303	Mechanical Process Engineering			
40304	Biological Process Engineering			
40401	Energy Process Engineering	404 Heat Energy Technology, Thermal Machines and Drives		
40402	Technical Thermodynamics			
40403	Fluid Mechanics			
40404	Hydraulic and Turbo Engines and Piston Engines			
40501	Structural and Functional Materials	405 Materials Engineering	43 Materials Science and Engineering	
40502	Sintered and Composite Materials			
40503	Surfaces, Coatings and Functional Layers			
40601	Raw Materials, Recycling, Mining and Metallurgy	406 Materials Science, Raw Materials		
40602	Metallic, Ceramic and Polymer Materials			
40603	Metallurgy, Thermodyn of Multiphase Metallic Sys			
40604	Biomaterials			
40701	Automation Technology, Control Systems and Robotics	407 System Engineering	44 Computer Science, Electrical and System Engineering	
40702	Measuring Systems			
40703	Microsystems			
40704	Traffic and Transport Systems, Logistics			
40705	Ergonomics, Human-Machine Systems			
40801	Electronic Semiconductors, Components, Circuits, Systems	408 Electrical Engineering		
40802	Communication and High-Frequency Technology			
40803	Electrical Energy Prod, Distribution, Application			
40901	Theoretical Computer Science	409 Computer Science		
40902	Software Technology			
40903	Operating, Communication and Information Systems			
40904	Artificial Intelligence, Image and Language Processing			
40905	Computer Architecture and Embedded Systems			
41001	Architecture, Construction Research and History	410 Construction Engineering and Architecture	45 Construction Engineering and Architecture	
41002	City, Regional, Traffic and Landscape Planning			
41003	Construction Material Sciences, Chemistry, Physics			
41004	Construction Engineering, Operation, Virtual Design			
41005	Continuum Mechanics, Statics and Dynamics			
41006	Geotechnics, Hydraulic Engineering			

D) Descriptive Survey Statistics

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
v1a_researcher	123	2.73	.544	1	3	3.00	3.00	3.00
v1b_teacher	123	1.75	1.029	0	3	1.00	2.00	3.00
v1c_coach	123	1.19	1.027	0	3	.00	1.00	2.00
v1d_programmer	123	1.16	1.148	0	3	.00	1.00	2.00
v1e_policymaker	123	.80	.911	0	3	.00	1.00	2.00
v1f_ictworker	123	.73	.860	0	3	.00	1.00	1.00
v2a_cscl	123	2.28	.835	0	3	2.00	2.00	3.00
v2b_forminform	123	1.84	1.019	0	3	1.00	2.00	3.00
v2c_context	123	1.85	1.030	0	3	1.00	2.00	3.00
v2d_emotiv	123	1.56	1.001	0	3	1.00	2.00	2.00
v2e_form	123	2.03	1.016	0	3	1.00	2.00	3.00
v2f_inform	123	1.53	1.027	0	3	1.00	2.00	2.00
v2g_interop	123	1.32	1.119	0	3	.00	1.00	2.00
v2h_person	123	1.56	1.017	0	3	1.00	2.00	2.00
v2i_divide	123	.77	.922	0	3	.00	1.00	1.00
v2j_mobile	123	1.02	.958	0	3	.00	1.00	2.00
v2k_workplace	123	1.15	.997	0	3	.00	1.00	2.00
v4a_intstudy1	123	2.56	1.313	0	4	1.00	3.00	4.00
v4b_intstudy2	123	1.89	1.483	0	4	1.00	1.00	3.00
v4c_intstudy3	123	1.99	1.358	0	4	1.00	2.00	3.00
v4d_intstudy4	123	1.61	1.452	0	4	.00	1.00	3.00
v5a_intwork1	123	2.88	1.245	0	4	3.00	3.00	4.00
v5b_intwork2	123	3.29	.733	0	4	3.00	3.00	4.00
v5c_intworkpubl	123	2.45	1.132	0	4	1.00	3.00	3.00
v5d_intwork3	123	3.03	.923	0	4	3.00	3.00	4.00
v5e_intwork4	123	2.98	1.097	0	4	3.00	3.00	4.00
v6a_identmulti	123	.15	.355	0	1	.00	.00	.00
v6b_identsocial	123	.54	.500	0	1	.00	1.00	1.00
v6c_identcomp	123	.28	.449	0	1	.00	.00	1.00
v6d_identnatur	123	.02	.155	0	1	.00	.00	.00
v6e_identlife	123	.01	.090	0	1	.00	.00	.00
v7a_intstate1	123	3.48	.717	0	4	3.00	4.00	4.00
v7b_intstate2	123	2.14	1.203	0	4	1.00	2.00	3.00

