Underlying Concepts and Theories of Learning with the Semantic Web

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Abstract: Developers of new learning scenarios – either from technological or educational background – act upon their (implicit) theories and concepts of learning and technology. Especially in the field of learning with the Semantic Web, there is – up to now – no awareness about the differing (and conflicting) underlying concepts. In this contribution, we try to identify and discuss fundamental aspects of implemented or discussed learning scenarios. For that, we screened selected (current) projects concerning learning with the Semantic Web according to their underlying or explicitly pointed out concepts and theories.

Introduction: Semantic Web as a source for educational hopes and fantasies

The Semantic Web is a research endeavour aiming at making Web content accessible to machines in a way that goes beyond mere presentation and rendering of content. Its goal may be briefly described as enriching the existing Web with meta-data and (meta-)data processing so as to provide Web-based systems with advanced (so-called intelligent) capabilities, in particular with context-awareness and decision support, strengthening a person centred, everyday use of the Web.

Semantic Web technologies are likely to significantly enhance future Web applications. On the "Semantic Web", Web applications and services can more easily communicate with each other, and data can be more easily exchanged between different systems. According to Berners-Lee & Miller (2002) the "Web will reach its full potential when it becomes an environment where data can be shared and processed by automated tools

as well as by people".

Semantic Web is often said to have the power to solve current problems in various fields. Especially in the field of e-learning with Semantic Web technology inspires fantasies about intelligent information retrieval, (automated) self adaptation of learning content or a recommendation for the next learning steps. We believe that the use of the Semantic Web – especially when used as the "Holy Grail" to solve all problems in the e-learning context – needs at least a conceptual definition on how to be used in a pedagogical setting.

One of the core challenges for the Semantic Web is the creation of the semantic information. There are two different approaches how meta data can be produced. However both of them are not easy to realise. One the one hand, humans can provide meta data by using a machine interpretable coding scheme, using e.g. XML, RDF, OWL or Topic Maps. But in practice "we can see a lot of practitioners showing resistance when asked to add structured metadata." (Koper 2004, 17). On the other hand we could also use inductive approaches of tagging and producing structure: Computers can produce meta data automatically, e.g. by natural language processing techniques like text mining (Furdík, Paralič & Smrž 2008) or latent semantic analysis (for texts, based on factor analysis, see Koper, 2004, 17, see also Kalz, Van Bruggen, Giesbers, Waterink, Eshuis & Koper 2007).

According to Koper (2004) the Semantic Web could support learning in the following two areas:

> "1. Staff can be helped to perform some of their tasks in flexible, online educational settings more efficiently and less isolated, this includes online course development tasks, learner support tasks, assessment tasks and course management and administrations tasks (e.g. setting-up new instances of courses)
>
> 2. Persons in different roles (learners, tutors, content providers) can be helped to perform tasks more effectively and efficiently in large, distributed, problem-based, multi-actor, multi-resource learning spaces that are set-up to establish learner-centred, non-linear, self-directed lifelong learning opportunities." (Koper 2004, p. 5)

The use of semantic technology is at the moment in its infancy. There are several projects and tools, which develop scenarios for the support of

knowledge development and/or retrieval, but only few of them with a special focus on learning. Especially semantic Wikis (e.g. IkeWiki[1]) and semantic collaboration tools/technologies (e.g. SIOC[2]) can be used for learning, in learning management systems or personal learning environments.

In this paper we do not discuss concrete projects or ideas how Semantic technologies can enhance Web-based learning environments. The focus of this contribution lies on a conceptual level, namely in the discussion about learning with the Semantic Web and the basic aspects which have to be taken into account. This discussion is related to existing publications and approaches, trying to categorise technology enhanced learning settings. For example one can distinguish between navigability, adaptivity and reactivity, according to Midoro, Olimpo, Persico and Sarti (1991, 181). But from our point of view, these and other existing concepts (e.g. Schulmeister 1997, 50) do not match the discussion sufficiently, because they neither take the learning content and resources, nor the social involvement into account.

