An e-learning approach to informed problem solving

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Abstract: When taking into account individualized learning processes not only content and interaction facilities need to be re-considered, but also the design of learning processes per se. Besides explicitness of learning objectives, interactive means of education need to enable intertwining content and communication elements as basic elements of active learning in a flexible way while preserving a certain structure of the learning process. *Intelligibility Catchers* are a theoretically grounded framework to enable such individualized processes. It allows learners and teachers agreeing and determining a desired learning outcome in written form. This type of e-learning contract enables students to individually explore content and participate in social interactions, while being guided by a transparent learning process structure. The developed implementation empowers learners in terms of creative problem-solving capabilities, and requires adaptation of classroom situations. The framework and its supporting semantic e-learning environment not only enables diverse learning and problem solving processes, but also supports the collaborative construction of e-learning contracts.

Keywords: e-Learning contracts; Intelligibility catchers; Progressive education; Social learning

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1. Introduction

When students become responsible for designing their individual learning processes, e-learning literacy has to be considered an umbrella term, as it requires the capability to

identify and organize information by means of information and communication technologies for learning purposes (cf. Di Sessa, 2001). As such, it comprises information and digital media literacy. Information and communication technologies are assumed to support learners of different types and teachers hereby (Tham & Werner, 2005). Learning literacy, and to be educated about learning (cf. Souto-Manning & Swick, 2006), are deceptively simple phrases as they imply an established and manageable set of (meta-cognitive) skills. If such skills are acquired it would make one knowledgeable about learning and guiding learning processes.

When the focus is on e-learning, additional skills are needed to operate instruments or tools. This skill set includes creating, finding, selecting, filtering, marking, managing, and transferring information for online reading, documenting, and communicating with peers online, along with those skills needed to navigate network spaces. A minimal skill set may need to include additional functions and competence depending on the discipline or subject content (cf. Clark & Mayer, 2011). For instance, learning literacy for math students who deal primarily with text or formulas would be different than literacy for science students.

E-learning as ICT-supported learning process provides an environment where constructivist principles like self-motivated and active learners pursuing their individual learning processes can be facilitated (Aqda, Hamidi, & Ghorbandordinejad, 2011). As such e-learning goes beyond providing laptops or web front ends to students and coaches. It affects the selection of learning tasks and information sources, the interaction and presentation formats. However, traditional e-learning platforms, such as fronter (www.fronter.de), follow a container / directory structure putting content elements aside to communication features, leading to linear structures, such as a content file is followed by a chat. They keep content management (i.e. cognitive activity support) and communication isolated, effecting learning outcomes, as cognitive and social processes should be intertwined and mutually context-sensitive for effective learning (cf. Bandura, 1985; Miyake, 1986; O'Malley, 1995).

Based on recent empirical findings (Eichelberger & Laner, 2010), the turn towards self-regulated e-learning environments is likely to continue. Putting learners to the centre of interest refers to a variety of aspects of individualization when designing learning processes in e-learning environments (cf. Hadjerrouit, 2005):

1. Knowledge should be actively constructed by learners. To that respect social interactions play a crucial role. They concern peers as well as teachers, as the latter need to change their role from passive transmitters of information to facilitators (cf. Stöckli, 2011).

2. According to this mathetic understanding of learning processes (cf. Schlömerkemper, 2004) construction processes have to be based on the learners' prior knowledge as foundation, with teachers serving primarily as facilitators in learning designs (cf. Sawyer, 2006).

3. Any problem-solving task should be specific to the subject matter, and authentic, to get learners actively involved in knowledge construction. Learning tasks should address problems that are situated in real world tasks (cf. Sawyer, 2006). The higher the orientation towards practical actions, the more learners get involved emotionally and are challenged with respect to their creativity (Zull, 2004).

In this paper we present a framework and its implementation for individualized learning management, tackling the cognitive and the social aspects of knowledge generation in a mutually tuned way. For the organization of learning processes, learning contracts embodying both aspects are revisited. Stemming from the field of progressive education (Parkhurst, 1924) they target towards deep understanding, generative and reflective action in the subject matter represented by domain content. In order to support learning as self-managed socially embedded process, both, conceptual, and technical innovation is required (cf. Allam, 2011). Besides domain-specific and didactic meta data, linking content elements to communication items directly, e.g., enabling a context-sensitive discussion about a certain definition, can be considered crucial for knowledge generation and its social dynamics. Hereby, learners are guided by the contract structure. It enables self-managed problem solving in a transparent and traceable way while acknowledging social interaction, even for defining learning contracts.

In the following we detail the design and implementation challenges when embodying social aspects in content-driven self-managed learning processes. In section 2 we review major concepts from learning sciences for developing an integrative framework for informed problem solving to that respect. In section 3 we briefly revisit e-learning contracts with respect to intertwining self-organized learning and peer/facilitator communication, before introducing the developed support for contracting. It lays ground for efficient class preparation and effective interaction between learners and facilitators (coaches, teachers, tutors). The contracts should lead to in-depth understanding of a subject matter while acting in a dynamic social learning setting, as demonstrated in section 4. In section 5 mechanisms for leveraging effective learning processes are described. Section 6 concludes the paper summarizing the results and providing an outlook to further research.

2. Conceptual foundations of informed problem solving

In this section we first deal with the social side of problem-solving (section 2.1) and its relation to cognitive processes in learning (environments) (section 2.2). We detail learner capabilities (section 2.3) before focusing on essential design elements of e-learning approaches (2.4), and development tasks (section 2.5).

2.1. Social learning

When considering learning processes, in particular in institutional settings, learning processes have social context (cf. Hüther, 2004). Besides the cognitive dimension learning is determined by observing, socializing, model building, and behavior imitation (cf. Bandura, 1976). In social learning theory the role of cognition in learning has increasingly been investigated in the last 30 years.