v7c_intstate3	123	2.42	1.235	0	4	1.00	3.00	3.00
v7d_intstate4	123	3.02	.923	1	4	3.00	3.00	4.00
v7e_intstate5	123	3.42	.701	1	4	3.00	4.00	4.00
v8a1_termintersoc	123	.41	.495	0	1	.00	.00	1.00
v8a2_termintertech	123	.13	.338	0	1	.00	.00	.00
v8a3_termintersys	123	.38	.488	0	1	.00	.00	1.00
v8b1_termevalusoc	123	.24	.431	0	1	.00	.00	.00
v8b2_termevalutech	123	.11	.309	0	1	.00	.00	.00
v8b3_termevalusys	123	.61	.490	0	1	.00	1.00	1.00
v8c1_termscenasoc	123	.32	.467	0	1	.00	.00	1.00
v8c2_termscenatech	123	.10	.298	0	1	.00	.00	.00
v8c3_termscenasys	123	.50	.502	0	1	.00	1.00	1.00
v9a_methcomptheo	123	.69	.933	0	3	.00	.00	1.00
v9b_methcompmodel	123	1.15	1.017	0	3	.00	1.00	2.00
v9c_methcompexperi	123	1.02	1.059	0	3	.00	1.00	2.00
v9d_methodteldbr	123	1.84	1.082	0	3	1.00	2.00	3.00
v9e_methodtelucd	123	1.93	1.038	0	3	1.00	2.00	3.00
v9f_methodtelste	123	1.13	1.056	0	3	.00	1.00	2.00
v9g_methodsocquan	123	1.99	.910	0	3	1.00	2.00	3.00
v9h_methodsocqual	123	2.26	.867	0	3	2.00	2.00	3.00
v9i_methodsocethn	123	1.07	1.143	0	3	.00	1.00	2.00
v10a_theocomptheo	123	.47	.813	0	3	.00	.00	1.00
v10b_theocomprepre	123	.54	.889	0	3	.00	.00	1.00
v10c_theocompartint	123	.85	1.017	0	3	.00	.00	2.00
v10d_theorytelcop	123	1.93	.998	0	3	1.00	2.00	3.00
v10e_theorytelant	123	.89	1.026	0	3	.00	1.00	2.00
v10f_theorytelcon	123	1.55	1.236	0	3	.00	2.00	3.00
v10g_theorylearncon	123	2.25	1.013	0	3	2.00	3.00	3.00
v10h_theorylearncog	123	1.53	1.066	0	3	1.00	2.00	2.00
v10i_theolearnbehav	123	.90	.970	0	3	.00	1.00	2.00
v11a_audown	123	.91	.287	0	1	1.00	1.00	1.00
v11b_audoth	123	.45	.499	0	1	.00	.00	1.00
v11c_audapp	123	.38	.488	0	1	.00	.00	1.00
v11d_audnon	123	.29	.457	0	1	.00	.00	1.00
v12_audinternat	123	2.95	1.070	0	4	3.00	3.00	4.00
v13a_pubconvjou	123	.76	.747	0	3	.00	1.00	1.00
v13b_pubconvprocee	123	1.32	.952	0	4	1.00	1.00	2.00
v13c_pubconvbook	123	.54	.591	0	2	.00	.00	1.00
v13d_pubconvmono	123	.02	.155	0	1	.00	.00	.00
v14a_pubopenjou	123	.53	.669	0	3	.00	.00	1.00

v14b_pubopenprocee	123	.89	.781	0	4	.00	1.00	1.00
v14c_pubopenbook	123	.19	.412	0	2	.00	.00	.00
v14d_pubopenmono	123	.07	.332	0	3	.00	.00	.00
v13_14new_journal	123	1.2927	1.20608	.00	4.00	.0000	1.0000	2.0000
v13_14new_proceed	123	2.2033	1.45399	.00	8.00	1.0000	2.0000	3.0000
v15_workplaceuniv	123	.84	.371	0	1	1.00	1.00	1.00
v16a_posprof	123	.16	.371	0	1	.00	.00	.00
v16b_poslect	123	.23	.421	0	1	.00	.00	.00
v16c_posasso	123	.23	.421	0	1	.00	.00	.00
v16d_posassi	123	.21	.410	0	1	.00	.00	.00
v16e_posstud	123	.18	.385	0	1	.00	.00	.00
v16f_posschola	123	.05	.216	0	1	.00	.00	.00
v17a_disccollsoc	123	.41	.495	0	1	.00	.00	1.00
v17b_disccollcomp	123	.31	.464	0	1	.00	.00	1.00
v17c_disccollmulti	123	.25	.436	0	1	.00	.00	1.00
v17d_disccollnatur	123	.01	.090	0	1	.00	.00	.00
v17e_disccolllife	123	.01	.090	0	1	.00	.00	.00
v18_location	123	118.64	58.059	10	186	64.00	131.00	169.00
v19_agegroup	120	1.35	1.171	0	4	.00	1.00	2.00
v19new_agegroup_binary	120	.72	.453	0	1	.00	1.00	1.00
v21_gender	123	.512	.4937	.0	1.0	.000	.500	1.000
v22new_project_binary	123	.56	.498	0	1	.00	1.00	1.00
v23new1_degree_binary	123	.69	.464	0	1	.00	1.00	1.00
v23new2_degree_ordinal	123	1.34	1.172	0	4	.00	1.00	2.00
v23new3_degree_scale	123	11.11	18.950	0	138	.00	4.00	12.00
v24new_stellar	123	.17	.378	0	1	.00	.00	.00
v3new_SB	123	2.13	.849	0	3	1.00	2.00	3.00