In the following paragraphs we try to discuss and illustrate the following basic aspects and their values for a distinct view on learning with the Semantic Web:

- Aspect 1: The Content:
  a) is the content a fixed "canned content", claiming to be objective or b) is it dynamic, permanently "under development" and only shallowly categorised (miscellaneous)?
- Aspect 2: The Learner:
  a) is the learner a consumer, being taught by a teacher/trainer or b) is he/she an active, self-organised creator of his/her own environment?
- Aspect 3: The Social Involvement:
  a) is the learner "isolated", on his/her own or b) does he/she communicate with humans, e.g. in terms of being involved in a learning community?

Coming from a constructivist background and as experts for social software, we believe, that the values b) of the above mentioned three aspects are necessary and important for the effective support of learners and are therefore the foundation for the (ongoing) paradigm shift from

[1] http://ikewiki.salzburgresearch.at
[2] http://sioc-project.org/

(rather static and instructor based) e-learning 1.0 towards (a more user oriented, socially enhanced) e-learning 2.0. This contribution is only a first sketch how the differences and variances of concepts in the field of learning with the Semantic Web could be described.

Based on the descriptions of these three identified aspects, we screened several projects focusing on learning with the Semantic Web. In the following we present our results and try to cluster our main findings according to the underlying concepts and aspects.

Aspect 1: The Content

The first part of this contribution addresses the *learning content* and its two aspects: a) fixed, canned and "objective" versus b) permanently under development and only shallowly categorised.

At first glance, the importance of this part for the practice of e-learning is not immediately apparent, especially in formal learning settings: it is quite usual that curricula or existing learning materials are used. But, as mentioned before, the underlying differences concerning the content are not obvious and need therefore clarification.

By looking on today's nature of (e-)learning content, we can identify projects that build on fixed and "canned" learning content, which tries to demonstrate/illustrate "reality". For this, authors (so called "domain experts") have to develop the materials for a course, which is viable for the target group, the situation and the learning objectives. In recent times, authors tend to develop small, re-usable learning units, which can be easily re-assembled according to different needs. On the contrary, learning content can be seen as something miscellaneous and therefore permanently under development (e.g. content, which is stored in a Wiki). For the realisation and implementation of the content within semantic applications this plays an important role.

At the moment, a majority of activities concerning Semantic Web and learning seems to be about fixed content (as in aspect a). From a technological perspective it means that a fixed ontology – "a specification of a conceptualization" (Gruber 1993) – has to be created by domain experts. A simple notion of a possible ontology may be a controlled vocabulary or a catalogue, more complex ontologies use logical formalisms like first order logics or description logics (e.g. in the Web Ontology Language OWL). Ontologies can be used e.g. for consistency checking, interoperability support, and support validation and verification

testing of data and schemas (McGuinness 2003), but also (using "reasoning") for supporting the user in searching and navigating (by "querying") or by adapting the content to personal preferences, user models, or context (e.g. in Semantic Wikis, cf. Krötsch, Schaffert & Vrandecic 2007).

Many publications and research on learning and the Semantic Web are done in the tradition of artificial intelligence and intelligent tutoring systems, where an "expert model" of the knowledge domain is used to draw conclusions and solve problems. Because expert systems only know the difference between declarative knowledge (e.g. definitions) and procedural knowledge (how to initiate an effect), they are limited to domains as science, mathematics, logics, moral and conventional knowledge: knowledge areas like history social or aesthetical knowledge are not represented in such systems due to the intricacies of expressing such knowledge in declarative and procedural ways (see Schulmeister 1997, 205, referring to Ohlsson 1992).

Another important issue is the categorisation of content. Most people tend to categorise things, because they are used to. The concept of categorisation as one approach to giving added value (in terms of metadata) and therefore "truth" to the content to make it more "objective" is a very traditional concept, based in the time, where content was in books and storable in shelves. In modern times, "truth" is not only in the content metadata by having it properly categorised by experts. Also "tags" by other users can give added value to the content, when it is used in different contexts. Here, especially technological experts refer to the discussions in the fields of information science to relativise the objectivism of knowledge and structures. Probably the most prominent promoter is David Weinberger with his book "Everything is Miscellaneous" (2007). In this book he describes the revolution of the classification of information from category-based library systems to folksonomies and tagging of content as a better way of information organisation, e.g. in online environments. As an example, the video of Michael Wesch (2007) illustrates these new ideas and effects of Social Software and semantics for the Web 2.0.