Individuals may learn by observing the behavior of others and the outcomes of those behaviors. However, learning can occur without a change in behavior or may not necessarily be shown in a learner's performance. Learning may or may not result in a behavior change (Omrod, 1999). However, social learning is not a straightforward process, as it occurs along several phases, mainly including the *identification and modeling of behaviors* before incorporating them.

Persons are often reinforced for modeling the behavior of others. Bandura (1976, 1985) suggested that the *environment could reinforce modeling*. An integrated e-learning environment may support that in several ways:

- *Imitated behavior leads to reinforcement.* Many behaviors learners perceive from others may produce satisfying or reinforcing results. This observation is of particular importance when changing learning styles, e.g. switching from linear to associative content work. For instance, a learner could perceive how linking content elements in a novel sequence facilitates a problem solving process significantly. By following the same strategy when handling content a learner would also enjoy the benefits of straightforward task accomplishment.

- *Learners are reinforced by a model.* For instance, a learner who changes communication behavior to fit in with a certain problem-solving community has a strong likelihood of being accepted and thus reinforced by that community. A discussion forum or chat communication reveals original behaviors as well as changes, as each contribution is recorded and visible to others. Even learners not being engaged will be able to follow communications about the current problem-solving task, and adapt their behavior.

- *Learners are reinforced by peers or facilitators.* In this case a person might be modeling the actions of someone else, for example, a learning-literate student. The teacher notices this and compliments the learner for modeling such behavior and reinforcing that behavior in this way. A typical example could be related to find the most elegant way combining content-work and social interaction for problem solving. Once the facilitator recognizes such a behavior it merits attention and the facilitator could inform other learners about it.

- *Consequences of a model's behavior affect individual behavior vicariously.* In social systems vicarious reinforcement is quite common. In the model reinforcement for a response is embodied leading to persons' increase in that same response. In e-learning learners could watch a certain problem solving behavior. This behavior is then shown being acclaimed by others. Without being further reinforced, the group of learners having watched those scenes, are likely to solve problems the same way.

Modeling is the central activity. It may be initiated by a learner (first case) or being looked for explicitly (second case). It may also be initiated by a facilitator (third case) or a model could be conveyed by acclamation (fourth case). Hence, once a model has been created it can be propagated by various actors and means.

Reinforcement is not the sole or main cause for learning. It has indirect effects on learning, influencing the extent to which an individual exhibits a behavior that has been learned. However, the *expectation of reinforcement influences cognitive processes that promote learning*. According to social learning theories, attention is influenced by the expectation of reinforcement. It seems to be crucial to raise attention when trying to induce learning processes. For instance, once a learning sequence is introduced by a scenario affecting learners, they will pay attention since due the expected impact on their problem solving behavior.

2.2. Cognitive factors

Social learning theories pay attention to cognition by distinguishing cognitive factors in social learning from operant factors. For the design of e-learning environments both are of crucial importance (cf. Jashapara & Tai, 2011):

- *Learning without performing*: Learning processes can be triggered and occur while not solving problems actively, by watching learning processes from others,

and probably repeating them. Bandura (1976) has identified learning through observation, and the actual imitation of what has been learned, when addressing this issue. Transferred to the context of e-learning, for learning without performing the process documentation and context-sensitivity of situations seems to be crucial.

- *Raising attention induces learning*: As already mentioned above, attention plays a crucial role in learning. It is influenced by the expectation of reinforcement. As such, e-learning environments could provide facilities that raise those expectations. A typical example is the use of Social Media, such as facebook (www.facebook.com), that trigger behavior sequences in both directions. They raise attention to follow others, and get involved as a person to be followed.

- *Raising expectations*: This factor continues to address the tension keeping persons interested in exchange processes. As a result of being reinforced, persons form expectations about the consequences that future behaviors are likely to bring. Consequently, learners could become aware of response reinforcements and increase response rates, and interactions.

- *Reciprocal causation*: Following Bandura's finding that behavior can influence both the environment and the person, in learning processes the person, the behavior, and the environment may influence each other. Thus, social dynamics may create cognitive dynamics, and vice verse, once people communicate in the course of learning. Cognitive dynamics may lead to content generation or rearrangement documenting a cognitive step, whereas social dynamics may lead to changing roles or novel role behavior.

In all of these factors models and the process of *modeling* play a crucial role. Besides having different shapes, living models and persons demonstrating behavior, content could encode models using symbols (audio, video, graphics, text etc.). Modeling enables learning of behaviors, at least partly. A typical example to that respect from social learning are learners observing problem solving procedures performed by others, e.g., through live demonstration, video, or in real time being logged in an e-learning platform where teachers and students share their activities.

2.3. Learning capabilities

Effective modeling requires a certain situation context, referring to *awareness* and *attitude*. According to Bandura (1976, 1985) several conditions need to be met before an individual can successfully model the behavior of someone else. We list them and their relation to (e-)learning:

1. *Attention*: A person must first pay attention to a model. A model needs to be recognized as such. The learner can either be alluded by the teacher (facilitator) or a peer. This can be facilitated through transparent interaction, e.g., setting respective objectives in the learning environment.

2. *Retention*: A person observing a certain situation needs to be able to recall the behavior that has been observed. Active listening, and thus, rephrasing is an effective way ensuring retention. It could be part of social interaction in e-learning and refer to already existing content.

3. *(Motor) Reproduction*: A person observing problem-solving procedures needs to have the ability to replicate the behavior that is demonstrated by the model.

Learners should be able to experience problem-solving activities themselves they have been observing. It requires the capability to understand, and also affects media literacy in e-learning environments.

