ANALYSIS OF SELF-REGULATED LEARNING FROM THE PERSPECTIVE OF SELF-DIDACTIS

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E-learning, didactics, focused interview, hypertext, learning, learning environment, log file analysis, navigation, process, self-didactics, self-regulated learning, thinking-aloud, triangulation.

INTRODUCTION

As current transformations in the context of *Social Web* exemplify, navigation emerges as media-supported, communicative and participative practice. At the same time, educational cultures evolve based on cooperation in informal learning communities. As there is no teacher predefining content and acquisitional processes in these communities, the learner is on his own with regard to being motivated, staying focused, solving learning related problems and evaluating results of his learning process. In this regard, the learner can be conceptualized as a *self-didactic learner* (see Iske & Meder, 2011) who is organizing and regulating his learning processes on his own, but in cooperation with others and in interaction with specific environments.

The concept of *self-didactics* is related to the concept of *self-regulated learning* and located within the discourse on *lifelong education* (Lengrand, 1972), *lifelong learning* (Delors, 1998), *informal learning* (Watkins & Marsick, 1990) and *self-directed learning* (Dohmen, 1998). Like in these discourses, the perspective of *self-didactics* implies a shift to increasing freedom of learners and changing demands on learning (and on teaching). In educational and psychological contexts, for instance, this transformation is described and discussed as a transition from teaching to learning; from teacher-oriented to learner-oriented instruction; from externally-directed to self-directed learning; from school-based to lifelong learning; from reactive to active learning; from the didactic triangle to learning arrangements (topology) and from formal to informal learning.

In a broad sense, the term “self-didactic learning” refers to different degrees of freedom concerning learning (Fig. 1). Key points are decisions on goals (for what?), content (what?), learning path (how?), evaluation (how successful?), forms of cooperation (with whom?), forms of support (which resources?), time (when? how long?) and place (where?).

These transitions have in common that the learner and the process of learning becomes the focus of teaching and learning efforts. For learners, this implies an increased level of activity and responsibility. During the last decades these transformations were subject of fierce debates – especially their relation to transformations within the field of Information and Communication Technology (ICT). In Germany, for instance, a federal initiative "Connecting Schools to the Net" (*Schulen ans Netz*) was established in 1996 in order to provide public schools with computer hardware and Internet access. While the initiative tries to improve media literacy, it also explicitly aims at the advancement of the school as an institution for learning and at the advancement of an academic learning culture. Currently, the potential and the implications of ICT are discussed as the potential of *New Media* and *Social Web* for fostering self-regulated learning.

regulated learning can be interpreted as the relation of control / guidance and giving space (Litt, 1965).

Based on the results of a European research project, Steffens (2008, p. 221) argued that there is some evidence that complex Technology Enhanced Learning Environments (TELEs) have a potential to foster self-regulated learning, but that there is only little empirical research on the question whether and to which extent this potential is actually perceived and realised.

In the following paragraphs, I will focus on this open question by presenting an approach to analyse *processes* of self-regulated learning from the perspective of self-didactics and by presenting empirical results of its application: (1) By outlining the *concept of self-didactics*, the theoretical background of this approach will be discribed; (2) then, *methodological aspects* of this approach and the

Fig. 1: From externally-regulated learning to self-regulated learning

To acquire strategies for self-didactic learning is a challenging and complex task. We cannot expect that every learner already is endowed with this competence, it needs to be developed and nourished. Concerning learning situations and processes, externally-regulated and self-regulated learning constitute the end points of a continuum of hybrid forms of learning, they may be considered as ideal types in the sense of Max Weber. From an educational pespective, the relation of externally- and self-

analysed dataset will be characterised; (3) main *empirical results* of an empirical analysis of learning processes (self-didactics) within a hypertextual learning environment will be outlined, focusing on reflexivity and acquisition of content as well as structure. (4) Finally, an *outlook* will be presented.