In the case of expert designed and annotated materials ("canned content"), learners (in their role as consumers) are not allowed/able to contribute to learning materials, probably because they lack of expertise. Educational concepts building upon this idea hinder the development of (new or adapted) learning materials. On the other hand, the notion of objective knowledge, distinguishable into categories is always connected to a certain

understanding of the teacher's role. Current publications on learning and Semantic Web deal mainly with teaching and instruction from a classical perspective with content that is fixed.

A helpful approach to support this discussion from a theoretical point of view would be e.g. the philosophical discussion of objectivism versus subjectivism. Furthermore, we suggest relying on the idea of constructivism, which is based on the idea that knowledge construction (and acquisition) is a subjective, collaborative, non-objective and dynamic process (e.g. Fosnot 1996), referring to the concept of "viability" of the content in different contexts (cf. Glasersfeld 1995).

Looking at educational practice, it looks as if the fact whether learning content is considered to be "canned" or considered to be "miscellaneous" is directly related to the domain – is it an relatively rigid domain e.g. mathematics (fixed in a school curricula in which it is more likely to be structured, canned content), or is a domain with an dynamic knowledge, e.g. aesthetical knowledge, where correctness of knowledge is not so well defined (in which case it is more likely to find content with a "miscellaneous" structure).

Aspect 2: The role of the learner

In this section, we go on with a more detailed look on the role of the learner. As far as we see, the role of the learner is located between two extremes. On the one hand a consumer of learning materials and a recipient of assignments and interventions or, on the other hand, a pro-active learner, who is aware of his/her learning process. The view on a learner has consequences for the choice of learning concepts, e.g.: are formal and structured instructional settings or open concepts for the self organised learners used?

Self organised learning can be seen as an activity in which the learners have primary responsibility for their planning, their performance and their evaluation of learning activities in order to attain specific learning goals. A related concept is "self directed learning". Malcolm Knowles describes it as a process "in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (1975, p. 18).

Even if a majority will not claim that self organised or self directed learning plays an important role for the development of competencies, a majority of publications, projects and tools focus on formalised learning settings, tending to develop competencies by structured curricula
The classical setting, where learners are in the role of consumers, can be described as follows: Experts usually refer to learning traditions when they make their view of the learner's role explicit. In educational sciences approaches where the learner does not act actively is the behaviourism and related concepts as the Instructional Design: The behaviourism is based on the first scientific observations of learning and describes how the relation between stimulus and responses can be modified. For example, these theories and related experiments show the best way to train a dog that it should not bark when a bell is ringing. The ideas of the behaviourism are the base for Instructional Design (see Schulmeister 1997). Instructional Design follows the idea of the possibility to foster learning in well dosed, sequenced instruction bits. According to learner's differences instruction is adapted automatically, in relation, e.g. to prior learning, learning styles and so on. Particularly in the domain of artificial intelligence the possibility of automatic "personalisation" of the content is considered as an automatic adaptation of the learning content to the learner's model or profile (according to the intelligent reasoning). For example these (pedagogical) ideas were taken to develop so called intelligent tutors: "the server should appear to act as an intelligent tutor with both domain and pedagogical knowledge to conduct a learning session. It should use a presentation planner to select, prepare, and adapt the domain material to show to the student. It also must gradually build the student model during his session, in order to keep track of the student's actions and learning progress, detect and correct his/her errors and misconceptions, and possibly redirect the session accordingly" (Devedižić 2004, p. 32). With these intelligent tutoring systems, the learner's possibilities are usually limited to structure and organise his/her learning steps.

As with any new media technology, there has been a tendency to imitate previous educational paradigms, such as – for instance – the "electronic classroom" (Geser 2007, 37). The disillusion about the missing successes of the e-learning hype and the new requirements on competence development have shown that the development and implementation of new technological supported learning and teaching methods are crucial.

So, the role of a learner as active, self-organised and self-directed learner is also not just discussed but also implemented as core attribute in projects for learning in the Semantic Web.

Especially educational experts often refer to the constructivist learning theory when they favour open educational practices or support learner centred approaches focussing the learner's interests and (informal) activities. Originally a philosophical approach, the constructivism it also used and adapted to the field of learning. The constructive view on learning results in a design of a learning environment facilitating the construction of learner's own constructs: "The ideas underlying constructivism suggest that we shift from designing learning environments that instruct to designing environments that influence the structure of autopoetic unities in ways that conserves organization and adaptation" (Knuth & Cunningham 1993, 167).

