Learning Activities Across Physical and Virtual Spaces (AcrossSpaces)

Workshop background and aim

Nowadays education does not happen exclusively face-to-face, in the physical space. Neither does it happen exclusively through online tools in the virtual space, like Virtual Learning Environments, blogs or wikis. There is a continuous transfer from one space to another: certain activities are done in the classroom, some are accessed on a web virtual learning environment or a 3D world, then the students perform the activities and collaborate ubiquitously either physically or digitally.

This is what has been traditionally understood under the heading of blended learning, but recent technological advances have opened broad opportunities to link these spaces more profoundly, thus enabling the realization of learning activities across spaces that incorporate and coordinate objects from them all. Examples are: the use of augmented reality, that superimposes a digital layer on top of the physical space, providing extra information or linking objects; the use of 3D virtual spaces mirroring the physical space (e.g. showing an image from the physical world coming from a camera); sensors or RFID technology in the physical space that can provide information such as identity or location to digital applications; or tangible computing devices that enable the manipulation of objects in the physical space that have impact on the digital space...

The main different spaces that can be linked to support innovative activities include virtual learning environments, 3D virtual worlds, physical classrooms and open learning spaces that can be integrated with virtual spaces through roomware, mobile and location-aware technologies. The main question to explore with workshop contributions is How to design and technologically support innovative learning scenarios across physical and virtual spaces? Associated research questions include: What are the opportunities and challenges that learning scenarios across spaces pose to the assessment of learners? Can educational technology specifications offer interoperability solutions to facilitate the transfer between spaces? How can educators orchestrate, adapt, monitor and evaluate the learning process occurring across different virtual and physical spaces?

September, 2011
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Keynote: “Through the interreality boundary: playful learning with Alphabot”

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Keywords: mobile robot, blended reality, interreality portal, informal learning, tangible interaction

Abstract: This talk explores the creation and formal evaluation of a developmentally-appropriate, technologically-enhanced playful learning experience for young, preschool-aged children. Rather than focus efforts on designing for two separate spaces, the platform presented computationally models a blended reality context of interaction perceived by the user as a singular, fused and continuous space. Blurring the boundaries between screen-based and tangible robotic media, the Alphabot, a blended reality character appears to seamlessly move on and off the screen fluidly transitioning from a computer graphics character to a mobile robot in physical reality. The technical underpinnings and formative design of the current platform are outlined as well as the challenges and future potential directions for educators and designers interested in this exciting new area of research.
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User Generated Contexts Across Spaces – Design Research Perspectives

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Abstract. This extended abstract explores a significant pedagogically focused challenge for User-Generated Contexts; namely, how do we design for and develop research insights into collaborative problem solving where learners/users generate their own ‘context for development and learning’ across spaces using ubiquitous digital devices as mediating tools? I will briefly present two case studies and use them to explore the challenge of moving towards an understanding of how to design for User-Generated Contexts across time and space. The paper concludes by posing questions for workshop discussion.

Keywords: Design across spaces, User-Generated Contexts, ubiquitous digital devices in learning, design research, people tagging

1. Introduction

User-Generated Contexts can be conceived in a way whereby users of ubiquitous digital devices are being ‘afforded’ synergies of knowledge distributed across: people, communities, locations, time (life-course), social contexts plus sites of practice (like socio-cultural milieus) and structures [1]. For me, a significant pedagogically focused challenge for User-Generated Contexts is to design for and develop research insights into collaborative problem solving where learners/users generate their own ‘context for development and learning’ using ubiquitous digital devices as mediating tools within what Vygotsky called a Zone of Proximal Development [2]. Specifically, in this extended abstract I report on previous and ongoing educational design research that investigates the workshop’s primary question: How to design and technologically support innovative learning scenarios across physical and virtual spaces? One aim of design research in education [3] is to identify and model technology-mediated, social learning and behaviours in order to design tools that support and promote the practices under investigation. Such a goal seems increasingly relevant given that society is currently witnessing a significant shift away from traditional forms of mass communication and editorial push towards User-Generated Content and enhanced communication contexts [4]. Consequently, in this extended abstract I will briefly
present two case studies and use them to explore the challenges mentioned above and to begin to move towards an understanding of how to design for User-Generated Contexts across time and space. The paper concludes questions for workshop discussion.