THEORETICAL BACKGROUND: SELF-DIDACTICS

In this paragraph, I will focus on processes of self-

regulated learning from an explicit educational perspective. Taking into account the above mentioned transformations from teaching to learning, navigation in hypertextual environments is conceptualized from a learners perspective as *self-didactics* (see Meder, 1997). Characterised by the absence of a teacher (who is animating, guiding and controlling, supporting and evaluating learning processes), a self-didactic learner is in charge of being involved in a topic, staying focused, facing learning related problems and barriers and integrating results of these processes into experience (see Iske & Meder, 2011).

From the perspective of self-didactics, navigational *processes* in online environments can be interpreted as the linear unfolding of a non-linear environment. In discussions of learning with ICT, its potential is often globally attributed to spatial and temporal aspects ("anywhere" and "anytime"), whereas the characteristic of navigating as the temporal process of this *unfolding* is usually neglected.

The term *didactics* refers to a long-standing pedagogical tradition of teaching and, to questions of *content* (what to teach) as well as questions of *structure* (how to teach) and emphasises *temporal processes* of teaching and learning (for instance as a "scheme of articulation", see Herbart, 1806; or "articulation as the main business of didactic communication, see Prange, 1995). In the following paragraphs, I will focus on the temporal process of navigating online environments, describing it as the *succession* of web pages, which are selected by a learner and which constitute a navigational path or sequence. Furthermore, reflections of learners on their specific selections will be focused.

The underlying conceptualization of *didactics*[1] refers to the work of Richard Hönigswald (1927) who defines it from a systematic-philosophical perspective as the *transformation of meaning into time* (Fig. 2): meaning is understood in a multi-relational, non-linear way and does not posses any specific temporal structure in itself. But for the purpose of teaching,

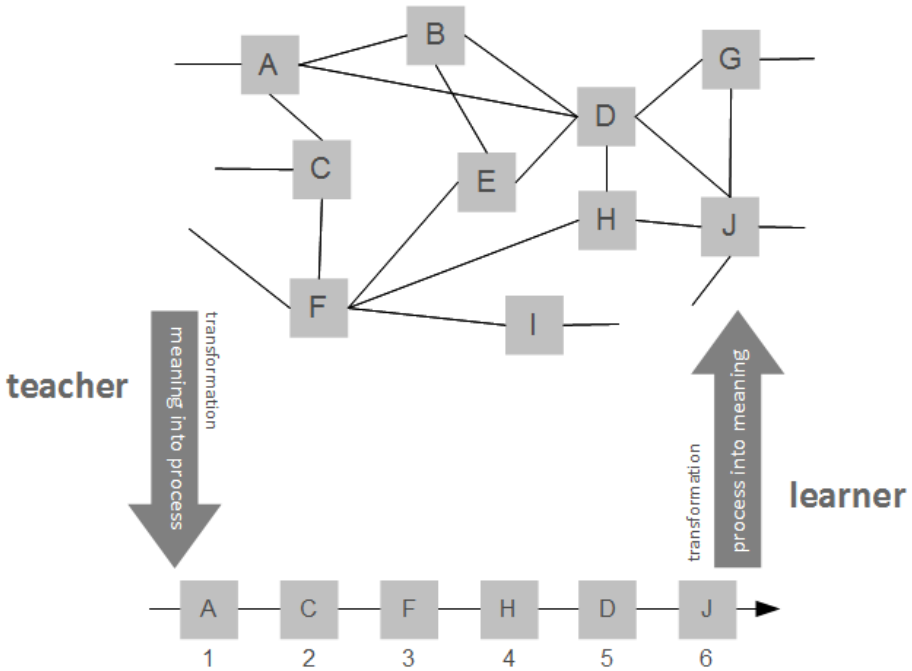

Fig. 2: Didactics

[1] In this article the term *didactic* is used without any connotation of disapproving or any connotation of teaching a moral (see „didactic", Cambridge Advanced Learner's Dictionary (2008), <http://dictionary.cambridge.org/dictionary/british/didactic>).

meaning is in need to be transformed into a temporal structure, into the process of teaching and learning, into the temporal structure of acting in general. Obviously, this transformation is in need of a medium: meaning is transformed *into time and space,* into the *process* of teaching and learning by means of a specific medium (this is the fundamental reference points of media education and instructional media).

Traditionally, this modularisation is a fundamental educational task and refers to the question of how learning should take place (in what time period, what content, with what tasks and in what social form).