Based on these ideas, learning in the Semantic Web focuses for example on the following prototypical implementations, where learners play an active role and the learning process is dominated by the user participation:

- Social Software (especially "semantically enhanced") supports user centered and active learning. Furthermore, it can be seen as a support for informal learning: Weblogs, Wikis, discussion forums, folksonomies etc. need on the one hand an active participation of users, on the other hand, they support user interaction and participation. For instance a Semantic Wiki can be seen/used as a possibility to enhance self-organised learning and open educational practices in terms of collaborative writing (see Schaffert; Bischof, Bürger, Gruber, Hilzensauer & Schaffert 2006).
- Personal learning environments (PLEs) allow a personalised and individual view on individual learning activities. PLEs are currently developed as "mash-up" services of existing Social Software applications. Semantic technologies are needed in the near future in order to further develop the PLEs.

After the discussion of the content's and the learner's role we will discuss the role of the social involvement of the learning process.

Aspect 3: The social involvement

The third important aspect is the amount of social involvement of the learners through collaborating with other humans, e.g. in social communities and networks: The question is, whether other humans – experts, teachers, students, class mates, a community of practice – play an active, important role in the learning process? Is collaboration, communication and the communication within the learning community enabled or supported?

Again, both extremes (the user on his/her own or a learning community as the base of the learning process) of this aspect can be found in technological and pedagogical concepts.

From pedagogical perspective, there are different theories and concepts, some with, some without concrete linkage or notion for a need of an active social environment. For example, the above mentioned behaviourism does not take social aspects into account. In contrary, the social involvement plays an important, even crucial role in constructivist learning concepts: Learning is a recursive, self-referential process and needs the stimulus and challenge through others (Siebert 1998).

From a technological perspective, the social aspects (in terms of the need of humans as teachers or for communication and collaboration) are not overseen but are obviously not in the centre. It is not very challenging (technically) to implement collaboration or communication in a learning environment. Concerning the discussion of semantics and learning, the social communities or teachers are more or less reduced to their provision of learning objects and meta data.

Especially approaches that are developed in the tradition of artificial intelligence forget or oversee the importance of social collaboration for learning and state that a human teacher could (or should) be replaceable by a computer. In this discussion, they totally forget to take the missing social aspects for learning into account. In a way that is surprising, because it is not very challenging to add-on collaboration and communication tools.

But again, there are some technical experts that are not only mentioned, but even concentrate on social aspects of learning: the Social Software experts favour the role of the community and their interaction. Social Software always needs and builds on communities. They are needed for contributors, co-actors, and last, but not least, for someone to provide /recommend (new) learning content and/or metadata to existing content. Current research tries to develop collaboration architectures for the Web to support the new framework characteristics: decentralisation, openness, dynamics and user orientation (e.g. Tapiador, Fumero, Salvachúa & Aguirre´2006). The vast number of tools, supporting collaboration on the Web is an indicator that social networking tools are not only a flash in the pan, but lead to a new notion of learning and a measure for sustainable competence development.

Results of a short exemplary project screening

Additionally, our descriptions of underlying concepts and theories could also be used as an outline how ideas, tools and concepts in the field of learning with the Semantic Web could be compared and assessed.

The goal of the following screening is to illustrate our assertion that a wide variety of concepts are used in the field and application area "learning with the Semantic Web". For that we selected some of the projects published in the last years and are from general interest (e.g. financed by the European Commission).

In the following summaries we tried to illustrate how intense the projects illustrate and/or take these three aspects into account: Is the learning content seen as something miscellaneous and under development? Is the role of learner that of an active, self-organised creator? Does the social involvement, e.g. the learning communities, play a role?

In the following tables, a small black square symbolises a focus on the different aspects, a grey one a moderate discussion or implementation of an aspect. A white square does not mean that the authors do not mention this aspect completely or deny it, but it definitely does not play an important role.

Concerning the following six projects and their developed or planned tools we found very differing approaches and underlying concepts (see Table 1). The classification was not so easy, because our data about the projects was limited to the current publication and self-descriptions at the homepage (because e.g. the full proposals are not published). On the other side, e.g. the APOSDLE project produced a long list of publications that are not easy to analyse (and where it is not easy to decide the tightness to the APOSDLE idea). So our findings are based on the current status of the self descriptions on the homepage, concentrating on the self descriptions and central position papers (end of February 2008)[3].

