Interaction Design and Architecture(s) Journal - IxD&A, N.22, 2014, pp. 48-59

Smart communities in virtual reality. A comparison of design approaches for academic education

Thomas Köhler[1, 2], Sander Münster[2], Lars Schlenker[2, 3]

[1] TU Dresden, Chair of Educational Technology, Department of Education, Weberplatz 5, 01217 Dresden, Germany
[2] TU Dresden, Media Center, Strehlener Straße 22/24, 01069 Dresden, Germany
[3] TU Dresden, Centre for Continuous Education, Strehlener Straße 22/24, 01069 Dresden, Germany
{thomas.koehler; sander.muenster; lars.schlenker}@tu-dresden.de

Abstract. Smart communities adopt „virtual reality" (VR) for many purposes, amongst others for educational purposes. However the development of educational technologies under the concept of „„VR is neither a core issue in academic education nor in applied research publications, although potential exists. With the goal of closing this gap, the authors investigate possibilities of VR in teaching and training. Whether we can speak of a new didactic technique and if certain smart communities adopt such is investigated through three cases. Our focus is on who the target audience is, what requirements need to be considered, and how this manifests in the teachers' activity. Subsequently, a starting point for a target group-oriented design of virtual reality in higher education is provided.

Keywords: virtual reality, educational technology, smart community, academic education, case study

1 Introduction

When using media to support academic education one expects to orient with the latest technical developments available. At the same time, media is not independent of the realities of the addressees of academic teaching, the students (21). Young people who study and work in colleges and universities are socialized by the unbridled technological dynamics as well as the willingness to adopt these technologies with completely different media than students five to ten years ago (16).

These new technologies include mainly social media and networks, as well as popular media such as computer games and online games. Regardless of the controversy surrounding the benefits of the latter, computer games are primarily designed for entertainment. Their users are assigned an active role and perceive options for action in virtual realities, and thus, they can define, realize and view their individual actions in the *virtual* reality. By such they benefit from the opportunity to experience the real world through play. In this sense, they act in virtual realities and with a cultural technique of a generation that integrates a variety of different media in their daily lives and has developed a new action in dealing with them, which has cardinality (23). It is, precisely, the use of media in academic education to consider the possibilities of adopting this media-cultural technique.

Smart communities are a relatively new concept with a high relevance for education. Since the late 1990s, however, communities have become an influential approach in the context of adopting online media in different fields of knowledge cooperation (40). Giovanella, Dascălu, and Scaccia (12) address smart cities as communities of highly skilled people who are continuously motivated and challenged, while their basic needs are satisfied. Members of a community collaborate and enable the social practice, wherefore technology can be applied. For the current consideration this media concept is linked to the area of higher education. Here increasing mobility lowers the need of a physical transportation infrastructure when it is connected with the technology of virtual reality. This is, however, a specific focus of how educational technology is conceptualized in general (18).

The concept of VR is set in context by different theoretical approaches and discusses the use of virtual reality in the context of learning and knowledge acquisition. Socio ecological configurations and especially smart communities define opportunities and framing conditions for its implementation. Subsequently, three different case studies present the applications of VR in academic education and discuss points of contact as well as recommendations for a target group-(in the sense of a smart community)-oriented design of virtual reality in academic education. The paper concludes with a summary of didactic usage and effects of virtual reality in the academic education.

2 The concept of virtual reality

Lexically, virtual reality stands for “computer simulated reality” and distinguishes itself from purely receptive media such as image and film, as well as from extended and “augmented” reality as the superposition of real and virtual elements. Approaches to classification of virtual reality are based, for example, on the degree of sensory integration (5) or interactivity (14) as well as the visual quality (39). Overlooking a classification of additional didactic use contexts, especially that of Schwan and Buder (35) is useful as it proposes a distinction based on visual quality, didactic function, actions, and representation of the learner in such virtual realities.