This concrete succession within the lesson is always structured temporally i.e. linear. It aims at the most

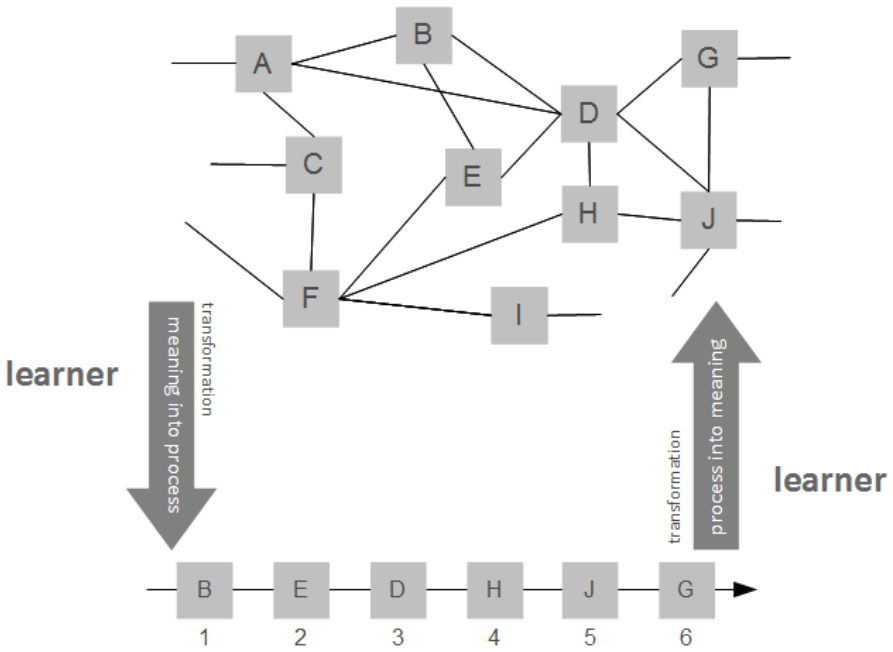

Fig. 3 Self-Didactics

This understanding of *didactics* - as the process of transforming meaning into time - can be illustrated by the *scheduling of a lesson* (left side of Fig. 2)*:* First a teacher acts *issue-oriented* and conducts an analysis of the specific topic (i.e. meaning), its structure and its relations. The result of this analysis is symbolised at the top of Fig. 2 as a semantic network consisting of concepts (nodes) and its relations (links). Second in a following *process analysis* the teacher creates a precise lesson plan as a sequence of teaching activities: How to start, what to do then, how to go on... how to end. In doing so, he decides on content (didactical reduction), on media type and on social form. As a result, at the bottom of Fig. 2, this teaching process is symbolised as a temporal succession of concepts (nodes) as content of a lesson.

adequate and suitable succession as a way of teaching a subject-matter to a group of learners. In short, the focus of *didactics* as a theory of action is on the transformation of spatial figures into temporal figures.

So far, within the concept of didactics, *teaching* and decisions of a teacher are focused (left side of Fig. 2): Complementary, *learning* corresponds to the transformation of a linear teaching process („a lesson“) into non-linear mental model („knowledge“) of a specific subject-matter (right side of Fig. 3).

Adapting the approach of Hönigswald, the process opposite to that of *didactics* can be conceptualized as *self-didactics* (Fig. 3): Whereas the term *didactics* stresses the teacher perspective and the process of teaching, the term *self-didactics* stresses the

perspective of a learner and the process of learning *without* processes of teaching. Concerning navigation in online environments, *self-didactics* implies that a learner is in charge of both transformations: (1) the transformation of *meaning into time*, and (2) the *learners* actually create spatial figures (a mental model of a topic) based on temporal figures: What kind of knowledge they create based on their navigational path?

