Knowledge Building in User-Generated Online Virtual Realities

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***Abstract*—In this article, we will point out the impact of user-generated online Virtual Realities (VRs) on individual learning and knowledge building. For this purpose, we will first explain some of the key features of VRs, such as *presence* and *immersion*. We will then describe the specific qualities of *user-generated online* VRs: They have typical features of the Web 2.0, in that users have the opportunity to create content and objects themselves. We will also explain the concept of knowledge building and highlight its applicability in the context of user-generated online VRs. We will point out the key factors of successful knowledge building by discussing the visualization of educational content, learner-object interaction, as well as personal, social and environmental presence.**

***Index Terms*—Virtual Reality, Knowledge Building, Learning, Web 2.0, Immersion, User-Generated Content**

I. INTRODUCTION

In user-generated online Virtual Realities, users can communicate and interact with each other using avatars. The content, form and shape of this user-generated online *Virtual Reality* may be defined and generated by its users. In this article, we will first define in general what Virtual Reality (VR) stands for and define what its key features are and how these may be classified. Then, the concepts of *presence* and *immersion* will be explained. Subsequently, we will describe specific features of *user-generated online* VR applications as systems that emphasize user communication and interaction, transferring Web 2.0 concepts to VRs. Social networking of users, in the sense of a *Social Web*, is one of the essential underlying ideas of the further development of the Internet. Other Web 2.0 concepts are also relevant for user-generated online VRs such as *mashups* of different applications and tools, the concept of user-generated content, and the idea that the web may replace the desktop as the main operating system and become the central entity for different applications.

Our aim is to describe the potential of user-generated online VRs for purposes of individual learning and for collaborative knowledge building. For this purpose, we will first introduce the knowledge building concept by Scardamalia and Bereiter [1,2], which seems appropriate to describe and explain individual learning and collaborative knowledge building. We will also present the co-evolution model by Cress and Kimmerle [3] that focuses on socio-cognitive conflicts between individual and collective knowledge as an important incitement factor of knowledge building. We will explain why this model may provide a suitable explanation of knowledge-building processes in the user-generated online VR context. We will point out the key factors of successful individual learning and knowledge building in user-generated online VRs: we will describe to what extent different forms of visualization of educational content can support learning and knowledge building. We will also point out the importance of learner-object interaction. Moreover, we will discuss the meaning of personal, social and environmental presence for knowledge-building purposes. Finally, we will point out that an online VR provides a platform for user-generated content, and describe in which way the opportunity that it provides to users to generate their own content may be relevant in the educational context.

II. VIRTUAL REALITIES

Virtual Realities (VRs) are artificial environments that were generated digitally. In its simple form, a VR is an interface between humans and machines that will allow human beings to perceive computer-generated data as reality [4]. The feature that defines VRs is interaction by a user with the virtual environment, or in other words, immediate feedback (output, as immediate as possible) from the system to user input, creating a perception of some reality, which is as realistic as possible by using three-dimensional presentation. Most definitions of VRs also imply that data generated by the computer may be perceived with more than one sensory organ (i.e. at least seeing and hearing).

The terms *Artificial Reality* [5] and *Cyberspace* [6] are frequently used as synonyms of VR. Talking of an “Artificial Reality” implies that it is possible to represent content or data, which have no corresponding “real” existence in the real world. “Cyberspace” refers not so much to technical aspects but to the concept of a world-wide data network between individuals. Located in different places, they can interact and communicate in a “social setting that exists purely within a space of representation and communication” [7], p. 535.

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A. *Presence and Immersion*

Classifying VRs by technical complexity of a system does not take into account their users' perception, which should, however, also be among the relevant criteria. Distinguishing VRs by the degree of *presence*, which they allow appears to be more useful [8,9,10]. Steuer uses the term *telepresence* [11], meaning "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment" (p. 76/77). The main point here is the feeling of *being there* [12], i.e. the personal perception of an individual, which depends on the available sensory information, but also on this person's control of attention, motivational factors and other mental processes.