Virtual reality has a special influence on the user characteristics like perception, cognition, communication and finally the behavior (4). Theoretically, this can be explained by the increased social presence, which is a feature of such interactive virtual environments (36). Recent findings differentiate a number of several variables, such as immersion, spatial presence, involvement, and authenticity (34). As research on pedagogical or even didactic use of such phenomena is rather limited, there is a relatively small amount of scientific publications that deal with virtual reality (VR) and education. Topics of special interest were the electronic classroom, first listed as key word in 1986, (cf. 19), VR and simulation (1995), virtual learning communities (since 1998), virtual universities (1999), and skills training for educational staff (2000). In addition, reviews were carried out about various learning software, which show that the use of VR technology to learn as well as to trigger the pedagogical collection of personal and social experiences is rarely found. In particular, VR technology is educationally used in academic and vocational contexts to simulate the operation of large technical systems such as airplanes, trains, and industrial plants.

In the area of learning and knowledge acquisition (18), VR finds some application for the display and transmission of knowledge as simulations as well as in pure 3D software environments in the context of e-learning (20, 17, 8, 32), which are used increasingly often. In this type of application, it may serve both as an illustration or a virtual world (35) and in the form of virtual learning objects (8, 15). With regard to a scientific localization of VR in an educational context, it has proven to be a highly interdisciplinary topic which includes not only those science areas specialized in content provision (social sciences and humanities, psychology, architecture, design science, and not least of all, computer science). Particularly in view of the latter discipline, case studies should be presented from the context of academic training to demonstrate both aspects of the target group oriented design and to introduce interfaces to the chosen topic smart communities' technology usage.

3 Case studies in a didactic design of virtual worlds in academic education

3.1 Case study: Online worlds as social learning environments

Virtual spaces and online worlds have become places for social encounter and interchange. Even simple network games from the early 1980s had formulated courts or spatially defined environments. The players used them as meeting places and stages, i.e. as places of communication and interaction. As a participatory framework they provide the same social features as their real spatial models. Spatial elements of human environments are socialized at different levels (3) and can only be understood through their cultural symbolism. Their structure always refers to behaviors that are learned and normalized in socio-cultural processes. The semantics of architectural space in virtual worlds is a welcome tool to create a symbolic environment. Their socio-cultural categories, rules, and standards are well known to most involved. Against this background, the interrelated actions of users and the constructing of independent virtual worlds is possible.

Early online worlds could only through language or graphical abstract elements give an idea of the design of their rooms. Their equipment elements and artifacts were agreed verbally or iconographically as symbolic references to social practices and methods of interacting with other users. The construction of a consistent world was left to the imagination and the mental images of users. In three-dimensional Multi-User Virtual Environments (MUVE) and Massively Multiplayer Online Role-Playing Games (MMORPG), buildings and facilities, actors, and content very realistically depicted. Equipment and objects are associated with concrete treatment instructions.

They can be used and modified in real time. Spatial configurations and the arrangement and activities of full body avatars can be actively experienced in the first-person perspective and perceived in terms of social interaction order.

The potency of these offers is reflected in their perception and use. Virtual spaces and online worlds are based on their socio-spatial features of „„Third Places"„. Third Places are public places to meet others in an informal atmosphere without domestic and professional commitments. Online environments such as MUVEs and MMORPGs have essential features of Third Places (7). Like real physical Third Places, they are neutral spaces, free to visit and leave for all and without restrictions. Within their borders, individual prestige and real status of their visitors play a subordinate role. The virtual appearance of informal places such as pubs and bars in online worlds can be seen as part of the same social concept. They offer a second (virtual) home or, like Third Places, a „„home away from home"„. The fact that online worlds are separated from other digital communication environments is considered a key characteristic. In addition to the persistence of the internal world, elements of a symbolic environment contain concrete references to architectural space. Architecture, as a consciously cultivated, semantic, and visible structure of the space in virtual environments has become a symbol of social order with the aim to support spatially referenced action.

