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InteractiveSchoolWall: A Digital Enriched Learning Environment for Systemic-Constructive Informal Learning Processes

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Abstract: In this paper we reflect on the impact of a novel digitally enriched learning space for teaching and teacher education. For this purpose we present a hypermedia presentation and interaction platform, publicly accessible in the lobby of a secondary school in northern Germany. We show how this learning space digitally extends learning spaces in a new way. Interactive navigation and self-determined networking allow active learning in an informal way, where students, teachers and, indeed, all other people involved in school engage in the presentation and exchange of views. We explain how to meet the pedagogical implications of a presentation and interaction tool, called InteractiveSchoolWall (ISW), with the requirements of *Open Learning*. The ISW consist of multiple multi-touch screens running specific applications, i.e. *Interactive Timeline, Hypervid Player, Semantic Map,* and *Media Gallery*. The technical construction of the ISW follows the logic of a novel digital network environment (NEMO). This framework allows the cross-wise use of personalized and semantic enriched multimedia objects. Referring to recent systemic-constructivist pedagogical approaches and media-theoretical considerations we reflect on the function and significance of the ISW as a specific multimedia learning environment. A first impression of teachers' reaction to the system is presented. Finally we discuss to what extent the interactive structure of the ISW encourages the reflective handling of complex knowledge, so that teaching models in teacher education and in-service teacher education programs can be enhanced. We envisage that the ISW will open new perspectives in the management and organization of schools, thus improving school development processes.

Introduction

We all live in a world where digital media have developed rapidly, and this exerts a powerful influence on people's lives. But the acceptance of these new media differs widely. Children and young people have grown up with this new world of computers. The enormous technical achievements have become part of students' everyday life and many know how to use them effectively. This is not so for many older people, among them teachers. Older citizens need to learn how to use the advanced technology that is more than just an extension of traditional office technology. This is not only a matter of handling them technically. These new media represent a totally new form of constructing knowledge, of processing reality.

In this paper we want to explain, in what way a web-based hypermedia platform for presentation and interaction at school, the so called *InteractiveSchoolWall* (ISW) (Figure 1),[1] may change the attitude of teachers by means of new additional learning space. We will deal with the problems emerging from this medial extension of learning space regarding teachers in school. But also the opportunities for school development provided by the ISW will be discussed. Further on we describe the technical and theoretical context, in which the design of a digitally enriched learning environment is embedded. We emphasize the importance of web-based software and the use of personalized, semantic-annotatable media objects, which can be used on a variety of different hardware with novel physical and spatial interfaces. These are considered in the context of systemic-constructive pedagogies, particularly in their role for the co-construction of knowledge, and the assistance in the symbolic organization of certain areas of experience (Holz, 2008). Regarding media theory, the design of the ISW is based on the thoughts of McLuhan, that media are extensions of man (McLuhan, 1964). deKerckhove extends this theory by saying that the increasing cross-linking by means of digital media effects changes in individuals as well as in society. Humans and digital media form a *dynamic interconnected system* that can be understood as *connected intelligence* (deKerckhove, 1997).

[1] The concept of this project and its realization was set up in cooperation between the *Institute for Multimedia and Interactive Systems* of the *University of Luebeck*, the *Institute for Quality Development at Schools in Schleswig-Holstein*, and the Secondary School *Carl-Jacob-Burckhardt Gymnasium*. They are located in northern Germany.

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Figure 1: The ISW. Above the multi-touch screen are webcams and below the screens RFID-reader.

Our research on an innovative learning environment is founded on Design-Based Research (Brown, 1992). According to this approach theory and real-world usage are conjoined and of equal importance. Thus theory and applications evolve simultaneously during the design process. In a collaborative design process the implementation of the ISW began in 2010. The applications were developed by a group of students in media computer science in cooperation with the users. The construction of the ISW consists of several multi-touch screens, speakers, web cams with microphones, RFID reader and embedded computers with Internet connectivity, built into a wall in the lobby of the school. There is a platform that provides a place with body-and space-related interfaces and applications that emphasize social and physical activities. This place is freely accessible for all those involved in school and offers playful and interdisciplinary, exploratory, collaborative work and learning.