Steuer suggests two independent factors: *vividness* and *interactivity* [11]. "Vividness means the representational richness of a mediated environment as defined by its formal features" (p. 81) (cf. also [13] or [14]). The definition of vividness includes *sensory breadth*, meaning the number of sensory dimensions, which are presented at the same time, and sensory, *depth* as the resolution in which these dimensions are presented. Interactivity is "the extent to which users can participate in modifying the form and content of a mediated environment in real time" (p. 84). The relevant factors of interactivity include *speed* of system response to user input, *range* of attributes that can be manipulated within the system, and *mapping* between input from human users and system responses [11]. In other words, this definition concentrates on those technical features of a media system, which define its presence. A media system may be called a VR if a high degree of presence is achieved, i.e. if there is a sufficient degree of vividness and interactivity that users have the impression to experience a "real" environment. Sheridan [8] even names five factors that will influence the perception of presence: "extent of sensory information", "control of sensors relative to environment", "ability to modify the physical environment", "task difficulty", and "degree of automation".

An even higher degree of reflection of an individual user's personal experience of a VR is contained in the concept of *immersion*, meaning the user's feeling of, so to speak, being immersed in the virtual environment which is provided by the technical system. So the concept of immersion not only takes into account technological aspects of a VR, but also emotional, motivational and cognitive processes of focusing attention. Obviously, a user's intrinsic motivation [15], personal involvement and interest in the respective topic may be considered as substantial factors for a high degree of immersion. The notion of flow [16], meaning a mental state of operation in which the person is fully immersed in what he or she is doing, may also have a great influence on the experience of immersion as defined here in the VR context. The degree of immersion will depend, on the one hand, on what technology provides (thus overlapping with definitions of the notion of presence), but takes into account non-technological aspects as well.

B. *User-Generated Online Virtual Realities*

The inexpensive and simple availability of fast Internet has established *online VRs*. These are network-based desktop applications (displaying presentations on a screen, using a mouse, joystick or 3D mouse), in which users are represented as *avatars* and may interact and communicate with each other. The online VR system normally provides a platform and involves its users in content production. In such a context, it will no longer make sense to distinguish between "authors" or "administrators" as content producers, on the one hand, and users as "consumers" of that content on the other. *User-generated content* as one of the key feature of the Web 2.0 becomes relevant in the context of VR applications, or in other words: User-generated online VRs may be understood as combination of technical facilities provided by an online VR with Web 2.0 concepts. On the one hand, this is an expansion of VRs by adding Web 2.0 features, and on the other hand, the concept of user-generated online VRs implies that the degree of presence and immersion of which a VR is capable will not primarily depend on technical features and not necessarily on the number and fidelity of the input and output channels that it uses [14]. The possibility to generate one's own content (even the appearance and behavior of one's own avatar) supports the experience of immersion. Another important feature for user-generated online VRs, which distinguish them from online games, is that they have no specified goals or rules or programmatic definition. By creating a user-generated online VR, its users decide by themselves how they use that reality and what they want to do in that virtual environment.

To sum it up, the following features characterize a user-generated online VR:

- A user-generated online VR is a 3D platform which is accessible online, not meant for playing a specific game or carrying out a specific program.
- Access is possible using a desktop computer, which is connected to the Internet, without technical barriers, not requiring any specific equipment.
- The appearance and behavior of avatars may be determined and influenced by users.
- Avatars may interact and communicate with each other using spoken and written language.
- Avatars in a user-generated online VR environment share the same perception of this environment.
- Users are represented by avatars, giving them presence in the sense of *being there*.
- Content and objects may be generated by users in real time.

An important prototype for user-generated online VRs is *Second Life* (http://www.secondlife.com). *Second Life* contains many of the above mentioned features. It integrates a voice chat that allows simple communication between users through spoken language. It is also possible to integrate external content (say, from web pages or video streams), and technical progress in this field is on the way. Many educational institutions have understood the benefit of user-generated online VRs and are using *Second Life* as a platform for their own activities, ranging from adult education programs, virtual campuses and language schools to libraries and cultural establishments. But the *Second Life* world is also inhabited by business companies, newspapers, marketing and advertising experts, concert and event agencies, training and coaching providers, financial services and staff providers, authors and musicians.

Second Life is, however, just one example of a user-generated online VR application; there are many others as well, which are considerably different in the range of facilities which they provide and technical requirements for using them. At the same time, we are witnessing a permanent process of technical improvement of user-generated online VR applications, mainly in the direction of more and more realistic photographic representations of three-dimensional environments, integration of external services and applications, and provision of facilities for programming and developing scripts and objects within the user-generated online VR.

III. Knowledge Building

The following section will explain the concept of knowledge building in general terms: what it is, what it implies and what educational philosophy is behind it. We will also introduce the co-evolution model by Cress and Kimmerle [3] that focuses on socio-cognitive conflicts as incitement factor for knowledge building. Finally, we will point out the role of knowledge building in user-generated online VRs.