4. *Motivation*: Learners need to be willing to demonstrate their learning effort and results. Motivation could be driven by social aspects, i.e. fitting to a peer group, or cognitive ones, aiming to achieve a certain level of competence or to practice a certain skill successfully.

Modeling has been observed to teach new behaviors, influence the frequency of previously learned behaviors, encourage previously unknown (even not appropriate) behaviors, and increases the frequency of similar behaviors. For example, a learner might observe a person from his peer group successfully accomplish an engineering task, and tries to excel in humanities when recognizing he is not talented in engineering. Modeling refers to representations, either in form of cognitively relevant content or social interaction. Both serve as baseline for self-empowerment through modeling.

Being empowered in turn increases self-efficacy of learning, encouraging persons to engage in certain behaviors. A major driving force is *believing to be capable of executing observed behaviors* successfully. In particular, learning could be experienced as joyful activity. As a result, individuals will tend to put more effort and activities in behaviors they consider to be successful in achieving (persistence) - a learning factor urgently needed to be addressed in learning settings (Gebauer, 2007).

Learners with high *self-efficacy* tend to achieve ambitious and challenging targets, in particular when managing learning by themselves (cf. Von Glasersfeld, 1989). When self-regulated individuals develop own ideas about what is appropriate or inappropriate behavior and chooses actions accordingly. It affects setting standards and goals, self observation and judgment. In learning process promoting *self-management* allows individuals to develop objectives, plan, and evaluate himself after implementing a certain problem-solving behavior. As a result, the organization of learning will fit to a person's learning attitude and capabilities (cf. Allam, 2011).

The development steps to self-management may not be apparent in the learning environment, i.e. when learners give themselves instructions guiding their behavior. According to social learning theory five steps to achieve self-instruction have been identified. First, learners need to build some cognitive representation of the model (behavior). This embodiment allows for overt external guidance to develop a certain behavior. This external guidance shifts to faded, overt self-guidance before covert self-instruction is enabled to finally implement a behavior (pattern).

Self-monitoring and self-reinforcement guide these change processes. They allow individuals to control them. Hence, learners need to accomplish monitoring and observing their own behavior, before being also able to change their behavior by reinforcing themselves.

2.4. Design implications

There are several implications of social learning theory to the design of e-learning environments (cf. Bandura, 2011; Schunk, 2012). We structure them according to their focus:

*   Development activities:
    *   o   Designs should strive for self-efficacy, as it leads to more self-

reflection and self-organization of learning processes. Learners should be able to develop structural support they could generate learning contracts by themselves. It requires editing facilities for structuring learning processes.

- o Besides sharing content handling and communication entries, the consequences of certain learning behavior should become evident. Such documentation could increase effective learning behaviors. It could also be enforced by involve discussing with learners about rewarding situations, and consequences of learning patterns, e.g., studying content before asking peers for support in problem solving.

- Preparing the setting for learning:

  - o Modeling is a learner-centered activity, in contrast to shaping when teaching new behavior. Instead of operant conditioning, modeling could provide a faster, more efficient means for accomplishing new behavior. However, it requires adjusting an e-learning environment and learning process design to raise attention, empower for retention and (motor) reproduction, and being motivating for learners.

  - o Facilitators themselves need to model appropriate behaviors. In particular, content providers need to be aware that a certain content and problem solving structure corresponds to their individual mental model, even when shared with (other) domain experts. As such, it is at disposal in the course of individualized learning processes.

  - o Learners should be exposed to a variety of models. This requirement can be considered as a prerequisite to encourage creative problem solving. However, teachers need to prepare various access paths to content, flexible social and content arrangements, and different patterns of solving learning tasks.

  - o Facilitators should help learners to set achievable, however, challenging objectives for their problem solving tasks. They need to guide learners to develop attracting learning expectations for themselves and their peer group. Reflection objectives of learning tasks could be the initial meta-cognitive activity in problem solving.

- Learners activities:

  - o Learners should be able to observing other's behavior. In doing so, they should be encouraged to identify the model that could become part of their behavior patterns. Documenting how content is handled by learners and social interactions occur in the course of learning lays ground for behavior modeling.

  - o Learners need to develop and apply individual assessment techniques to develop belief in their capabilities to accomplish problem solving tasks. This is part of developing a sense of self-efficacy. Learners could achieve that by experiencing success on their own after exploring content and communication.

  - o Finally, learners should recognize that self-reflection is part of each learning process. They need to discipline themselves for reflecting the initial structure of learning processes. On the long run, they should be

> qualified to design their own learning process structures, such as the learning contracts presented in section 3.

Being able to apply (learning) behavior acquired according to the theory of social cognition in a new (creative) way to a problem is the highest competence learners can acquire (see Fig. 1).

Highest level of competence ↑ Lowest level of competence	**Problem solving**	Apply learned content to new situations
	Transfer	Apply learned content to similar situation
	Reorganisation	Use content from a different point of view
	Reproduction	(exact) Reproduction of learned content

Fig. 1. Levels of competence (Deutscher Bildungsrat 1970, quoted in Mankel 2008)

Problem-solving in general requires skills ranging from creativity, over analytical skills to skills that allow the learner to put theories and ideas into practical application (Aqda, Hamidi, & Ghorbandordinejad, 2011; Davis, Smith, & Leflore, 2008). As learning how to solve problems in life occurs not in isolation, but rather in communities or organizations, social interactions need to be addressed explicitly when designing learning tasks, as mentioned above.

Learning in this way does not only train the reflection and communication of problems. It also trains sharing of results and in teams of people working together, as they exercise, verify, and test their knowledge through discussion, and information sharing. Hence, learning should take place in an environment that supports collaboration and interaction.