2. Case 1: CONTSENS and Higher Education spaces

The completed CONTSENS project ([http://bit.ly/oU9bj](http://bit.ly/oU9bj)) focused on the development of learning materials and activities for mobile learning enhanced by context sensitive and location based delivery. Workpackages were conducted by LTRI in architectural studies, urban education, language learning and marketing. The multimedia designer for the project (Carl Smith) made use of rich 3D visualizations and multimedia (see example in Fig 1) to augment the context for learning in such a way that would, we predicted (i.e. the development team), allow collaborating learners to interact: with each other, with the mobile phones and with the physical environment in order to generate their own context for development within a ZPD (Fig 2).

![Fig 1: Screen shot of wire-frame movie reconstruction of Nine Alters](image1.png)  ![Fig 2: Students interacting at the Cistercian Abbey (Fountains)](image2.png)

Tasks were devised with an archaeology tutor from Sheffield University, UK, that gave students a framework within which to operate when on a field trip to a Cistercian Abbey in Yorkshire, UK. One task, which is triggered when the mobile phone was in the correct GPS location on the site (at the Abbey), stated: “Look at a movie [see Figure 1] of the reconstruction of the interior of the church including the Nine Altars. Discuss the evolution of the structure of the abbey. Make a video blog of your discussion using the Nokia phone.” The collaborating pairs had two phones, one with the 3D/multimedia visualizations running the location-based software MediaScape ([http://www.mscapers.com/](http://www.mscapers.com/)) and another mobile device for recording the video blog. Students were videoed on the site by a researcher as they carried out the task and a questionnaire was used to gather feedback after the session.

An analysis of participant interactions in the architectural studies workpackage described above [5] suggests that User-Generated Contexts for “development” appears to involve multiple and complex layers of representational activity. The analysis surfaced the emergence of an Augmented Context for Development [5] (for Vygotsky development is an episode that leads to learning) which includes a ‘co-constructed area’ linking the physical world (i.e. what is left of the Cistercian Abbey) and the virtual world that is visualised in 3D on the mobile devices (Figure 1); this
‘area’ is inhabited by a shared representation that is jointly developed and owned by the students. The Augmented Context for Development that we have created for the students appears to act as part of a substitute for what Vygotsky calls the ‘more capable peer’. To summarise, the elements of an Augmented Contexts for Development are: (i) the physical environment (Cistercian Abbey); (ii) pedagogical plan provided in advance by the tutor; (iii) tools for visualisation/augmentation oriented approach that create an umbrella ‘Augmented Context for Development’ for location based mobile devices (acts as part of the substitute for Vygotsky’s “more capable peer”); (iv) learner co-constructed ‘temporal context for development’ (see [5]), created within a wider Augmented Context for Development through (v) collaborative learners’ interpersonal interactions using tools (e.g. language, mobiles, etc) and signs; (vi) these aforementioned elements (i-v) lead to intrapersonal (internal) representations of the above functions. Such a dialectical view of human meaning-making carries with it significant methodological challenges for design research in education.

3. Case 2: MATURE and work-based (user generated) spaces

The MATURE Project (http://mature-ip.eu) conceives individual workplace learning processes to be interlinked (the output of a learning process is input to others) in a knowledge-maturing process in which knowledge changes in nature across time and space(s). This knowledge can take the form of classical content in varying degrees of maturity, but also involves people, tasks and processes or semantic structures. MATURE systematically makes use of a design research approach that has included Use Cases that were linked to personas (developed from an ethnographically informed study) and particular knowledge maturing activities.