The concept of knowledge building, introduced by Scardamalia and Bereiter [1,2,17,18], describes the creation of new knowledge in modern knowledge societies as a socio-cultural process. New knowledge is created in a social process and in concrete situations, and this will occur if a community has reached the boundaries of its existing knowledge, and if members of that community are no longer able to explain experiences in their environment with their existing knowledge. Scardamalia and Bereiter compare that situation with a scientific community in which a group of scientists generates new knowledge and then shares it with the rest of the community. According to these authors this ideal form of a knowledge-building community should also be the model for other forms of learning in schools, higher education and job training. Even if such a knowledge-building community will not necessarily create “new” knowledge in the scientific or academic sense, this knowledge – say, of a school class working on physical phenomena – will still be “new” to that respective community (i.e. that class or group of pupils). New experiences with one’s environment will necessitate the construction of new knowledge, regardless of whether or not this knowledge had previously been available to other individuals. Knowledge building is always a discourse-oriented process. By participating in some common discourse, community members will share their knowledge with other members and in this way contribute to the advance of collective knowledge [19].

The services of Web 2.0 offer great opportunities for such a knowledge-building discourse. Through active user participation in the production of content, individuals have the opportunity to participate in a collective development of knowledge and, at the same time, benefit from a vast amount of knowledge that is available worldwide. Knowledge building is intensified by what is offered through the web: individuals participate in self-regulated learning through informal learning spaces, as members of a community of knowledge. The worldwide availability of (mainly free) Web 2.0 tools has opened up a new dimension of knowledge processes: large numbers of users can work jointly on shared digital artifacts [20]. This will not only lead to cumulation of knowledge, by which the knowledge of many individuals is brought together and made available to others, but also to emergence or creation of new knowledge [21].

Cress and Kimmerle [3,22,23,24] propose a model that takes up Scardamalia and Bereiter's approach in more depth, specifying the underlying processes and adopting it to larger knowledge-building communities. Their co-evolution model describes how a large *community of interest* can use a shared digital artifact to construct knowledge jointly. In this context the authors refer to the *wiki* technology. Wikis are collections of web pages in the Internet or local intranets. These web pages may not only be read, but also edited by any user, and users may also create new content, add to, modify or even delete existing content [25,26]. In doing so, several users can create one digital artifact together, and this activity may support the collaborative development of knowledge [27,28,29]. The co-evolution model [3] explains how individuals use the collective knowledge of a community which is stored in digital artifacts (e.g. a wiki). The argument is that wikis support learning (as an individual process) and knowledge building (as a process within a community) in precisely the way that was described by Scardamalia and Bereiter. It is argued that people’s individual knowledge can be used as a supply for learning processes of other people [30] and that a wiki, as a shared digital artifact, is perfectly suited for supporting this kind of mutual use and development of knowledge [31].

Cress and Kimmerle argue that learning and knowledge building are stimulated by socio-cognitive conflicts which exist between the prior knowledge of an individual and the collective knowledge within a community. Such socio-cognitive conflicts may be solved by mutual adaptation of knowledge through discursive processes. In this way, according to the model, new knowledge will be constructed.

Apart from wikis, the model may also be applied to other software tools that individuals use to work jointly on a digital artifact. The authors also describe the joint development of individual and collective knowledge by using *social-tagging systems* or *pattern-based task management systems* [32,33].

One step further is applying this model to individual learning and collective knowledge building in user-generated online VRs. Like other Web 2.0 tools, a user-generated online VR provides a shared digital artifact and an environment with the opportunity to cooperate with other individuals and get access to their knowledge. In this way, user-generated online VRs may induce socio-cognitive conflicts and provide a framework to solve these conflicts. This may occur, for example, if users work jointly on a model, prepare a simulation or represent their knowledge in a concept map and notice in this context that they have different points of view or different degrees of prior knowledge, and try to find a solution together.

In VRs the users are part of the digital artifact represented by their own avatar. Experiencing the social presence of the other community members during the knowledge-building processes may enhance socio-cognitive conflicts. At the same time, the VR provides a framework to solve these conflicts. Individuals may use the opportunities of the VR to visualize own knowledge, interact with learning-objects and communicate with others via written and spoken language.