Especially important in learning processes is that learners are physically present and recognize other learners as real communication partners. Specifically designed online environments, such as the virtual campus of Duisburg Learning Lab at the University of Duisburg-Essen in Second Life, can support the emergence of social interaction and communicative acts (1). The online campus of Duisburg Learning Lab offers differently designed virtual learning and working rooms for web-based collaboration for students (see Fig.1). Depending on the chosen room, a specific micro-context is created. This provides signals to the stakeholders regarding the social context of the common interaction. Formal and informal spatial contexts can be distinguished. The latter are the popular virtual hangouts, such as online bars and cafes. The choice of a specific spatial typology and the associated social spatial pattern provides a contextualization of the interaction based on well-known and observed social rules.

Fig. 1. Students working together in the online world Second Life.

The strong three-dimensional reality orientation of MUVEs, like Second Life, and the associated high visual presence of spatial online environments push the effect of social contextualization, i.e. community is a central aspect of the activity to be completed by the learners. With a high level of presence, it becomes easier to detect a specific room. The social functions of these spaces and buildings may be similar to those in the real physical world and may be experienced depending on the technical possibilities of the online world (32). Virtual spaces and online worlds, as communication and action spaces, are gaining in importance in view of their increasingly complex environmental character. Online worlds and games must be accepted as complex social environments. It is therefore possible to design them more specifically as learning environments. The micro context that can contribute as a function of sociability and planned interaction to form a social atmosphere within communication and collaboration situations represents a possible expression of successful design and equipment (33).

3.2 Case Study: Anti-Crime behavioral training at college level

In the project CrimCity (see http://www.futurestudies.org/crimcity/), the focus on “street crime” is set as an example for the examination of European level comparable teaching contents and implications for the design of VR-based simulations. Derived from content requirement analyses and design studies, an educational tool utilizing

VR technology has been developed for schools and colleges to address the issue of street crime. The tool consists of an interactive 3D-simulation in the form of a game in which the students deal with a number of situations involving street crime scenes. The starting point for the instructional design is the combination of features of 3D games with the advantages of an RPG. This creates an issue for the original street crime because of new and ultimately improved educational learning context in the form of a software package. As the trials and tests of CrimCity use, which ranged from high school through college and until police academy, show, the VR scenario offers a high potential for re-use in other themes of study or curriculum. In particular, this approach has the following characteristics (see also Fig. 2):

- It is an educational tool applicable to schools and universities that adopt VR technology to convey the theme of street crime.
- The interactive 3D simulation in the form of a game is located in a city environment and includes a number of situations that are typical for street crime, asking the user (i.e. learner) to act in several key roles (victims, observers, perpetrators) and to allow them to evaluate their own actions, inter alia, from a juridical perspective.
- Through a network of thematically and media didactically interested universities in several European countries, the spread of VR is performed as an educational tool.

Fig. 2. Example scenarios for Anti-Crime behavioral training from CrimCity

The main results of CrimCity for the use of VR in social or forensic educational practices are as follows:

- a software package that focuses on questions related to street crime and safety, through the use of an interactive simulation,

- innovations and materials for the training of teachers, as well as other interested professional groups such as the general public, police, and planning authorities,
- a web presence for the dissemination of up-to-date information on the use of VR on security, social responsibility, and active citizenship,
- models for the future development of virtual environments as an educational tool and appropriate teaching strategies,
- statements regarding pedagogical and didactic frameworks for the use of VR in schools and colleges for use by students and other young learners,
- definition of VR-based learning activities that are applicable and transferable to a wide range of specialized content and subjects such as geography, design and technology, environmental and social sciences.