2.5. Development tasks

Active and creative problem solving in collaborative settings cannot be taken for granted in traditional e-learning environments. It rather requires contextual representations, with respect to content and communication, as well as features for individualization. For context-sensitive and focused interaction and collaboration, content elements should become an integral part of communication patterns (cf. Derntl, 2005). Social behavior has to be considered as integral part of cognitively grounded learning processes today. It affects personal emotions and learning attitudes and vice versa (cf. Roth, 2003; Zull, 2004).

Ontologies, as the one proposed by Meder (2000), can be considered a first step towards structuring e-learning design, as they allow conveying the social setting and the didactical value as meta-information of the subject matter on the same level of abstraction, using a single notation. The latter enables not only capturing communication- or subject-relevant information but also their semantic relationships explicitly (cf. Martin, 2008). The represented meta-data support learning processes and their design in a

manifold way: searching for and filtering of particular categories of information, e.g., explanation, definition, example, background information, and developing individual perspectives (views) on specific content elements, e.g., on a case study, that can also be stored in addition to contextual information (cf. Fürlinger, Auinger, & Stary, 2004). These views might contain comments, supplements in form of internal and external links to content elements, and links to conversations in a forum, via a chat or blogging on certain topics (content elements).

E-learning features of that kind have become key elements of didactically reflected design of learning tasks. The didactic value of content has already turned out as decisive factor for e-learning empowering self-management (Leidig, 2001). However, the design of the social context of subject items is still a challenge for learner-centered knowledge generation (Hassenzahl & Tractinsky, 2006). In particular, the active (re-) construction of knowledge in the actual social setting of the learners should be supported. Learners should be able to pursue their individual interests, while being motivated to communicate their understanding to others – also termed the situated and public nature of construction activities (cf. Farmer & Hughes, 2005). Hence, learning support mainly depends on didactically grounded content preparation and social computing features that allow for dynamic intertwining of subject-matter content and communication elements on a concrete task level, both, on the individual and group level (cf. Gücker, 2007).

3.   (Co-)Construction and learning contracts

We have proposed *Intelligibility Catchers* (ICs) as learning contracts when designing individualized learning processes (cf. Stary, 2007). They incorporate features for self-regulated learning into the structure of the Dalton Plan, as proposed by Parkhurst (1924). Rather than focusing on particular components that might be cognitively relevant for information reproduction, as e.g., the concept of learning objects (cf. Wiley, 2002), the flow of contextual capacity building and shared knowledge generation is at the center of design (cf. Polsani, 2003).

3.1. Intelligibility catchers method

In contrast to traditional assignments, ICs refer directly to the knowledge individualization and sharing features of semantic e-learning systems, such as filters and views. As ICs are (e-learning) contracts, they need to be negotiated between learners and teachers (and eventually modified) before the actual learning process starts. Table 1 shows a typical IC. It has been designed to grasp daily life in the time after World War II in Vienna, while exploring the expressiveness of historical story telling. In this case, besides factual information (the time after war) methodological knowledge (historical story telling) should be re-constructed.

Table 1
Intelligibility catcher '1945 – Remember childhood' designed for Junior High Schools

1 – Preface / Orientation	As war times shape societies, life of individuals and families is affected in a particular way. So far we have heard about the ending of World War II from the political and military perspective. Now we consider ordinary people, in order to reflect significant changes in daily living after years of conflict and grief. We use stories structured and compiled by historians. They asked

	persons living in the period following the end of the war in Vienna to remember their personal life at that time. The assignment helps you to understand what it means for individuals to rebuild a society after massive global disturbances of civil life.
2 – Objectives	Understand history from a micro-perspective supplementing the macro-perspective; Reveal patterns of individual and group behavior to learn for the management of crises.
3 – Tasks	Capture the structure of individual stories Identify significant events and routines affecting persons of your age at that time Reflect your individual life of today with peers in light of the situation at that time
3.a Documented Work (platform features are in *Italics*)	The platform supports you identifying relevant content items of prepared material, supplementing it, and interacting with peers and the coach. • *Filter* content for the *content category* (content block type) you consider relevant, such as 'childhood', 'friendship', 'trading' • Set up individual *view* '\<name\>MyEvidence' • *Annotate* in your view prominent elements of three stories as they provide insights into the life of persons of your age • Search the Internet for stories describing daily life in the years after World War II in Vienna and *set direct links* from compatible story elements in the platform to the Internet resource (the links become part of your view) • *Comment* on the links – try to capture differences with respect to setting up historical stories (the comments also become part of your view) • *Set your view public* to your peer group – it now becomes visible to your peers • *Select another view* from the view list, and study the results of one of your peers • *Search for* this peer via the platform's *buddy* list • *Create a forum* for your selected peer and you • Allow peer comments and prepare your peer comments to the findings by providing *forum entries*. Refer to both, the content of the stories and the way to set up stories • When you are both ready for feedback, make sure that the *forum entries are directly linked to the stories* you have studied and the *annotations (views)* you have created. Otherwise, the coach and other peers are not able to provide context-sensitive feedback.
3.b Intellectual Challenge	(Re-)Construction of material and method Provision of constructive comments and feedback
4 – Conferences	Feedback from peers and coaches
5 – References	Riegler, I., Stockinger, H. (Hg.) (2005). Generationen erzählen. Geschichten aus Wien und Linz, 1945–1955. Böhlau, Wien
6 – Bulletins	Infoboard@Scholion.ce.jku.at
7 – Equivalents	This assignment should take you no longer than 4 hours.

Each structure element contributes to developing shared understanding, either by emotional involvement, or cognitive and social challenges:

- The *title* should provide a thematic scope, and if possible convey emotional appeal. It should trigger expectations on how to engage and get involved when working on the addressed issue.

- The *orientation / preface* section addresses the stage of capacity building the IC should be used and what learners can expect when accomplishing the IC tasks. Its intention is to motivate and raise attention.