[3] A reviewer of this paper commented: "I don't think one can easily say whether or not a project addresses a certain dimension – there are shades of grey. Moreover, three out of six projects dealt with have just started within the FP7 framework. I doubt whether the initial self-descriptions can be used as some sort of trend analysis." Nevertheless, the screening is still included in this contribution, because we a) neither found variances of the classification done by two of us independently, nor convincing arguments why we could not use project self descriptions (or which alternatively products we should assess).

	content not fixed or objective	learner as active creator	social interaction and communication
ActiveMath: Web-based, user-adaptive ActiveMath platform for mathematics in school, university, and in life-long learning (developed by the Universität des Saarlandes et al., www.activemath.org):	▪	□	□
LUISA: learning content management system using Semantic Web applications (EC funded FP6 STREP, http://www.luisa-project.eu/www/)	▪	□	□
GRAPPLE: Generic Responsive Adaptive Personalized Learning Environment (EC funded FP7 STREP, 02/2008-02/2011, http://www.grapple-project.org/)	□	□	▪
APOSDLE: Advanced Process-Oriented Self-Directed Learning Environment (EC funded FP6 IP, 03/2006-02/2010, http://www.aposdle.tugraz.at)	■	■	■
MATURE: conceives individual learning processes and knowledge to be interlinked in a knowledge-maturing process (EC funded FP7 IP, http://mature-ip.eu/)	■	■	■
LTfLL project: Language Technology for Lifelong Learning (EC funded FP7 STREP, 03/2008-02/2011, http://ltfll-project.org/)	■	■	■

Table 1: Content analysis of projects and tools in the field of Learning with Semantic technologies

The screened self descriptions of the projects show that a majority is located either on the "left" OR on the "right" part of the scale – we did not find combinations of both aspects (see Figure 1). This illustrates the paradigm shift from (rather static and instructor based) e-learning 1.0 to (a more user oriented, socially enhanced) e-learning 2.0.

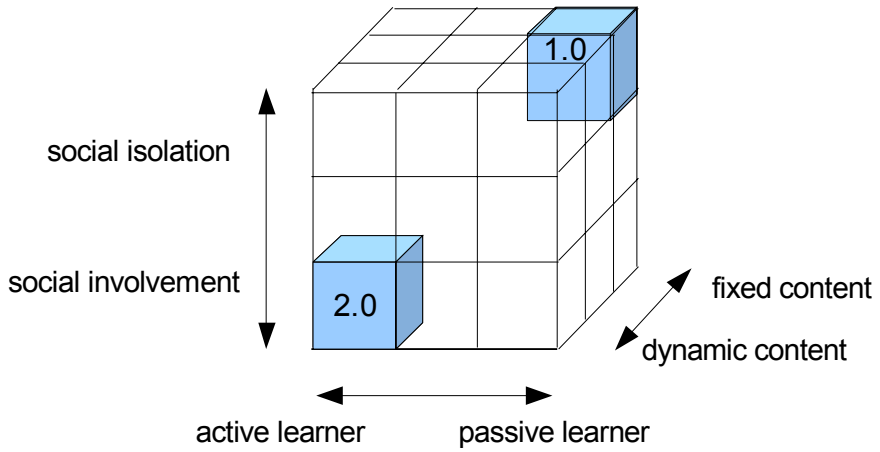

Figure 1: The two dominant types of projects concerning to the three aspects of their underlying concepts in the field of learning with the Semantic Web: Illustrating the paradigm shift from e-learning 1.0 to e-learning 2.0 (just for illustration purpose; the aspects are not orthogonal as depicted in the figure)

So, with this screening we tried to illustrate our assumptions and some critical statements about a wide range of underlying concepts in the field of Semantic Web and learning concerning the identified three aspects.

Summary and Outlook

This paper tried to clarify and illustrate differences and contradictory underlying concepts of learning with the Semantic Web.