In a first, very early survey teachers were asked about the combination of subjects they teach, whether they have used the ISW already, how they like the ISW, and whether they want to use the ISW for their work. Because the currently available applications of the ISW are in a still ongoing co-design process, influenced by pedagogical implications, accompanying evaluations are ongoing and will be performed in future. This is and will be done in several stages and at different levels of evaluations with different users: students at school, their parents, teachers, and teachers in education.

New opportunities for learning with digital technology

In the future people may well intercommunicate with their digitally-enriched physical environment not only via keyboard and screen, but with their whole body. Intelligent spaces, digitally enriched everyday objects, mobile devices, as well as body-worn computer systems, such as interactive and intelligent clothing and jewelry will radically change our learning spaces. Also a key role is played by systems across, Internet-based connectivity of applications with specific reference to body and space. In order to realize learning scenarios with this interconnectedness we are developing and implementing a platform called *NEMO* (*Network Environment for Multimedia Objects*). NEMO is a new kind of media repository, which provides the user with access to contextualized, personalized, semantically enriched and device-specific *NEMO Multimedia Objects (NMOs)* (Winkler & Cassens, 2010). These NMOs are containers for metadata and media objects, which consist of media entities like videos, audio files, texts or 3D objects. These media hold different kinds of meta-information like authorship, access rights, content descriptions, semantic annotations, location data, or device-specific information. These data make the NMOs much “richer” than most multimedia data, which allows deducing dependencies between NMOs or retrieving user- and location-related information (Winkler Scharf, 2011).

NEMO Multimedia Objects can be accessed and manipulated from a variety of computing platforms and interaction devices, such as mobile phones, multi-touch tables, desktop computers and of course the ISW. NEMO facilitates the communication and exchange of data between those devices. Users are able to work on the same set of data, while making use of the distinct advantages and capabilities of the current computing device they use. For example, en route, one can survey objects or make small annotations on a mobile device, while at home at the desktop computer, complex and optimized tools can be used on the same object for further processing. As NEMO knows which device and device type it is communicating with, it is able to adjust the content of the NMOs to adjust to the capabilities of the different devices. Multi-touch screens need information about position, rotation and scale of an image, while cellular phones just need basic and low-resolution images. The ISW will get larger sized versions of videos and pictures or more additional information of the same object than mobile devices because of their greater resolution and display size. The digitally enhanced learning environment ISW in context with NEMO can be a powerful informal space for professional education, playful and exploratory learning and working. Most notably, the importance of direct social interaction in groups is promoted. As an exploratory space, the available applications function almost as a kind of new instrument. In communal experience, they allow us to see, survey, orient and interact with the digitally shaped world.

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Systemic Constructivist pedagogy in context of a digitally enriched learning environment

Our world, including the world of schools, can no longer be structured deterministically or generally. According to Leo Marx, this is …*"truly an almost a miraculous era. What is before us no one can say, what is upon us no one can hardly realize."* (Marx, 2010). Nothing is how it seems any longer: reality is not clearly or objectively interpretable. Hence, in the future it is important that students learn to gather knowledge (which is always unique for every individual) from new contexts, and to recognize the underlying knowledge structures. School must evolve to *"allow new educational products, such as reconstruction, new construction, deconstruction of knowledge, ...for future applications, contexts and situations."* (Kösel, 2007) According to Kösel, knowledge differs from information in this way: that information is transformed into personal knowledge through the process of acquisition, judgment and reflection of the viewer in relation to others (for example, through common usage), through contradiction, and through recognition of distinctions; and thus becomes available as a tool for coping with existence. "New and different" structures of awareness, precipitated by today's new forms of identity representation, media aesthetics and body orientation, must be integrated into students' "cognitive toolkit". Nevertheless, teachers react primarily in the confines of their own "cognitive" structures – they cannot see what they have not learned to see. The ability to develop and promote autodidactic competence is strongly influenced by the extent to which educators themselves were able to experience self-directed learning or not. These paradoxes can be observed as the inner self-contradiction of Teacher Education: one argues for new learning culture in forms and methods of the old culture of learning (Arnold, 2007). Teachers themselves need to make statements about the architecture of their learning, to be able to reveal them, to finally have the ability for new designs. For the mediation process in the sense of an "organized knowledge work" it must be asked in what way digitally enriched "metaphors" allow a learning culture, in which learners are able to construct and communicate knowledge, self-determined and socially interactive rich in connotative references. The didactic potentiality of digitally enriched learning environments, as implemented with the ISW, is based on the dynamic knowledge representation, which initiates a highly visual, affected, "intelligent" communication and interaction between learners and computer system. In particular, the exposure to visually represented complexity is essential for the construction of structures of understanding. This culture of learning is motivated and promoted by visualizing the ongoing disciplinary and interdisciplinary debate on "intelligence", i.e. contextually and in semantic relation. Participation and co-construction of knowledge occurs by the connection between cognition and action, due to the appreciation of patterns in which the student learns to ask questions.