- The *objectives* set the scope in terms of the topics that are addressed in the learning tasks and the understanding that should result from exploring and processing learning content.

- The *task section* comprises a *documented* and an *intellectual work* part. The task section should contain different types of learning tasks which address different learning styles (i.e. tasks ranging from reproduction tasks to problem-solving tasks – cf. Mankel, 2008; Rozendaal, Minnaert, & Boekaerts, 2001). It encourages active information search and exploration, communication, and individual problem-solving. On one hand, it refers to the concrete steps with respect to handle content and communication, on the other hand, it allows for model building in the sense of social learning theory. For self-organized learning, it is most essential to provide an indicative structure without anticipating the actual content. It would not only hinder model identification, modeling, and model embodiment, but also lead to standardized learning behavior patterns. In particular, the latter would prohibit model identification, and thus be not productive to social learning (see section 2).

- The *conference section* sets deadlines and content for virtual and face-to-face meetings of the addressed learning community. It includes the time and date, the participants and the work to be prepared to be presented to the participants.

- The *reference section* provides links and literature that could help to accomplish the tasks.

- In e-learning, the *bulletins section* can be dynamically created using an online info board.

- *Equivalents* reveal the estimated individual effort for learners to meet the objectives.

The following Fig. 2 reveals the overall structure and the relationships between its parts.

After agreeing to the contract learners might immediately start to work, reading the orientation section and reflecting the objectives. They can be encouraged to scan prepared content according to domain-relevant structures, once it has been marked up with didactically relevant meta-data. The shown IC in Table 1 refers to such meta-data ('childhood', 'trading' a.t.l.).

In addition it provides a touching theme when learners look for the proper category of information and search the Internet. Sharing outcomes with peers is enabled by creating task-specific views and by focused, since content-related discussion (in the forum). Finally, all results can be traced and validated by the coach (and peers) who

provide feedback, not only in order to ensure correct learner representations, but also to indicate further ways of exploring the subject matter.
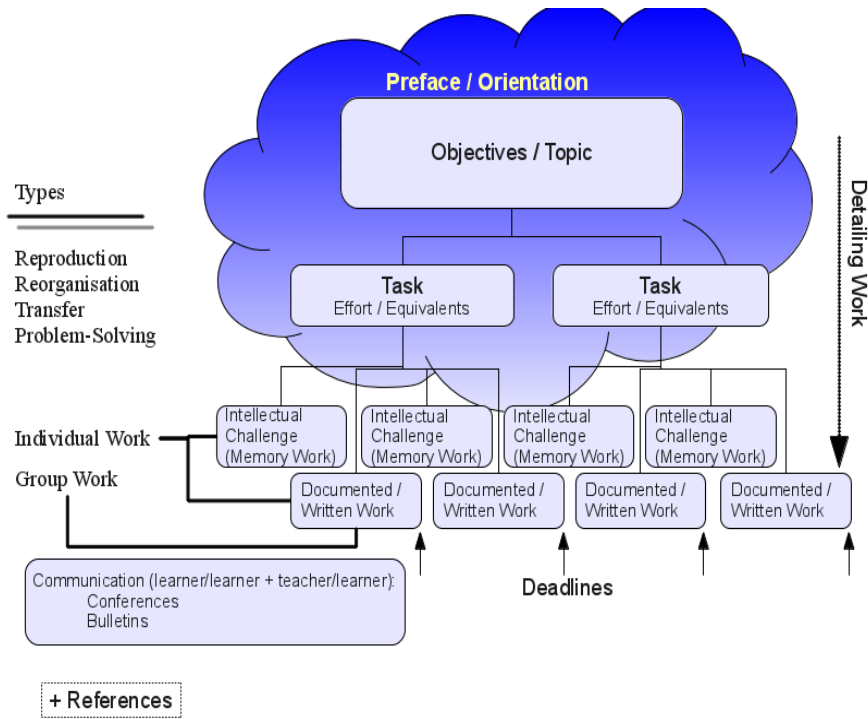

Fig. 2. IC Structure and relationships between its parts

In this way context-sensitive feedback loops can be implemented, as they play a crucial role in learning. 'Recent studies have shown that feedback is most effective when it results from interaction with a context rather than from outside the context. That is, learning is most effective when brains are allowed time to reflect on "errors" rather than when information is presented as *a priori.'* (Davis, Smith, & Leflore, 2008, p. 30).

Reference points for exploration and communication are the content categories (content block types) of the subject matter at hand, such as 'trading' (see IC subsection 3a), and the views reflecting learner perspectives. In general, content categories should reflect access or learning patterns, such as a 'motivation' serving as entry point to an 'explanation' being followed by a 'definition' or an 'example', in order to support individual learning styles and situational preference, e.g., starting to learn by studying examples.

In this way ICs make learner control explicit. They reveal the variety of paths that can be followed in the course of exploring material. The filter feature allows individually selecting and arranging prepared content elements, whereas the view feature supports the different phases of knowledge generation and sharing. Actually, views can be specified at any time of interaction. For sharing individual findings the view feature also allows teachers and coaches complementing prepared or embodied information, even based on previous annotations (when views are set public by a peer or the coach).

Views (as detailed in section 3.2) represent learning models that indicate learning behavior to be modeled by peers. They may lead to re-enforcements either when being exchanged among learners, leading to enhancements, or when being discussed in social media. Whenever a view is created and shared, a learning behavior might be triggered and is at disposal for social learning processes.

Guidance might be provided by teachers or coaches passing on subject-specific information and practical experiences. Learning and teaching are multifaceted activities, including sorting out information, communicating with others, presenting results to others, depending on the situation and process. It seems a set of different skills will hold for literacy across learning settings.