E) Selected Hypothesis Test Statistics*

Kruskal-Wallis *H* Test:
IV: Study Background (V3), DV: TEL Activities (V1)

Ranks

v1b_teacher	Multidisciplinary Study Background (MSB)	31	56.53
	Computer Science Study Background (CSB)	39	64.00
	Social Science Study Background (SSB)	51	61.42
	Total	121	
v1c_coach	MSB	31	64.26
	CSB	39	48.17
	SSB	51	68.83
	Total	121	
v1d_programmer	MSB	31	59.55
	CSB	39	87.99
	SSB	51	41.25
	Total	121	
v1e_policymaker	MSB	31	66.94
	CSB	39	49.78
	SSB	51	65.97
	Total	121	

Test Statistics[a,b]

	v1a_researcher	v1b_teacher	v1c_coach	v1d_programmer	v1e_policymaker
Chi-Square	.203	.861	8.788	43.099	6.851
df	2	2	2	2	2
Asymp. Sig.	.903	.650	.012	.000	.033

* Complete test statistics are available in the digital appendix.

Mann-Whitney *U* Test:

IV: Age (V19), DV: Platform Degree of Connections (V23)

v23new2_degree_ordinal[107]	under 31	34	71.74	2439.00
	31 and above	86	56.06	4821.00
	Total	120		
v23new3_degree_scale	under 31	34	71.74	2439.00
	31 and above	86	56.06	4821.00
	Total	120		

Test Statistics[a]

	degree_ordinal	degree_scale
Mann-Whitney U	1080.000	1080.000
Wilcoxon W	4821.000	4821.000
Z	-2.302	-2.262
Asymp. Sig. (2-tailed)	.021	.024

a. Grouping Variable: v19new_agegroup_binary

Mann-Whitney *U* Test:

IV: Study Background (V3), DV: Core TEL Research Areas (V2)

	v3new_SB	N	Mean Rank	Sum of Ranks
v2a_cscl	Computer Science Study Background (CSB)	39	46.88	1828.50
	Social Science Study Back-ground (SSB)	51	44.44	2266.50
	Total	90		
v2b_forminform	CSB	39	39.45	1538.50
	SSB	51	50.13	2556.50
	Total	90		
v2c_context	CSB	39	44.74	1745.00
	SSB	51	46.08	2350.00
	Total	90		
v2d_emoti	CSB	39	38.62	1506.00
	SSB	51	50.76	2589.00

[107] Ordinal scaling: 0; 1-5; 6-20; 21-50; over 50 connections

v2e_form	CSB	39	39.81	1552.50
	SSB	51	49.85	2542.50
	Total	90		
v2f_inform	CSB	39	36.62	1428.00
	SSB	51	52.29	2667.00
	Total	90		
v2g_interop	CSB	39	54.54	2127.00
	SSB	51	38.59	1968.00
	Total	90		
v2h_person	CSB	39	50.12	1954.50
	SSB	51	41.97	2140.50
	Total	90		
v2i_divide	CSB	39	41.08	1602.00
	SSB	51	48.88	2493.00
	Total	90		
v2j_mobile	CSB	39	46.41	1810.00
	SSB	51	44.80	2285.00
	Total	90		
v2k_workplace	CSB	39	45.85	1788.00
	SSB	51	45.24	2307.00
	Total	90		

Test Statistics[a]

	v2a_cscl	v2b_forminform	v2c_context	v2d_emotiv	v2e_form
Mann-Whitney U	940.500	758.500	965.000	726.000	772.500
Wilcoxon W	2266.500	1538.500	1745.000	1506.000	1552.500
Z	-.479	-2.010	-.252	-2.275	-1.910
Asymp. Sig. (2-tailed)	.632	.044	.801	.023	.056

Test Statistics[a]

v2f_inform	v2g_interop	v2h_person	v2i_divide	v2j_mobile	v2k_workplace
648.000	642.000	814.500	822.000	959.000	981.000
1428.000	1968.000	2140.500	1602.000	2285.000	2307.000
-2.939	-2.980	-1.525	-1.509	-.305	-.115
.003	.003	.127	.131	.761	.908