IV. Knowledge Building in User-Generated Online Virtual Realities

The following section will describe some features of user-generated online VRs that may support knowledge building. We will characterize different forms of **visualization of educational content**, and describe why such visualizations can support learning and knowledge building. Users may interact with learning objects, move around them, look below or behind them, or manipulate the form, shape or behavior of an object. We will point out this in the section **learner-object interaction**. The **personal and social presence** of users (i.e. the fact that avatars of other users are also present in the VR at the same time) and opportunities provided for social interaction are also features of the system that may support knowledge building. In addition to simple ‘who’s online’ information in Web 2.0 applications, user-generated online VRs offer more specific information about other users and a wide scope of social interaction. **Environmental presence** allows users to meet each other in the same environment; they are able to point to things or work together directly on learning objects. Finally, we will point out that a user-generated online VR provides a **platform for user-generated content**. As in other Web 2.0 applications, users are invited to introduce their own content and build their own objects. Taking a constructivist view of learning, one might describe this integration of learners in the role of active constructors of knowledge as an important and relevant factor of successful learning and knowledge building.

A. Visualization of Educational Content

In a VR it is possible to visualize or imitate objects from the real world. The technical features, which VRs provide, can make such a visualization look very realistic, close to the real thing, and in this way users may experience a high degree of immersion in the learning environment. Consequently, learning is a more immediate experience and may be more effective [34]. A close-to-reality presentation gives learners an additional benefit because this resembles what they look at every day and can be understood more easily. An advantage also results from the fact that visual learning content may be processed and remembered more easily than text [35,36]. Imagine a real estate agent who could use a three-dimensional presentation of an apartment. This presentation may be more convincing and understandable than detailed plans of the building. A presentation that is close to reality may also be a good way to “anchor” content from a learning environment in a context that is close to real-life situations. The benefits of this type of learning content have been described in research on *anchored instruction* [37,38]. At the same time, this content is more authentic and refers to some concrete application of what is being learned, which may be an important requirement for motivating learners. This will allow situated learning – knowledge will not remain inert, but may be applied directly.

Realistic visualization of learning objects in a VR may be particularly suitable in those cases in which actual observation of the object or a visit to the real place would be too complicated, expensive or dangerous, or if learners are separated from each other. An example is a geography class that visits a virtual volcano in *Second Life*.

A VR may also be enriched with information that would normally be invisible. This may consist of schematic or abstract information that is not available in real life, like street names on a satellite view of a city, or information which is available but could not normally be perceived by humans without a change or transduction of scale (see below).

Apart from displaying real content, a VR may also visualize or simulate abstract concepts or translate them into some concrete shape. It is possible to materialize data, processes or semantic structures and make mental models explicit. An example is a complex computer network with thousands of workstations, servers and other hardware. The visualization of this network in a VR could help administrators to develop an understanding of the network’s structure and the relations of single elements. In this context a VR is a cognitive tool for problem solving and it extends the scope of a person’s perception and cognition [39]. Understanding abstract concepts, a complex cognitive process, may be easier with a concrete representation. Recognizing connections and patterns requires a smaller extent of mental effort. In the sense of *embodied cognition* [40] thinking is not regarded as a formal operation based on abstract symbols, but it is embedded in a situational and cultural context [41].

VRs also permit a representation of content that could not be perceived or registered by human beings without changing its scale or transduction [42]. *Scaling* may be necessary because the size of the learning object (say, a human cell or the solar system) would rule out direct observation without appropriate enlargement or reduction. The term *transduction* refers to representations of information, which could not normally be perceived by the sensory system of human beings (say, by using different colors for showing a body's emission of different degrees of warmth).

To sum it up, a VR is an environment that provides various opportunities for visualizing educational content. This may support knowledge building especially in such domains in which spatial information is essential for understanding.

B. Learner-Object Interaction

The benefit of three-dimensional representation from the learner's point of view is increased by the opportunity to interact with objects in a virtual environment, manipulate and change them. First of all, learners in a VR can inspect a learning object from all sides, go around it, and look at it from underneath, from above or from the other side. This is an advantage from the point of view of *discovery learning* [43].

What is particularly relevant in the context of knowledge development is an adequate representation of the transition from abstract visualization with schematic diagrams etc. to other forms of representation, which depict and closely resemble reality. This provides external models for mental processes, which can be internalized by learners more easily [44]. The VR provides the model of a cognitive operation that learners have to carry out mentally in order to create their own mental model of certain facts or of a topic of instruction. A dynamic overlay of realistic and abstract representations of the same thing may be controlled by learners through an interactive process, say, by replacing a schematic presentation of an object step by step with more realistic pictures, depending on the individual progress of learning or the extent of prior knowledge.

Scaling of visualized objects may (ideally) also be performed as an interactive process, in order to enable learners, say, to start with the original size of an object and zoom into more detail.