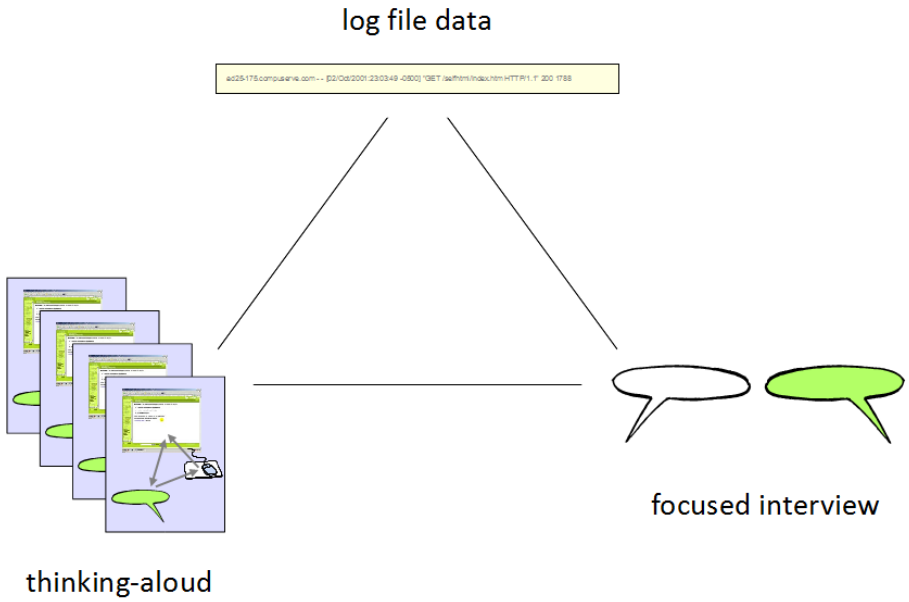

Fig. 4: Research Design: Triangulation

transformation of *time into meaning*. The learner is in charge of navigating the online environment. By this, he makes decisions which are made within a *didactic* setting by a teacher (1) and at the same time he is in charge of an appropriate learning result (developing an appropriate mental model) based on his navigational path.

Therefore, specific knowledge of one's own learning processes and learning strategies is required. This process of *self-didactic* practice constitutes a challenging and complex task and varies from incidental learning to the application of sophisticated strategies. However, its execution should be supported by an appropriate arrangement of the learning environment.

From a pedagogical perspective, the crucial questions of *self-didactics* are: (1) how do *learners* actually translate spatial figures (mearning) into temporal figures (their linear learning path): Which criteria and strategies do they employ for navigation? (2) how do

In general, this approach of analyzing processes of *self-didactics* relies on the assumptions that navigation in online environments (a) is *not contingent*, but contains specific patterns, structures and regularities within the action of learners (behavioral patterns); (b) is an *index* for -implicit and explicit- strategies of learners, which reflect the learners' decisions on goals, content, path, evaluation etc. (see Fig. 1). In this respect, navigational paths reflect a specific „habitus" which according to Bourdieu (1982) can be characterised as structured structures predisposed to function as structuring structures. Finally, it is assumed that navigation in online environments (c) refers to the *context* of a specific online environment and therefore expresses a specific relation between the structure of the online environment on the one hand and empirical navigational paths on the other hand.

METHODOLOGY AND DATASET

As the analysis of *self-didactic learning* is a complex

and challenging task, the following approach aims at analysing *self-didactics* in online environments based on triangulation of the following methods and data (Fig. 4): (1) Log file data analysis, (2) thinking-aloud protocols and (3) retrospective focused interviews.

From a methodological perspective, central analytical questions are: How can the processes of *self-didactic* practice appropriately be analysed? How do learners empirically realise the potential of increased degrees of freedom? Based on which processes do they acquire knowledge? Which criteria and strategies do learners employ to regulate their learning processes?

The data analysed in this article originate from a research project where navigational paths within an online learning environment were analysed (Iske, 2007). The learning environment was structured according to the didactical ontology of *Web Didactics* (Meder, 2006); i.e. content as well as links were classified by didactical meta-data. A subject matter (e.g. descriptive statistics) is de-contextualised in *learning units* (e.g. "measures of central tendencies", "mode", "median" or "arithmetic mean"). These learning units are re-contextualised by links to form a semantic network. In general, a learning unit is a container for *knowledge units*, which characterise the learning unit among others by means of different *knowledge types*. For instance, the learning unit "median" contains the following knowledge types:

- *orientation knowledge*, which provides, for example, an overview or a summary in order to help learners to find their way around a subject ('know that');
- *exlanation knowledge*, which provides learners with arguments to explain why something is the way it is ('know that'),
- *action knowledge* helps learners to appropriate subject-specific practices, methods, techniques or strategies ('know how')
- and *source knowledge*, which shows learners where they can find additional or more detailed information on a specific subject ('know where').