Teachers can only utilize the capabilities of a semantic e-learning environment, once they develop a didactic scheme for the subject matter and encode their material according to that scheme. It allows them making explicit their perspective on the subject matter. In this way, it shapes their interventions along knowledge generation processes of learners. Moreover, for their own peer group such a scheme might serve as a reference point when reflecting and comparing knowledge structures of textbooks, hypermedia or other study material.

3.2. Platform support

Any learning platform, providing both, flexible content arrangement, and embodied social spaces for communication and intervention could support self-regulated learning based on ICs. As the social processes should be context-sensitive, the binding capability of conversations to fine-grain content elements is obligatory.

Sharing knowledge and conversations requires both, recognizing content elements as focal points, and separating own inputs (comments, markings, links) from prepared content elements (e.g., using views on the content). The capability of developing individual views seems to be the key feature of individualized e-learning. Views allow perspective giving and taking in an action-oriented way. In this way, creativity, emotion, cognition and social behavior can be tightly coupled.

Annotations (stored in views) empower learners to individualize content to their needs and preferences. The respective features comprise commenting, marking or highlighting, and links to other content elements and communication entries. In this way, content can either be adapted to learners' knowledge or being actively modified by learners. Links to communication entries form a major source for learning with and from peers. As such, annotation facilities are core enablers of individualization and collaboration. They enable learners to (i) mark a specific position in a content element for learning or as reference point, (ii) post questions, answers or comments, and (iii) link the individual contribution to a theme in a discussion board when working with content, ensuring focused interactions.

The implementation of annotations is a challenging task: As soon as content is displayed, a view is generated like an overlay transparency. The view is kept for further access and reloaded when the content is accessed again. Users can manage views, including modification, deletion, and the transfer to other users. The access to views of other users might include user groups - collaboration is enabled through sharing views. Vice versa, public views can be copied by other users, and imported to their list of individual views on content. Those learners might also make imported views public, e.g., after supplementing annotations, leading to cascaded views.

Since e-learning environments should allow users editing links to internal or external sources of information, navigation elements to manage information sources are required. Links can be external URLs as well as internal references, such as links to entries in a discussion forum or info board. Links can also refer to elements within a learning module.

In Fig. 3 a semantic learning system is shown as developed for history education (as explained above), linking the content element 'background information' to an entry of the discussion forum. The Scholion platform (Auinger & Stary, 2005; also http://scholion.jku.at) serves as our test bed for learner-centered developments.

Fig. 3. Sample screen showing intertwined communication and content management

In the left part of the screen the navigation through the content (upper part) and the communication themes (lower part) is displayed. The text in the center contains parts of a story (upper part), structured according to semantic content types, such as 'background information'. The circled tool bar shows the various annotation features, ranging from highlighting text to linking content elements, such as the selected background information, to forum entries (lower part), as indicated through the arrows. Users can switch between content handling and communication any time, according to their needs and preferences.

E-learning environments traditionally do not provide an integrated tool-set supporting the use of e-learning-contracts. However, some tools facilitating the development and maintenance of contracts exist. They make the management of contracts and resulting "documented work" more efficient, as they allow distributing, sharing and managing different versions of electronic documents. For instance, COOL (COoperatives Offenes Lernen, Neuhauser, and Wittwer, 2002) is a teaching approach grounded on the Dalton plan by Parkhurst which uses learning-contracts extensively. The eCOOL

platform, built on moodle, supports students and teachers managing contracts and documented work by using an ePortfolio (Hölbling, Wittwer, & Neuhauser 2008). This approach and e-learning support is a practical and applied framework for education. It is used by a number of high-schools across Austria.

The integration of the contract's structure within the e-learning platform allows making use of existing functionality. For instance, it is possible to use the annotation features and views (see above) on learning-contracts in Scholion. An integrated contract editor facilitates contributions of both parties (students and teachers) to the contract. Integrating additional features like search functionality to access (parts of) existing contracts, supports sharing of exemplary contracts between teachers in an efficient way. The following Fig. 4 shows the contract editor (in Scholion 2.0) with a list of parts of contracts written by other platform users for selected contract parts (lower part).
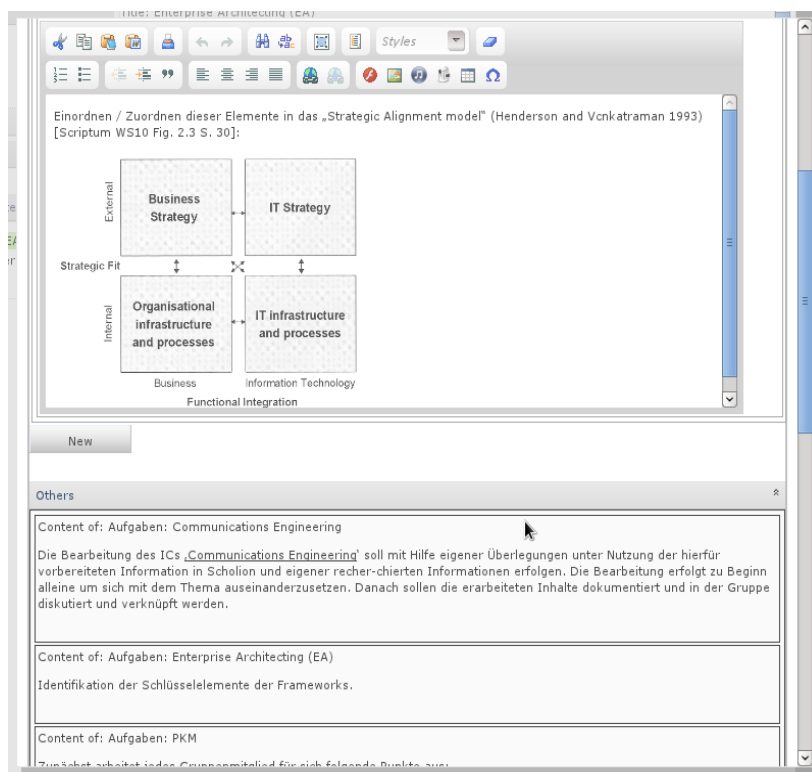