C. Personal and Social Presence

When describing the main features of a VR, reference was made to the notion of presence. Heeter proposes *personal presence*, *social presence* and *environmental presence* as the main dimensions of this concept [45]. The following subsection describes personal and social presence, whereas environmental presence will be dealt with in a separate section. Users in a user-generated online VR have to be represented by avatars. This is a requirement both for personal presence of an individual, i.e. the personal feeling of a user to be there in an environment created by media, and for social presence of other individuals as "sense of being with another" [46], p. 456. In other words, learning in a VR is embedded in a social environment. Social-psychological aspects such as identification with the group, anonymity of group members and the perception of social identity [47,48] are extremely important. What is essential here is the fact that presence will not only depend on the degree of realism of which a VR is technically capable, or, in other words, a technologically sophisticated VR will not automatically lead to a higher degree of presence. The key factor of a feeling of social presence is the amount of available social information, i.e. information that allows interpreting a situation as a truly social, interactive situation. Avatars will not need to be as realistic as possible – the point is that users should perceive them as valid representations of real people.

As far as the significance of personal and social presence for knowledge building is concerned, both are decisive for establishing a knowledge-building community. If knowledge building is regarded as a socio-cognitive process, the perception of presence of one's own self and other group members in a learning environment is necessary for discourse-oriented forms of learning. The existence of media-based representations of other group members makes it easier for socio-cognitive conflicts to occur and to perceive these conflicts. Compared to other Web 2.0 environments, the members of the knowledge-building community are not only represented by short "is online"-messages or various online profiles. Their personal and social presence is evident through acting avatars. At the same time, online VRs provide a framework for solving such conflicts by offering a broad range of activity and communication options.

Such realistic forms of interaction and communication within a user-generated online VR make it easier to establish some *common ground*. This term refers to knowledge about information which is shared between participants of a conversation, their shared understanding [49]. In face-to-face communication, the existence of some common ground is demonstrated by *grounding* activities like nodding, shaking one's head, giving an immediate reply or simply by paying attention. In media-based communication the effort required for grounding depends on the type of media and is relatively small in user-generated online VRs, resembling natural face-to-face communication.

Generally, there is a great similarity between VRs and face-to-face arrangements. Even if sensory perception is restricted in comparison to real life, the perception of one's own self as part of a learning environment and of the presence of other people is similar as in a setting in the real world. This is even more the case if people are affected personally and see some connection between their own person and what happens in a VR. This will increase their feeling of presence. It will also increase *collective cognitive responsibility* of a group for succeeding together [19], a key factor for efficient learning. Learning in a community will only be successful if individual learners perceive themselves as important members of the group and jointly accept responsibility for achieving the targets of the group. In this way a genuine learning community will be formed in which all members of a group of users with different backgrounds and experiences can bring in their knowledge to the benefit of all.

The observation of what other members of such a group are doing will lead to a form of social observational learning [50]. Bandura's argument is that individuals (as observers) learn by observing other individuals (models), and that consequences of the model's behavior (acceptance or punishment) encourage or discourage the observer as well. Current user-generated online VRs do not allow learning by observing in complex domains (e.g. technical movements) because they lack realistic avatar movements and input devices that monitor the real movements of a user. But observational learning in VRs may work for less "embodied" procedural knowledge, such as handling complaints by angry customers, or inter-cultural training. A user-generated online VR may provide learning situations that are closer to reality than other learning material (like written text or even videos), because they allow learners to act in a social environment as active learners.

D. Environmental Presence

Environmental presence is closely linked with personal and social presence. Different learners represented by their avatars are simultaneously present in the online VR, share the same (or similar) awareness about their situation and environment. This contains two substantial benefits for cooperative knowledge building: user-generated online VR users may refer to objects in their (learning) environment without any ambiguity (say, by pointing at whatever it is). These learners will find it easier to enter into an exchange and discussion on learning content and objects, and in this way cooperative knowledge building will occur. At the same time, it is relatively easy to create *group awareness* in an online VR. Group awareness means the perception and knowledge of the presence (who and where) of other people and of what they are doing at this moment [51,52,53,54] – one of the basic requirements for cooperative knowledge building. The shared environment (as the external representation of what goes in a user's mind) facilitates non-verbal communication by allowing, for example, manifesting actions that make explicit verbal *back-channeling* unnecessary, or observation of other avatars' behavior, from which the conclusion may be drawn that everything was understood by all [49]. Grounding is also much easier in such a shared environment. In this way a VR may be rather close to the opportunities which face-to-face learning settings provide, and at the same time it solves the classical communication problem in computer-mediated learning arrangements that results from the absence of a shared environment. While in computer-mediated communication fewer social stimuli are available [55] and those involved in interaction have fewer opportunities to express themselves and understand the background of their partner than in face-to-face communication [56], such social stimuli and background information exist abundantly in a user-generated online VR, in fact, very similar to a face-to-face communication.