Following the concept of Web-Didactics, each page of the learning environment is build to contain exactly one type of knowledge. This is important for further analysis as it becomes traceable and interpretable, which type of knowledge users selected while navigating the online environment. Based on these didactical meta-data, for instance, strategies can be deduced from the succession of selected knowledge types (web pages).

LOG FILE ANALYSIS

On the one hand, server-based log file data documenting the usage of the online learning environment were analysed. Users accessed the learning environment over the Internet, so this data represent actions of users in authentic situations. From this perspective, log file data represent a specific form of transcription of the user – online environment interaction. For this reason, log file data collection can be characterised as *unobtrusive, detailed, objective* and *non-reactive* (see Web, Campbell, Schwartz, Sechrest, 1966). In contrast to forms of retrospective data collection (i.e. interview, questionnaire) it is characterised as *process-generated* data (see Bergmann & Meier, 2000).

The overall data set consists of about 1500 navigational paths (sequences) containing about 4700 elements (web pages) and is based on data of how the hypertext online learning environment was used over the period of about one year (06/2005 – 06/2006).

Two different approaches were used to analyse this log file data set. First, log file data were aggregated and analysed by quantitative descriptive statistics: Frequencies of sequences, frequencies of elements as well as frequencies of identical sequences were calculated. Second, navigational paths where analysed heuristically in order to identify patterns, structures and regularities within paths as well as in order to identify similar paths. Furthermore, navigational pahts were analysed confirmatively in order to compare identified empirical patterns and regularities to known theoretical patterns (i.e. „explanation-oriented" or „task-oriented" strategies). This approach of analysing navigational paths is based on the quantitative approach to sequence analysis called Optimal-Matching (Abbott & Forrest, 1986) with subsequent cluster analysis.[2]

CONCURRENT THINKING-ALOUD INTERVIEWS

[2] The application of sequence analysis by means of Optimal-Matching in the field of e-learning is described in more detail in Iske (2007, 2008).

On the other hand, data on the process of navigating in online environments were collected using the method of thinking-aloud. In reference to the framework of Ericsson and Simon (1984, "Protocol Analysis: Verbal Protocols as Data"), "thinking-aloud" is conceptualized as verbalizing one's own thoughts while carrying out a task: The learner is focusing on a specific task (primary task) and is asked to verbalise his actual thoughts (secondary task). In this article, we will not go into the controversial discussion of thinking-aloud protocols (e.g. effect-of-verbalisation; incompleteness-argument; epiphenomenality or irrelevance argument, see Ericsson & Simon, 1984, 61).

Using thinking-aloud interviews within the field of e-Learning basically aims at coming as close as possible to the actual processes of navigation. In contrast to retrospective forms of data collection, these verbalisation are related to actual behaviour within the learning environment: the interviewee was coping with a task and thinking-aloud while navigating in an online-learning environment (concurrency of verbalising and acting). In doing so, his verbalisation as well as his interaction with the learning environment were documented by screen-recording software for further analysis.

But in contrast to the framework of Ericsson and Simon (1984), these recordings were analysed in terms of structure as well as content in order to identify the subjective relevance and the strategies of the learners (in addition to the formal analysis of navigational process by means of sequenced log file analysis).

Overall, nineteen thinking-aloud interviews were conducted with students of the natural sciences and the humanities which were based on the prior instruction to think-aloud (in order to avoid social communication) and related to a specific task within the field of descriptive statistics.

> Example: "Please imagine the following situation: you are attending a seminar at your university. You are given a statistical data set which you are to analyse with regard to measures of central tendencies. As you do not know how to accomplish this analysis, you are navigating in this online environment in order learn about (a) which measures of central tendencies exist and (b) how they are calculated."