Fig. 4. Contract editor providing access to peer contracts

4.   Co-Construction of e-learning contracts

According to constructivist and mathetic learning theories (Aqda, Hamidi, & Ghorbandordinejad, 2011; Eichelberger & Laner, 2010; Davis, Smith, & Leflore, 2008), teachers are facilitators of learning processes. They monitor the progress of learners and provide impulses to the learning process, rather than giving pre-packaged solutions. They provide a structure and a plan, making the envisioned process and expected achievements in terms of milestones transparent. E-Learning contracts need to provide information about the planned activities and social interactions (e.g., meetings).

Several obstacles exist for teachers developing e-learning contracts. The development of e-learning contracts requires experience (Hackl, 2002). However, many teachers have been educated in traditional settings, and hence do not have this experience (Fernandez and Ritchie, 1992), and exemplary contracts are rarely provided. If such contracts are made available, it is often not possible to transfer these between different schools / curricula. In addition, they often do not meet pedagogical requirements (Popp, 2002). This also holds for the examples given by Parkhurst (Skiera, 2003).

It is possible to handle these challenges in a constructive way, namely by integrating the learners in the creation process. The demonstrated e-learning environment allows learners also accessing the editor (see Fig. 4). The inclusion of learners makes the creation process of ICs more efficient. Learners may negotiate individual objectives, allowing for ICs for weaker and stronger students. Having access to ICs created by others allows learning from existing work.

As the ICs and their editor are embedded in a generic learning environment, the same environment may be used to learn about the planning of learning tasks. Using the ICs and the learning environment in this way, supports the development of meta-cognitive competences. However, it requires practice by learners and likewise, by teachers.

The editor and the approach have been evaluated by teachers. The evaluations have highlighted the need for a few adjustments. Some benefits of the e-learning-contract environment have been highlighted as well. For example, it provides the possibility to include videos in the motivation and preface to the contract (see Fig. 5).

Fig. 5. Contract view displaying preface and bulleting study sections, including multimedia elements as part of contracts.

A major requirement and change to the editor is the need to incorporate a tested guide for writing intelligibility catchers. While an initial guide has been developed, it shows several weaknesses and currently only exists on "paper". In the next version the guide will be integrated in the editor.

5. Implications

Problem-solving requires creative skills, critical thinking as well as skills enabling practical implementation of ideas and theories (cf. Aqda, Hamidi, & Ghorbandordinejad, 2011; Davis, Thomas, & Leflore, 2008). Mathetic assignments (and therefore also Intelligibility Catchers) in progressive education are used to support active, self-organized learning and creative problem-solving. This learning occurs individually and in groups.

We have researched and applied a framework consisting of an informed approach to structuring learning and a supporting semantic e-learning environment. Our developments and experiences have revealed some mechanisms how to leverage effective learning processes. The demonstrated results embed findings in social learning theory in a variety of ways:

- *Development of e-learning environments*: The presented designs target self-efficacy of learning processes, as it asks for self-reflection and self-organization of learning processes. Learners are enabled to fill in e-learning contracts and learn to structure learning processes themselves on both levels, intellectual and actual problem solving. The contract structure is an inherent part of interactive content exploration, perspective sharing, and intertwined. Not only the cognitive acts are documented, but also their consequences in terms of making evident certain learning behavior, and results from problem solving. Both representations might increase effective learning behaviors as learners can reflect on the process and consequences of learning patterns, such as working on content items in groups before accomplishing learning tasks.

- *Shifting from shaping to modeling*: Behavior can be studied in the course of learning or observing by learners rather than being prescribed by facilitators or teachers. It reduces effort when accomplishing new behavior. The enablers that have been tried in the presented implementation are: (i) raise attention - learning tasks are challenging and require some meta-cognitive effort, (ii) empower for retention - once the learning task has been structured, content exploration and communication become self-evident, (iii) empower for reproduction - learning tasks engage in active reconstruction of knowledge, (iv) motivate - learning tasks refer to themes learners are familiar with, however, have not been tackled so far. Content providers and teaches need to open up in several ways. Firstly, they need to model appropriate behaviors by letting learners challenge their implemented content and problem solving structure, as it corresponds to their individual mental model, and might be at disposal when explored in the course of individualized learning processes. Content needs to be accessible and configured in a variety of ways. Besides different modalities various access paths to content, intertwined with social interactions need to be prepared by teachers.

- *Self-management and reconstruction:* As learner behavior becomes traceable in e-learning environments, learners can be encouraged in learning contracts to

reflect on other's behavior, identify a model, and embody it. Transparent learning steps in problem-solving tasks, including the reflection of learning behavior support to build up self-confidence for complex and creative problem solving, i.e. developing a sense of self-efficacy. Reflecting the structure of learning processes can be enforced through explicit learning tasks. Once capacity has been built on the meta-cognitive level, learners are qualified to design learning contracts by themselves - the ultimate goal in self-organized knowledge acquisition and creative problem sovling.