Principally, the most important didactic approach of the underlying project was to combine virtual learning environments and role-playing techniques to develop a simulated VR game. This offline teaching methodology can support learning (31) effectively because it is fun and motivating and the strengthening of social or civic engagement is trained. For the thematized application field of street crime, this approach was chosen because recent studies (29) have shown that stories and role-plays offer many learning opportunities. More generally, it results from the integration of learning into context, i.e. situating, which is always a specific motivation for learning. In this respect, the project-based “CrimCity” scenario “proves the effectiveness of learning through computer games and socially embedded virtual environments. The smart communities trigger the adoption of the chosen setting and offer as described by (12) a variety of educational opportunities to highly skilled people as well as continuously motivating and challenging them. After their basic needs are satisfied, the members of the crime related community collaborate in a virtually shared social practice,

3.3 Case study: Virtual 3D reconstruction of history in higher education contexts

Especially for no longer extant historical objects, digital three-dimensional reconstructions and their presentation with Virtual Reality (VR) technologies offer the chance to convey holistic and easily accessible impressions of the past. While technical procedures for the creation of 3D reconstructions are widely unchanged for over a decade, various new technologies and tools for creation and visualization as well as web-based publishing opportunities have changed user communities and usage scenarios significantly.

The central element of the 3D reconstruction workflow is the creation of a three-dimensional virtual model. While technical workflows for a modeling of no longer extant, never realized, or altered objects are widely established and similar to other 3D modeling tasks in engineering and design, a unique and challenging aspect is the creation based on historical sources and – in academic contexts – striving for historical accuracy. Due the required high level of expertise and professional competency for both an interpretation and extrapolation of historical sources as well as for the creation of VR applications, interdisciplinary work teams (27) mostly realize these projects.

In the context of higher education, virtual reconstructions of historical objects and VR applications are primarily used to illustrate and teach history. Another increasingly important scenario is to encourage students to research and explore historical objects by reproducing them virtually (11). In a third scenario of usage the primary subjects of teaching are modeling techniques or VR technologies while the historical object is used “only” as a training example.

Realistic representation | Abstracting presentation | Schematic illustration

Fig. 3. Qualities of 3D reconstruction (cf. 35)

Although rendered images and animations as depictions of the created 3D model are the primary outcome of 3D reconstruction projects, interactive VR or augmented reality applications are becoming increasingly important (30). Closely related are questions concerning purposes and intentions of visualizations as well as for their visual qualities (Fig. 3). Moreover, preferences and recognition abilities are highly influenced by the level of expertise and professional background of the observer and various levels of abstraction impose different demands varying with a particular discipline and the professional vision capabilities (13). Novices typically perceive holistic impressions, experts mentally employ visual pattern recognition (37) strategies as a comparison of rendered 3D models with pictorial sources or mental models. As an example, archaeologists are trained to judge rather on realistic” visual impressions (38), whilst more abstract representations are more familiar among architects. Against this background it is widely discussed in literature, especially for scientific communication and higher education scenarios, how to disclose an underlying research process as well as included sources of information in a visual result (24). In contrast to text-based research, even for entities that are not sufficiently described by historical sources, a hypothesis for their design has to be made. This leads to the question of how to visualize these various levels of certainty within a VR application. As possible approaches, a reduction and schematization of visual qualities is recommended, on the one hand, which should focus attention on essential attributes and allow observers to negotiate 3D reconstruction qualities easily. On the other hand, complex and vivid reproductions of everyday life are intended to provide living and easy perceptible impressions of the past (10, 22, 6).

While an academic discourse focuses on visual qualities of VR applications, interaction capabilities are usually limited to altering a point of view. In only a few cases are more complex actions, such as an interaction with virtual agents as representatives of historical tribes (2), possible. What this mean for the smart community? The new type of reconstruction goes beyond the mere deployment of technology because a smart community presents conscious effort to use information technology to transform research work fundamentally different by bringing 3D (spatial) and even 4D (timely) aspects. The later one is especially smart as deals with the communities challenge to link itself to historic or future community experiences.

4. Conclusions

In the documented application scenarios the use of information technologies, i.e. virtual reality, is strongly influenced by purpose and target audience, but also by the specific educational or knowledge collaboration context. As a result, the case studies contribute both starting points as well as recommendations for a target group oriented design of virtual reality in education contexts in general, but especially for academic knowledge collaboration.