In addition, log file data resulting from these thinking-aloud interviews became part of the overall log file data set. The triangulation of data and methods as described above allowed us to compare navigational sequences resulting from thinking-aloud interviews with navigational sequences performed via the Internet. We were therefore able to estimate the influence of thinking-aloud on the sequence of coping with the task.

RETROSPECTIVE FOCUSED INTERVIEWS

In addition to formal and process-focused analysis, retrospective focused interviews (Merton & Kendall, 1979) were conducted with our nineteen interviewees after their thinking-aloud protocols had been taken.

The main focus of the interview was put on the navigational sequence and the navigational strategies employed while carrying out the preceding task. In contrast to the thinking-aloud interviews, these focused interviews aimed at the retrospective and meta-cognitive interpretation and evaluation of the task-oriented navigational process (e.g. first impression of the online environment; its relevance for learning; positive and negative aspects of the online environment; most helpful node to accomplish the task; evaluation of the navigational process; evaluation of the employed strategies; influence of thinking-aloud on navigation). In addition, sociodemographic data of the interviewees were collected.

RESULTS

In this paragraph, the main results of the triangulation of log file data, thinking-aloud data and retrospective focused interviews will be outlined.

The most important conclusion from the analysis is the *diversity and plurality* of the navigational paths taken by the learners: There is no single 'golden' navigational path. Quite to the contrary, sequenced log file data revealed that there are hardly any identical sequences concerning micro-navigation (navigation *within a learning unit* like "measures of central tendencies", "mode", "median" or "arithmetic mean") containing more than five elements as length of sequence. This plurality and diversity holds especially true for macro-navigation as navigation

between learning units (as navigation *between learning units* like “measures of central tendencies”, “mode”, “median” or “arithmetic mean”).

Furthermore, this diversity and plurality can be interpreted as a *quality indicator* of the analysed learning environment: From a conceptional and pragmatic point of view, the analysed environment provides a multiplicity of different navigational sequences and therefore provides *self-didactic plurality*. These various possibilities to navigate in the learning environment and to employ different navigational strategies were judged in the focused interviews to represent a specific potential of the analysed online environment and to be beneficial for learning.

There were, however, *groups of similar sequences* based on the typical succession of pages (knowledge types) within the navigational path (corresponding to sequence analysis by means of optimal-matching). In accordance with this overall diversity and plurality, the empirical data based on the formal analysis of sequenced log files as well as on thinking-aloud verbalization and on retrospective focused interviews revealed a *multitude of navigational strategies*. As a result specific *navigational strategies* were identified, which can be differentiated at a general level as *linear strategies* depending on the layout and the navigation bars of the online environment and *non-linear strategies* of direct and selective navigation like “examination” and “exploration”. Based on the data from focused interviews, *explanation-oriented* strategies as a form of direct and selective strategies can be characterised as follows: A user picks a module representing a specific kind of knowledge (in this case the knowledge type “explanation”) and skips all the others. Comparable to using a lexicon, this procedure is characterised as “looking-up”. In a similar way, *test-oriented* strategies can be characterised as follows: A user tries to find out if he can pass a test on a specific subject-matter. In case he can not pass it, he will further navigate in corresponding modules to get the needed information. In addition, it should be stated that there are various navigational sequences which can not be related to plausible strategies.[3] This is especially true for very long and complex sequences.

As a specific aspect of this diversity and plurality, log file analysis, thinking-aloud protocols and focused interviews exposed a *high interpersonal variance* of navigational strategies. Users employed various strategies depending on factors like previous knowledge, topic, intention and situation: they choose between different strategies, reflect and evaluate their use and change strategy if necessary.

Particularly the *layout-oriented* strategy is a good example of what we found in the analysis of self-didactic learning: users navigated following the interface design of the online environment (e.g. navigation bar from *left to right* or *top-down*). From the analysis of thinking-aloud protocols and focused interviews we can see that this strategy was often employed in order to get acquainted with the structure of the online environment. Based on the analysis of transformations within this strategy, it is possible to differentiate between two processes of acquisition and to analyse their transition: the acquisition of the meta-cognitive representation of the online environment and the acquisition of content. For example, while getting acquainted with the structure of the learning environment, users often make use of browser-integrated navigational functionality (back / forward; history). After getting acquainted, users increasingly employ learning environment integrated functionality for navigation, as restrospective interviews reveals in accordance to thinking-aloud protocols and log file analysis.