Media theory as inspiration for the design of digital enriched learning space

Today the phrases and aphorisms *the global village* and *the medium is the message* by McLuhan are standard terms in our contemporary vocabulary. Media have always expanded our body, but now this is done at a very rapid pace. Through the novel web-based media with new body- and space related interfaces, our culture, and our relation to time and space is changing in a radical way (McLuhan, 1964). Computer systems with which we live almost in symbiosis are understood here as the so far most flexible extension of man, in terms of McLuhan, or as autonomous dialogue partner or agents. The rapidly increasing networking with these changing media effects individuals and society. Humans and digital media form a dynamic, *interconnected system* that can be understood as *connected intelligence*. According to de Kerckhove it is important, that we are involved in the design process on these media, such as neural networks, so they do not design us. Here a major role is played by *open source* and *common media data*, like public domain and free license, which all people are allowed to use (de Kerckhove, 1997).

The InteractiveSchoolWall and their (current) applications

The ISW serves as a platform for presentation and interaction for informal learning. Groups of learners can structure and arrange information, supported by visual aids. Although no systems similar to the ISW exist at school, many applications akin to those found in the ISW have already been developed in other contexts and examined in research. Based on our experience in developing several interactive applications for learning during the last years (Winkler & Ide, 2011; Winkler & Ide, 2010; Winkler & Ide, 2009, Winkler & Ide, 2008) we argue that body- and space related digital learning applications at school can only accomplish sustainable enhancement if they are always present and accessible for all students as well as the teachers. Our solution to this challenge is based on the idea of a

physical-dominant user-interface, placed centrally inside the school building. We explain how social co-operation of students can be fostered by placing the InteractiveSchoolWall (ISW) at a vital, physical place at school, on permanent display. The ISW provides new options for co-operative, explorative, informal and in further time game based learning. By means of a multimodal (haptic, acoustic, visual, etc.) and multicodal (images, writing, music, etc.) interface students are able to communicate and interact with the ISW and with each other. The design of the ISW supports various body- and space-related applications, e.g. *timeline*, *hypervid*, *media gallery*, and *semantic map*. In the near future the ISW will be also a place for partial learning with the *Mobile Learning Exploration System* (*Moles*), a place for performances using the webcams imbedded in the ISW, or a place for imploding physical space by communicating and interacting with others at distant places all over the world in real time.

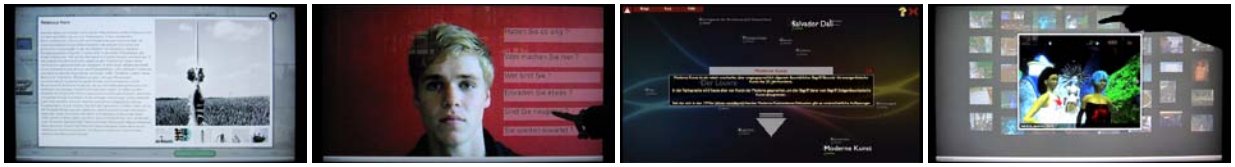

Figure 2: Timeline, Hypervid Player, Semantic Map, Media Gallery.

Timeline

The timeline of the ISW is implemented as an organizational tool in the context of learning. It can visualize the contents of existing courses at school basically in cross-curricular connections. The design of the timeline tool makes complex relationships comprehensible in an intuitive way. The composition of each timeline is designed dynamically. That means, the timeline interface allows you to place content on a specific issue-oriented timeline in a specific way, so that the content and timing relationships are visible between the different subject areas (Figure 2). For the user every single item on the timeline is represented by an icon. An enormous amount of data is hidden behind it, visualized by means of image, text and video. The respective data entries describe information in relation to the time entry, which the viewer can explore by navigating freely. In parallel, contextual linking to other topics, simultaneously a multiple way of looking at things appears, indicating new contents (not previously imagined) to the viewer. The form of data-visualization is essential for the thinking in networked contexts. It helps students to understand specific events in interdisciplinary contexts.