The observed findings on didactic use and modes of action can be summarized in the following propositions. First, the use of VR as an educational tool should always be established in specifically defined teaching-learning scenarios, to avoid being too spread out. Usually the first orientation of each approach should be a simulation in which the human-machine interaction is paramount. Current educational VR scenarios should, meanwhile, enable the training of interpersonal actions, i.e. communication and cooperation. All in all VR should offer the possibility to create complex learning and working environments in terms of social interaction in communication and collaboration processes as well as in terms of their associated teaching and learning content management options.

Of particular importance to learning in VR is the acquisition of foreign roles and, at the same time, de-personalization. The described VR-based scenarios should equally serve learning and research, as well as the use of a theory-practice transfer. In contradiction to the widespread classical forms and formats of online learning, such as learning platforms, E-Learning courses, forums and wikis, learning is still not broadly anchored in and with VR in academic education, though it should be.

Smart communities should occur as well in VR, and offer a variety of educational communities. Beyond the widespread adoption of ICT, in general smart communities may especially profit by the application of VR technologies as it allows bridging spatial (3D) and timely (4D) gaps in potential collaboration.

References

1. Adamus, T., Nattland, A., Schlenker, L.: Second Life as a social environment. In: A. Hebbel-Seeger, A. Reiners, T. Schäffer (Ed.). Synthetic Worlds: Emerging Technologies in Education and Economics. Series: Integrated Series in Information Systems, Vol. 33, Springer, New York. (in press).
2. Ancona, M., Mascardi, V., Quercini, G., Bogdanovych, A., Lumley, H. D., Papaleo, L., Simoff, S., Traverso, A.: Virtual institutions for preserving and simulating the culture of mount bego’s ancient people. In: A. Artusi, M. Joly-Parvex, G. Lucet, A. Ribes, Pitzalis, D.: 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST, Proceedings (pp. 005-008). (2010) http://www.eg.org/EG/DL/WS/VAST/VAST10/005-008.pdf (Retrieved on October 2011).