Furthermore, navigational strategies were analysed with respect to *faculty cultures* (humanities and natural sciences). Based on the analysis of sequenced log file data, thinking-aloud protocols and focused interviews it can be stated that learners’ understanding depends on different pages (e.g. different knowledge types) of the online environment. In the area of descriptive statistics, students of the natural sciences (mathematics) perceive understanding as being first and foremost related to the knowledge type of „formula“: As mentioned in the focused interviews, the formula is „all you need to know". To paraphrase a student: “I do not need any further information, I can deduce everything important from the formula”. In contrast, for students of the humanities (educational sciences), understanding is not at all related to the knowledge type of „formula“. As mentioned in focused interviews, a formula is regarded as something like an abstract painting. With these students, understanding is foremost related to

[3] As these complex and long sequences originate from log file analysis, there is no complementary data from thinking-aloud or focused interview to further analyse these processes.

the knowledge type "example", which illustrates the important characteristics of the corresponding topic. But although understanding is related to different knowledge types and to different strategies of navigation, the result in both cases is quite similar: Most students of the thinking-aloud interviews solved the task correctly, but based on different periods of time and on different navigational strategies.

Although, in the first instance, the described analysis did not aim at evaluating the employed methodological approach, empirical data reveal insight into the relation of log file analysis and thinking-aloud protocols. In the context of thinking-aloud protocols, it is often argued that the concurrency of coping with a task and verbalising influences the subsequent sequence of navigation (see above, *effect-of-verbalisation*). and correspondingly the scientific interpretability of thinking-aloud data in general. However, concerning the analysed data set and based on sequenced log file analysis, it can be stated that the navigational sequences resulting from thinking-aloud does not differ recognisable from navigational sequence resulting from access over the Internet: Within 28 empirically identified strategies based on cluster analysis, there are no clusters which exclusively contain navigational sequences of the thinking-aloud condition. In contrast, a corresponding preliminary study revealed a serious influence of concurrent acting and verbalising on subsequent navigational paths in case of a modified procedure of „thinking-aloud": while navigating, the learner was asked for explanatory statements of his navigational decisions. As cluster analysis shows, these navigational sequence differ in evidence from navigational sequences resulting from access over the Internet and do not correspond to the above mentioned empirically identified strategies. These methodological aspect will be subject of future research.

In addition, it should be emphasized that the approach presented here enables us to perform a detailed content-related analysis of the respective online environment, for instance with respect to learning barriers like lack of understanding or ambiguity of information. In this respect, the approach of thinking-aloud yielded specific insights (especially in case two interviewees are carrying out the task cooperatively).

CONCLUCSIONS AND OUTLOOK

The described methodological approach of triangulation is highly efficient in analysing self-regulated learning in online environments from the perspective of self-didactics. First of all, self-didactic practice can be analysed by taking into account the fundamental temporality of navigation. Consequently, hypotheses about navigational strategies and their effects can be made objectives of empirical educational research (for instance of research in cultural dependent navigation, processes of informal learning, cognitive load, or serendipity).

Moreover, the currently dominant focus on results of e-learning can be put into perspective. Focusing on the outcome of navigational processes is unsatisfactory from a pedagogical point of view because processes of learning and training are a fundamental topic of pedagogy. Knowledge about these processes allows for a multitude of pedagogical practices and interventions, i.e. the pedagogical design of an online learning environment and the support of learners. In general, hypertext environments represent a space of possibilities. But it is extremely difficult to infer empirical practice from structure alone: a space of possibilities is neither a perceived nor a realised space. It remains an empirical question how (specific) learners interact with the structure and content of (specific) learning environments and how this interaction can be characterised (for instance as self-regulated learning).

The methodological approach presented here is an effective extension to a structural analysis of online environments with respect to its potential to foster self-regulated learning because it allows for analysing navigational processes as indicators of underlying navigational strategies. In doing so, it makes a substantial contribution to the analysis and understanding of self-regulated navigation in hypertext online environments.

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