Hypervid Player

Hypervid is a browser-based interactive system for creating, editing, managing and playing hyper video. Due to time jumps within a video hypervid enables to understand a story not as a rigid structure. Instead, while watching, the story can be generated within a specific scope. The hyperstructure is reticulate, associative thinking comparable. The advantage of hyperstructure is that no context-dependent, tree-like classification systems are necessary for systematization or acquisition of terms. The design of hyperstructures implies more than another form of presentation level. It allows you to look at information in their intercorellation with each other in networked contexts, also implies playful thinking, and focused not on monocausal solutions in terms of explicability of objects but uses the potential of navigation of the interaction of the user for a variable set of perspectives. The linked video fragments can be shown by hypervid player in a secured browser (Figure 2). On the one hand, this blocked the ability for users to leave the resulting hypervideo. On the other hand, it increases the degree of immersion, because the hypervideo does not leave the full picture and the video fragments load dynamically inside the player. Also *hypervid* offers the possibility to create groups. Making videos for one specific group accessible and manipulable, groups can communicate with each other. Therefore the systems stay abreast of changes in today's increasingly networked media society and allows for shared learning all over the world.

Semantic Map

The potential of the *semantic map* lies in the possibility to visualize documents of various types of content in their relationship to each other and spatially adjacent (Figure 2). The basis of the interface is that we must act on the assumption of changing organizational forms and ways of thinking in the acquirement of world view, information may no longer be taught sequentially but by fragmentation and linkage (Kuhlen, 1991). By connecting information on similarity principles in meshed complexities, the semantic map organizes and visualizes such multiple perspectives on the world (Bush, 1945; Fleischmann, 2001-2010). It illustrates in what context of a whole and a detail a

term can stay, which references and links exist to related content, and in which spatial relationships this can be arranged. Thus, the observer finds it easier to navigate and orientate in wide range of topics than in a traditional online search, where content is distributed without regard to context in various pages. The fact that the viewer behaves actively using the semantic map, selecting individually specific terms, an expanded idea of knowledge as a way of thinking in higher complexities can be promoted.

Media Gallery

Contemporary forms and formats of representation of "self" have changed. Young people increasingly communicate and interact via chat and pictures on internet forums. The media gallery represents in their possibility for presentation of images and videos a surface, in which potentially reflect all facets of school life (Figure 2). Divided into content categories such as projects, working groups, study tours, forums, art, music, theater, sports, etc, it provides almost unlimited space to visualize the variety of school life in image and video for students, teachers, parents, and guests. So that it becomes an important tool of social interaction within the school, which can contribute to identity formation and appreciation. Free navigation and content selection allows investigating individual projects that are always expandable. Depending on the priority of specific projects and priorities within the school work, the presence of content on the ISW can be controlled temporarily, to make an emphasis on the visualization of specific content.

Evaluation results as focus of a new role for teachers in the learning environment at School

Background

This section describes preliminary results of a questionnaire provided to the 67 teachers of the school. The questionnaire was distributed to the teachers in the teachers' room together with envelopes for anonymous return. Participation was voluntary and no incentive was given to the participants. The ISW ran for test purposes for three month. This offered the chance for teachers and students to get in contact with the system. The ISW was in regular service on 7 schooldays when the questionnaire was distributed. Different applications ran on the ISW (timeline, media gallery and hypervid player)[2] and all teachers and students of the school had access to the system and could become acquainted with it. The sample consisted of 18 teachers with two persons excluded due to missing values and lack of demographic information.[3] So the final sample consisted of 16 persons. This small sample size corresponds to a response rate of 24%. The sample comprised 9 men and 7 women. The participants' mean age was 44.6 years (SD=9.4) with ages ranging from 31 years to 62 years. The participants taught subjects covering the whole range of subjects of the school (table 1).