3. Bahrdt, H.P.: Umwelterfahrung: soziologische Betrachtungen über den Beitrag des Subjekts zur Konstitution von Umwelt. Wissenschaftliche Buchgesellschaft, Darmstadt. (1974)
4. Biocca, F., Levy, M.R.: Communication in the Age of Virtual Reality. Erlbaum Associates, Mahwah. (1995)
5. Ch'ng, E.: Experiential archaeology: Is virtual time travel possible? Journal of Cultural Heritage, 10, 4, 458-470. (2009)
6. de Heras Ciechomski, P., Schertenleib, S., Maïm, J., Maupu, D., Thalmann, D.: Real-time shader rendering for crowds in virtual heritage. 6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST, Proceedings (pp. 91-98). (2005) http://www.eg.org/EG/DL/WS/VAST/VAST05/013-020.pdf (Retrieved on October 2011).
7. Ducheneaut, N., Moore, R.J., Nickell, E.: Virtual "third places": A case study of sociability in Massively Multiplayer Games. Computer Supported Cooperative Work 16, 129-166. (2007)
8. El-Sabagh, H., Köhler, T.: The impact of a web-based Virtual Lab on developing conceptual understanding and science process skills of primary school students; In: Gomez Chova, L., Marti Belenguer, D, Candel Torres, I.: ICERI2010 Proceedings CD. (2010)
9. El-Sabagh, H.: Enhance science learning with virtual labs. The impact of a web-based virtual lab on the development of students' conceptual understanding and Science process skills. LAP Publishers. (2011) http://www.qucosa.de/fileadmin/data/qucosa/documents/6489/Dissertation_Hassan_28_01_2011.pdf (Retrieved on March 2013).
10. Feneley, M.,T., Chandler, T., Gleissenberger, N.H., Alexander, B.D.: Reconstructing the West Mebon Vishnu: A marriage of traditional artefactual analysis with digital 3d visualization. In T.G. Wyeld, S. Kenderdine, Docherty M.: Virtual Systems and Multimedia (S. 73-87). Springer, Berlin. (2008)
11. Gerth, B., Berndt, R., Havemann, S., Fellner, D.W.: 3D modeling for non-expert users with the Castle Construction Kit v0.5. 6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST, Proceedings (pp. 49-57). (2005) http://www.eg.org/EG/DL/WS/VAST/VAST05/049-057.pdf (Retrieved on March 2013).
12. Giovannella, C., Dascalu, M., Scaccia, F.: Smart City Analytics: state of the art and future perspectives. Interact. Des. Archit. J. 20, 72–87 (2014)
13. Goodwin, C.: Professional Vision; American Anthropologist no. 96 (3), 606-633. (1994)
14. Grissom, S., McNally, M.F., Naps, T.: Algorithm visualization in CS education: Comparing levels of student engagement. ACM Symposium on Software Visualization, Proceedings (pp. 87-94). (2003) http://dl.acm.org/citation.cfm?id=774846&dl=ACM&coll=DL&CFID=196285902&CFTOKEN=96611718 (Retrieved on December 2014).
15. Hesse, S. & Gumhold, S.: Web based interactive 3D learning objects for Learning Management Systems. Proceedings of the 2nd International Conference on Education, Training and Informatics. Orlando. (2011) http://www.inf.tu-dresden.de/content/institutes/smt/cg/publications/paper/ICETI2011.pdf (Retrieved on March 2013).
16. Kahnwald, N., Albrecht, S., Köhler, T., Herbst, S., Fraas, C., Gerth, M., Morgner, S., Hofmann, D., Kawalek, J., Pentzold, C., Saupe, V., Schwendel, J.; Stark, A., Weller, A., Welz, T.: Informelles Lernen Studierender mit Social Software unterstützen. Strategische Empfehlungen für Hochschulen. Waxmann, Münster. (in press)
17. Köhler, T., Börner, C.: Exploring issues of citizenship and criminality using virtual 3D environments. The crimcity evaluation. Research report for the Project Crimcity. Dresden / Manchester. (2007)
18. Köhler, T., Kahnwald, N., Reitmaier, M. Lehren und Lernen mit Multimedia und Internet. In Batinic, B., Appel, M.: Medienpsychologie (S. 477-502). Springer, Berlin. (2008)