To summarise our analysis: We have the impression that self organised and self directed learning is mostly discussed in the educational field and in the field of Social Software (e-learning 2.0), whereas the technological field in general focuses on teaching and instruction (e-learning 1.0). So, interestingly, the differences are not only based on differences between pedagogical and technological perspectives of learning: There are also differences within both disciplines, according to theories, research traditions and philosophies: We find big differences in the use of semantics for learning between technologists coming from the artificial intelligence traditions on the one side and Social Software experts on the other side. Besides this distinction there are also differences between e-learning experts favouring Instructional Design and programmed learning on the one side and others, favouring open educational approaches (see Table 2).

To be fair, neither formal logics nor artificial intelligence actually preclude a constructivist approach to learning. On the contrary, artificial

intelligence technologies could result in much better constructivist learning environments by e.g. providing appropriate situations or recommendations. Unfortunately, most e-learning researchers with artificial intelligence background are still primarily focused on instructional design and behaviourism, presumably because these learning approaches are much closer to the formal tradition these researchers are used to.

	E-Learning 1.0	E-Learning 2.0
Pedagogical background	Instructional Design and behaviorism	Constructivism and adapted learning concepts
Technological background	formal logics, artificial intelligence	Social Software, (new) information science
Domains	e.g. mathematics, languages	e.g. psychology, history
Focus of Semantics for Learning	to enhance instruction and teaching	to support personal, collaborative learning settings

Table 2: Features of the two extremes of underlying concepts of learning with the Semantic Web: e-learning 1.0 and 2.0

Beyond the three discussed aspects we assume that the role of the technology itself could be an additional possible aspect that could be used to differ and identify underlying concepts in the field of learning with semantics: is technology seen as an "answer to all" or is it reduced or limited as an additional (nevertheless important) solution to support learning? We do not spread this discussion, because it can easily be seen that in a way we had put the cart before the horse when we describe the role of the Web and technology and different perspectives on it, because this is directly connected with the role of the learner, just the perspective changes.

What we did not do inside this paper is to refer on experiences and evidence with the different theories and technological implementations of and for learning. Nevertheless, with this paper, we hope that we can initiate and contribute to a discussion on a meta level and an appeal for a more profound and theory based construction of ideas and tools.

We hope that we could also clarify and illustrate, that the idea of the support of self-organised learning and self-directed learning does not fit to a lot of papers, ideas, and tools concerning the topic of "Semantic Web and learning". Supporting self-organised learning means that the learner can be act self-controlled and self-responsible. This might contradict to an adaptive environment arranging all learning objects and learning paths around his learner's profile.

In the introduction we already emphasised to support self-organised learning and teaching methods which supports the learner. But, such a statement needs some additional remarks: We know a lot of situations and topics where predefined learning paths and "programmed learning", including instructional design could be an appropriate tool, e.g. for young learners, for well defined factual knowledge (e.g. math exercises, learning additional languages). Additionally we are also aware of the fact that self-organised learning abilities could not be assumed for every learner and that open learning practices privilege special groups of learners, e.g. children from middle classes (see Sertl 2007). But besides these specialities and challenges we would like to favour educational settings and teaching methods which encourages and foster the learner and his/her self organised learning abilities in general. Open educational practices and tools which support self-organised learning are the appropriate means facing the requirements of a so-called knowledge society trying to enable and foster life long learning.

Concluding, we want (again) to emphasise our perspective of an adequate usage of the Semantic Web for learning: We follow a competency-focused, collaborative paradigm of learning and knowledge acquisition and favour open educational practices. This means that priority should be given to learning communities instead of teacher-centred education. The development of knowledge requires to tackle and to solve problems instead of subject-centred knowledge transfer. Generally, this will demand an active, constructive engagement with content, tools and services in the learning process (see Geser 2007, 38). Semantics could be an up-and-coming add-on to deal with meta data, which could enhance the collaboration, appropriateness search for learning objects and learning in general. So, especially in the field/area of self organised learning and open educational and technologically enhanced practices, such as Webquests or e-portfolio, and in a clever adaptation and usage of Semantic Social Software we see possibilities to enhance learning (e.g. Schaffert & Geser 2008; Attwell, Chrzaszcz, Hilzensauer, Hornung-Prähauser & Pallister 2007).

For that, a stronger commitment and collaboration between educational and technological experts would be needed, which is not easy. Formal (in the sense of mathematical logics), well defined concepts, wordings, and requirements do not fit with assumptions of educational experts looking at learning as a dialectical, fuzzy and unregulated phenomenon.
We know how hard it is ☺!

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