Subjects	N	(%)
German, foreign languages, art, music, performance art	11	(68.8%)
history, geography, economics/politics, religion, philosophy	9	(56.3%)
mathematics, biology, chemistry, physics, information technology	3	(18.8%)
sports	3	(18.8%)

Table 1: Teachers' school subjects (N=16). Note: Teachers often belong to more than one category.

Activities and applications

Teachers were asked to report frequencies of different activities concerning the ISW. The activities were reading or viewing information presented by the ISW, the use of applications by the persons themselves, the search for information and a visit to the ISW along with students. Participants specified whether they had performed activities "never", "occasionally" or "often". Because the system was very new, it was not surprising that none of the activities was performed "often". The results indicate that the majority of the respondents had read or viewed information and half of them used, started or quit applications. This might suggest a rather exploratory approach to the system. The distribution of answers is depicted in table 2.

[2] At this time the semantic map was not running, because of technical enhancements.
[3] Teachers who were involved in the developing process of the ISW did not participate in the evaluation.

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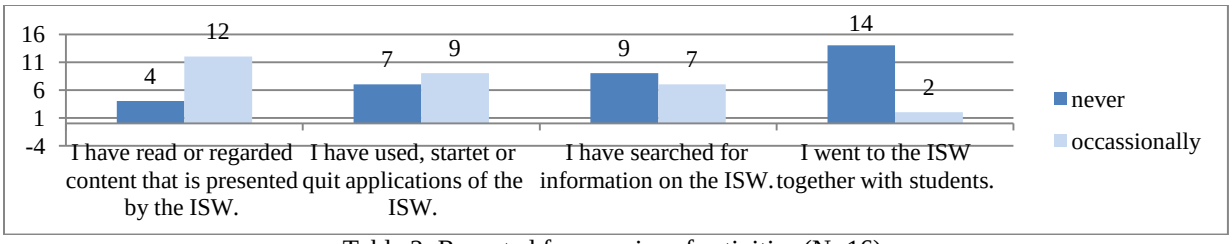


Table 2: Reported frequencies of activities (N=16).

Further, respondents were asked to report their affinity for the existing applications. Additionally, they were asked if they knew of the applications. The affinity was judged on a 7-point scale (ranging from -3="very bad" to 3="very good"). For this rating it has to be kept in mind, that sample sizes were very small. The applications timeline and media gallery were rated positively by the respondents (table 3). Both means were significant different from the middle of the scale (timeline $t(7)=3.90$, $p<.01$, media gallery $t(9)=3.50$, $p<.01$, hypervid player $t(1)=-0.33$, ns). Only two persons rated their liking for hypervid player, which 12 participants reported not to know. This might be explained by the demonstrative nature of the application during operation time. Table 4 reports upper and lower limits of confidence intervals of the means.

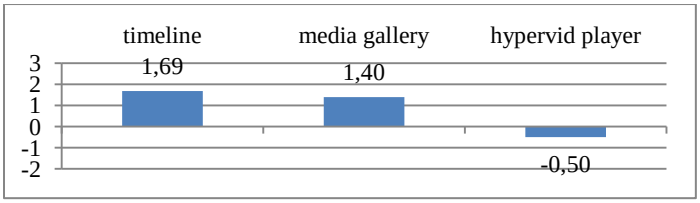


Table 3: Means of rating the existing applications.

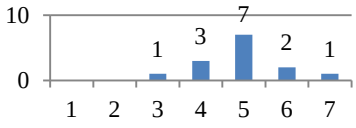
	timeline	media gallery	hypervid player
N	8	10	2
Mean	1.69	1.40	-0.50
Standard deviation	1.22	1.26	2.12
Upper limit (95%)	2.71	2.30	18,56
Lower limit (95%)	0.67	0.50	-19,56
N application unknown	6	5	12

Table 4: Means and confidence intervals of liking for the applications.

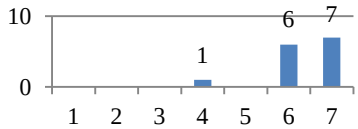
Further, teachers were asked whether they intended to use the system in class, e.g. for presenting or searching for information. Seven of the participants declared that they intended to use the ISW in class, whereas one person negated this. Eight participants did not know yet whether they wanted to use the system in class or not.