Creative ways to problem solving include the co-construction of learning contracts, as it refers to meta-cognitive skills. It also allows to make the creation process more efficient, as facilitators are enabled to develop the ICs in collaboration with the learners and only to some extend have to be developed a-priory. The ICs are also more effective, as facilitators are able to better react to individual requirements of learners.
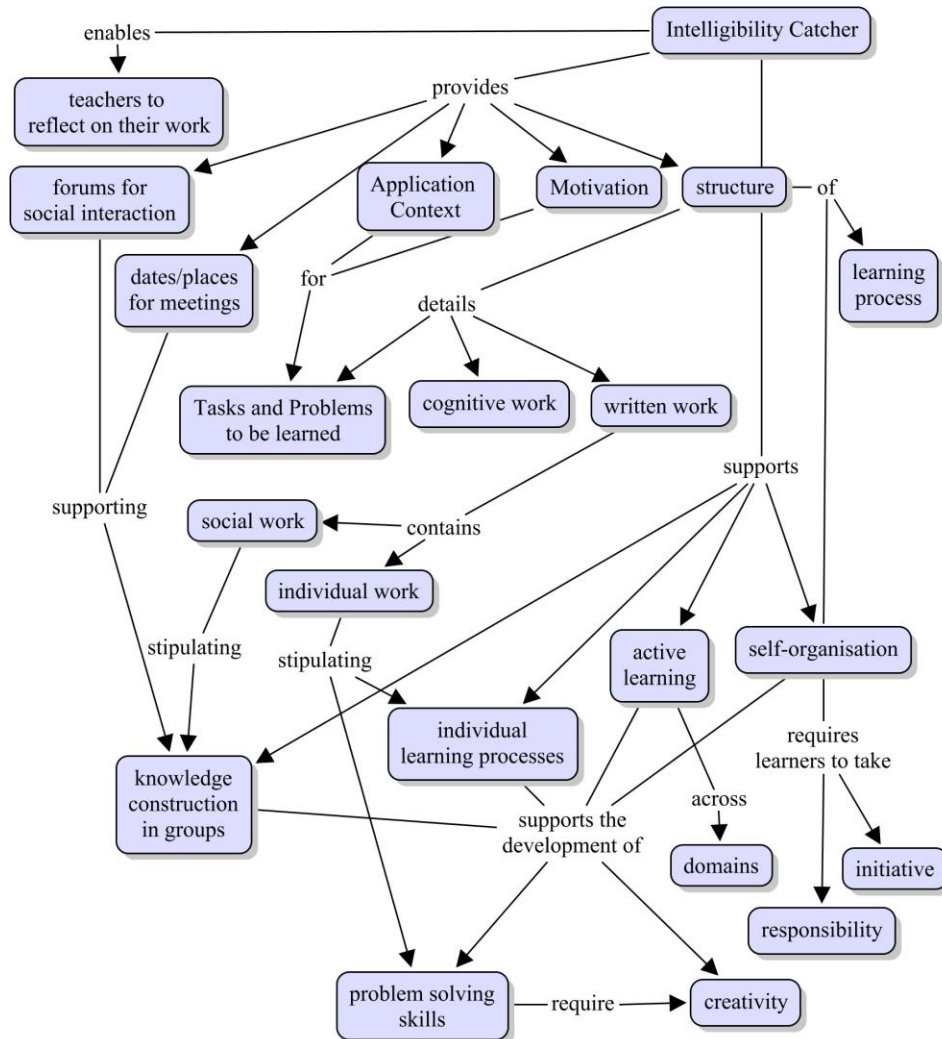

Fig. 6. Intelligibility catcher support for learning

In Fig. 6 concept map highlights different aspects of the researched approach and relationships between these aspects. In the upper part features provided by the IC are described. In the lower part the embodied learning concepts are put in to mutual context, both for individual and collaborative learning processes.

It needs to be stressed that, in order to support the development of creativity and problem-solving skills, teachers have to change their roles. Teachers are facilitators of the learning process. They monitor the progress of learners and provide impulses to the learning process, rather than giving pre-packaged solutions. This requires planning and a transparency of the work structure (e.g. tasks and associated deadlines where preliminary results are discussed). ICs therefore need to provide information about the planned activities and social interactions (e.g., meetings, conferences).

Having a document that makes the overall learning process explicit, allows (at the end of the process) to reflect on it and improve the process over time. In order to induce sustainable learning effects, not only teachers but also learners should become part of continuous improvement. Additionally these documents may be shared in a group of teachers allowing teachers to learn and improve their work over time.

6. Conclusions

According to the compound concept of learning literacy individualizing learning processes requires digital media and information management competences. Self-regulated learning processes built on these competences change the way of teaching and learning dramatically. Besides contracting the self-managed adaptation to learner needs and the arrangement of material in a variety of ways are crucial.

Intelligibility Catchers (E-learning contracts) provide an accurate structure of informed e-learning. They address both, individual and group work. They need to be grounded in real-world application contexts and should have a certain level of complexity to facilitate creative problem solving. Learning tasks, which produce documents (i.e. written or documented work) guide the learning process but keep the results open. They make clear that it is the learner's responsibility to generate outcome (rather than output). The overall approach is in line with constructivist didactics, which has been found to be effective for e-learning environments.

The presented framework and its support for individualized learning management, tackles the cognitive and the social aspects of knowledge generation (and creative problem solving) in a mutually tuned way. The approach supports e-learning contracts with a semantic learning environment. Building blocks are domain-specific and didactic meta-data, and features linking content elements to communication items directly, e.g., enabling a context-sensitive discussion about a certain definition. The view concept enables model building the sense of social learning, and as such enables knowledge generation in its social dynamics. Hereby, learners are guided by the contract structure. Self-managed problem solving becomes transparent, traceable, and thus, can be shared under the control of the involved individuals, even for (re-)defining learning contracts.

Besides further empirical studies institutional anchoring of learning contracts and socio-cognitive e-learning environments is required due to the (re-)organization of learning processes, and the required changes in attitude towards learner control (cf. Antonacopoulou & Gabriel, 2001). We intend to promote field tests in occupational and academic settings, as the effects need to be expressed in terms of development effort,

attitude change of learners, content providers, and learning guides (facilitators, tutors, and teachers).

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