The context in which knowledge is developed is of paramount importance for effective learning and later recall of what has been learned [57]. Learning and cognition are always situated [58], what people know depends on the context in which this knowledge was developed and is being used [59]. The *distributed cognition* approach [60] goes even one step further by regarding artifacts, as parts of a socio-technical system, as the main components: Cognition is always distributed between the individual and some artifact, so dealing with artifacts is the main requirement for knowledge building.

The context and situation in which knowledge is developed is even more relevant for the development of procedural knowledge. Here, learning takes place through observation of other individuals (as in observational learning, cf. above), observation of their interaction with the environment and learning objects, and trying it out together as a form of *learning by doing*. This is impossible without a shared environment. The user-generated online VR context with its close affinity to reality makes it easier to transfer what has been learned into situations outside this learning context. So a VR provides ideal conditions for developing skills and concepts in realistic situations and contexts, even if it would be too costly or dangerous in reality.

E. Platform for User-Generated Content

A user-generated online VR enables learners to create their own content and objects. An example is a group of learners who produce jointly a complex simulation of a virtual high-rise building. They do not only build real objects, like furnishing, but also non-visible or abstract information, like water pipes or escape routes. Different objects of the virtual building may be linked with brief documents or references that provide further information, say, about relevant bylaws or safety requirements.

Active construction of learning content has the decisive advantage that active involvement in a learning environment leads to deeper understanding of its content and promotes knowledge development [61]. In the process of active construction, users create a mental model of their learning content. There is no need to create abstractions, as the learning content may be experienced in an environment that resembles reality, and may be manipulated. This makes "learning by design" [62,63] possible, understood as construction of real objects in a user-generated online VR. Ideally, the same laws of physics apply in a user-generated online VR as in the real world. So it is possible to put hypotheses to an immediate test in "reality" and learn by experience.

At the same time, construction of an environment will always take place in some context of cooperation. Content is produced from within the user-generated online VR and shared between users from the very beginning. Other users may watch the process of construction, comment on it or even interfere. Experienced learners or experts in the role of tutors have a platform with a user-generated online VR that they can use to support less experienced learners or novices in the sense of cognitive apprenticeship [64]. But unlike face-to-face tutoring, in user-generated online VR settings tutors may be replaced (completely or in part) by programmed virtual agents that support learners in their knowledge development process or check and correct their steps and results. Another benefit for learning that results from the construction of objects and creation of content is due to the *self-explanation effect* [65].

Explaining learning content to other users leads to deeper insights of the person who does the explanation. Externalizing knowledge supports elaboration.

Furthermore a user-generated online VR permits the integration of external content. An integrated web browser can display web pages in a user-generated online VR, and films, pictures or other multi-media files may be included as well. There is no break between different media, between user-generated online VRs and other content and users are not required to adapt their search and navigation strategies to changing media. External content becomes part of the learning environment, is embedded in the learning context, and the advantages of environmental presence (as described above) will come to bear.

And one final aspect: user-generated online VRs are also environments where informal learning takes place. We can observe a convergence between formal settings and informal processes of knowledge communication. User-generated online VRs bring together learning and living in a way that will encourage lifelong learning, situational learning and implicit or informal learning. In other words – this combination of games and learning has a great potential for educational purpose [66].

V. Conclusion

In this article, we have explored to what extent user-generated online VR systems are suitable tools for collaborative knowledge building and individual learning. The main difference to classical VR applications lies in the platform character of user-generated online VR and the role of user-generated content. User-generated online VR allows users to produce their own content. This permits learning in the form of active construction of knowledge, in a realistic applied context. What is also important is the social and communicative aspect. Users have online access to a user-generated online VR and meet other users from all over the world. This allows communication and interaction with other users, a key requirement for socio-cultural learning. With these features, user-generated online VR has a great potential for knowledge building in schools, universities and job training. Many aspects of a VR learning platform may be compared, in terms of what they can achieve, to face-to-face settings, and some of their built-in facilities even go far beyond that. In this way user-generated online VR systems may be important milestones for ubiquitous and life-long learning.

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