Finally, the agreement on simple statements on pedagogical issues concerning the ISW were rated by the participants (7-point scale ranging from 1="I do not agree" to 7="I totally agree"). The distributions of answers (table 5) as well as mean, standard deviation and median (table 6) are reported for a simple descriptive inspection.

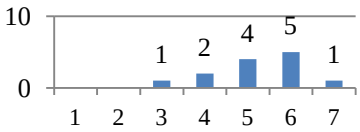
1. The ISW encourages me to present and work on content.



2. The ISW can support students in learning.



3. The ISW enhances informal learning.



4. The ISW offers special opportunities to the school.

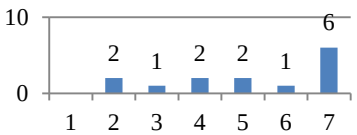


Table 5: Distribution of answers.

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Statement	Mean (standard deviation)	Median	N
1. The ISW encourages me to present and work on content.	4.89 (0.92)	5.00	14
2. The ISW can support students in learning.	6.36 (0.84)	6.50	14
3. The ISW enhances informal learning.	5.23 (1.01)	5.00	13
4. The ISW offers special opportunities to the school.	5.21 (1.93)	5.50	14

Table 6: Mean, standard deviation and median of the statements.

It has to be taken into account that this data is based on a very basic method. Nevertheless, we want to present a first impression of a sample of teachers' reactions to the system. According to demographic information the participants covered a wide range of the school, but no information is available on representativeness regarding the investigated issues.

Conclusions

Processes of teaching and learning, which are in principle open and not constricted by linear models of mediation, open spaces for independent learning and various forms of appropriation of knowledge. This thinking underlines, that learners can only learn by themselves. But it is necessary to create motivational events for self-directed learning and reflexive use of complex knowledge. In this context the ISW, as a dynamic, enriched digital presentation and form of interaction, extends the existing learning environment in school to this important didactic function: it represents diverse perceptions and scripts by the learners to acquire a picture of world in such a way, that the appropriation and self-learning competences can be strengthened.

The result of the initial evaluation makes clear, that a larger number of teachers surveyed, are observant, cautious, undetermined, or in opposition to changes regarding previously practiced knowledge-oriented ways of teaching. This is reflected in the number of those who have not participated in the evaluation (table 1). Simultaneously, this can also be an expression of an inner, structural uncertainty of the teacher, questioning his role as "facilitator of content" by a systemic-constructivist teaching-learning model, as it is based on the ISW. In contrast to this, the distribution of the responses of those who have participated in the evaluation, a predominantly constructive attitude towards the ISW is shown: in their opinion, the ISW opens special facilities for the school, promotes informal learning of pupils and the teachers feel encouraged, to work with the ISW to present content (table 5).

The first survey shows that in daily contact with the ISW a high affinity for the timeline is identifiable. In comparison, the *Media Gallery* is a little less used (table 3). These responses are interesting, as this visual and auditory form of restructuring and integration of knowledge obviously arouses interest. The *Hypervid Player* requires a high degree of willingness on the part of the teachers to question the usual thinking in linear structures. Currently, the survey suggests that the low affinity for hypervid could be a result even less pronounced form of thinking in hyperstructures. Particularly by divergent scripts of perceptions of teachers and students, it is necessary to initiate systemic-constructivist motivated thinking to design new learning spaces within teacher education and further teacher education. Here are the media more than just technology: As a mediator of learning processes different media unfold options for different kind of thinking about their content, messages, and diverse ways of offerings. It is similar to the ISW, which can improve a new framework and context for teaching - and the school life in general.

In the context of ongoing evaluation, we look to what extent the ISW will open new perspectives in the management and organization of schools. It serves in particular as a place of knowledge construction for learners. In its non-hierarchical structure, the ISW provides a new architecture for knowledge construction. It does not meet the conventional academic structures of learning, but expands them. As an example for teaching models in teacher education and in-service teacher education programs the ISW provides new ways of thinking and learning structures and therefore improves learning and school development processes. The existing training formats referring specifically to ISW applications, e.g. hypervid (Winkler, 2011), are developed on the basis of ongoing evaluation in a way that shows how this learning space digitally extends learning spaces at school in a new way. Interactive navigation and self-determined networking allow active learning in an informal way, where students, teachers and other people that are involved in school are engaged in the presentation and exchange of views.

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