19. Köhler, T., Münster, S., Schlenker, L.: Didaktik virtueller Realität: Ansätze für eine zielgruppengerechte Gestaltung im Kontext akademischer Bildung; In: Reinmann, G., Ebner, M., Schön, S.: Hochschuldidaktik im Zeichen von Heterogenität und Vielfalt. Doppelfestschrift für Peter Baumgartner und Rolf Schulmeister. BIMS e.V., Norderstedt. http://openaccess.bimsev.de (2013)
20. Köhler, T., Scheuermann, F.: Application of 3D environments in school education. In: Szücs, A., Bo, I.: E-competences for life, employment and innovation-E-learning Enabling Education in Evolving Europe (pp. 548-552). EDEN Publishers, Vienna. (2006)
21. Lievrouw, L.A., Bucy, E., Frindte, W., Gershon, R., Haythornthwaite, C., Köhler, T., Metz, J., Sundar, S.S.: Current research in new media: An overview of communication and technology. In W. Gudykunst (Ed.), Communication Yearbook 24 (pp. 271-295). Erlbaum, Mahwah. (2000)
22. Maim, J., Haegler, S., Yersin, B., Mueller, P., Thalmann, D., Gool, L.V.: Populating ancient Pompeii with crowds of virtual Romans. In: David B. Arnold, Franco Niccolucci, Alan Chalmers (Hrsg.): 8th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST, Proceedings (pp. 109-116). (2007) http://www.eg.org/EG/DL/WS/VAST/VAST07/109-116.pdf. (Retrieved on October 2011)
23. Mikos, L.: Kulturtechnik Computerspiel. Computer + Unterricht, 21(84), pp. 11-13. (2011)
24. Münster, S., Köhler, T.: 3D modeling as tool to reconstruct historic items. In: Proceedings of the Visual Learning Conference. Budapest. (2011)
25. Münster, S., Köhler. T.; 3D reconstruction of cultural heritage artifacts. A literature based survey. Proceedings of the CHCD 2012 Conference. Beijing. (2012)
26. Münster, S.: Entstehungs- und Verwendungskontexte von 3D-CAD-Modellen in den Geschichtswissenschaften. In: Meissner, K., Engelien, M.: Virtual Enterprises, Communities & Social Networks (pp. 99-108). Dresden, TUDPress. (2011)
27. Münster, S.: Militärgeschichte aus der digitalen Retorte – Computergenerierte 3D-Visualisierung als Filmtechnik. Zeitschrift für Militärgeschichte der frühen Neuzeit, 15(2), pp. 457-486. (2011). http://opus.kobv.de/ubp/volltexte/2012/5788/pdf/mgfn15_02.pdf (Retrieved on March 2013)
28. Münster, S.: Workflows and the role of images for a virtual 3D reconstruction of no longer extant historic objects. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences no. XL-5/W2 (XXIV International CIPA Symposium), pp. 197-202. (2013)
29. Papastergiou, M.: Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation; In: Computers & Education 52 (1). pp.1-12 (2009)
30. Prechtel, N., Münster, S., Kröber, C., Schubert, C., Schietzold S.: Presenting Cultural heritage Landscapes-From GIS via 3D Models to Interactive Presentation Frameworks. In: ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences no. XL-5/W2 (XXIV International CIPA Symposium), pp. 253-258. (2013)
31. Prensky, M.: Digital game-based learning. McGraw-Hill, New York. (2001)
32. Schlenker, L.: Soziale Kontextualisierung von symbolischen Lern- und Arbeitsräumen am Beispiel des dreidimensionalen Multi User Virtual Environment Second Life. Dissertation. Universität Duisburg-Essen. (2012a)
33. Schlenker, L.: Soziale Umgebung Online-Welt. Gestaltungsfaktoren virtueller Räume. In: Reiterer, H.: Mensch & Computer 2012: 12. fachübergreifende Konferenz für interaktive und kooperative Medien. Interaktiv informiert. Oldenbourg, München. (2012b)
34. Schubert, T.: The sense of presence in virtual environments: A three-component scale measuring spatial presence, involvement, and realness. Zeitschrift für Medienpsychologie, 15, pp. 69-71. (2004)

35. Schwan, S., J. Buder: Virtuelle Realität und E-Learning. In: E-Teaching.org, Tübingen. (2006). http://www.e-teaching.org/didaktik/gestaltung/vr/vr.pdf (Retrieved on März 2013)
36. Short, J., Williams, E., Christie, B.: The social psychology of telecommunications. Wiley, Chichester. (1976)
37. Simon, H. A.: Invariants of human behavior; Annual Review of Psychology no. 41, 1-19. (1990)
38. Tversky, B.: Spatial Schemas in Depictions; In: Spatial Schemas and Abstract Thought, edited by M. Gattis, 79-112. MIT Press, Cambridge. (2002)
39. Viola, I., Gröller, M.E.: Smart visibility in visualization. In: Neumann, L., Sbert, M., Gooch, B., Purgathofer, W.: Computational Aesthetics in Graphics, Visualization and Imaging. (2005) http://www.cg.tuwien.ac.at/research/publications/2005/Viola-05-Smart/Viola-05-Smart-Paper.pdf (Retrieved on March 2013)
40. Wenger, E.: Communities of practice: Learning, meaning and identity. Cambridge University Press, Cambridge. (1998)
41. Zöllner, M., M. Becker, et al.: Snapshot augmented reality – Augmented photography. In: A. Artusi, M. Joly-Parvex, G. Lucet, A. Ribes, Pitzalis, D.: 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST (2010) Proceedings, pp. 53-56). http://www.eg.org/EG/DL/WS/VAST/VAST10/053-056.pdf (Retrieved on October 2011)