One important continuing aspect of the MATURE work is ‘people tagging’, which aims at improving the development of knowledge about other’s expertise and improved informal relationships based on a people tagging approach (e.g. see [6]). MATURE uses a lightweight approach based on collaborative tagging as a principle to gather the information about persons inside and outside a company (if and where relevant): individuals tag each other according to the topics they associate with this person. The ‘People Tagging tool’ can be used to gain a collective review of existing skills and competencies. Knowledge can be shared and awareness strengthened within the organisational context around ‘who knows what?’ This tagging information can then potentially be used to search for persons to talk to in a particular task-oriented situation. Braun et al. [6], have observed that “each target context of a people tagging system will require a different ‘configuration’, which depends on cultural aspects as well as the actual goals that are associated with introducing people tagging”. Braun et al.’s [6] also highlight various areas of User-Generated Context concern: (i) there should be a ‘use by date’ for tags, it is important that a person tag is time-bound, so people who have this tag do not feel they are making a completely open-ended commitment; (ii) ‘lazy-practice’ issue, here some practitioners may abuse the system where, for example, ‘lazy’ colleagues may resist entering details about themselves and may tag others with expertise they may have (to deflect additional queries); and (iii)
‘sharing could increase workload’. It can be noted that the organization (Connections Kent careers advisory, UK) currently continues to use the system, and a MATURE summative evaluation study is collecting usage logs to study the user-generated tagging behaviour across time and space(s).

4. Key questions for discussion

- What does the shift in the use of ubiquitous digital devices for informal, formal and work-based learning mean for the collection and analysis of data; what are the emerging pedagogical models; and what methods might we employ in a systematic, iterative and interventionist design research effort?
- During their continuing learning activities, what will the learning trail left behind by learners/users tell us as they move from one learning context/space to the next? How can we improve our understanding of how elements of context can be maintained over time and space, so as to scaffold a perceived continuity of learning?
- What are the implications of user-generated tagging behaviour across time and space(s)? How do we scale up to large scale users populations?

5. Acknowledgments

CONTESENS was funded by the EU Leonardo Lifelong Learning Programme. MATURE is funded by FP7.

6. References

A Model for Design-Oriented Pedagogy to Educate Learners to Meet the Future Needs

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Abstract. In the paper we introduce an instructional model for design-oriented pedagogy to connect learning in formal, non-formal or informal settings. The model is based on collaborative designing of learning objects representing real objects in nature and culture environments. Project-based learning, whole task approach, object-oriented learning, multiple perspectives and semantically rich objects constitute the framework for collaborative design process to articulate, build and share knowledge constructed in the community of learners, teacher and experts with support of social media and mobile technologies. The co-development process supported by socially shared tools will provide possibilities for working with the knowledge objects related to the physical, conceptual or cultural artifacts so that the constructed learning objects can serve as starting points for the others to adapt, integrate and develop them further to represent better the phenomenon in question.

Keywords. pedagogical model, learning by collaborative designing, learning object, project-based learning

1 Introduction

The topical challenge in the international educational community is to find new ways to educate our students to meet the challenges of today’s complex world, and particularly for the future. Many of today’s researchers have emphasized that most of the learning that occurs across a person’s life span takes place in various informal and non-formal environments and communities. Learning is a lifelong process (Life long) that takes place in various situations (Life wide) and in cultural practices in which we participate (Life deep). It is proposed that those practices are also the most powerful mediators in learning (Banks et al., 2007). Research in cognitive science has illustrated that human cognition is not only in the mind of the individual but distributed among people, artifacts and applied tools (Salomon, 1997). Consequently, because we as human beings learn in formal, non-formal and informal settings from other people, physical and conceptual artifacts, and tools that we are interacting during our activities, there is a need to develop new models to enhance learning in natural settings where the people interact with their environments that lie outside of educational institutes.

In order to respond to the challenges, learning environments should be seen as a kind of extended school environment. In addition to traditional classrooms, they should be built around authentic activities that are situated outside the school, as well as technological tools that can function as bridges between school and the environments external to it (Edelson and Reiser, 2006). Embedding the real world objects with formal education is opening up new kind of possibilities for learning, where students can create ideas, combine their expertise to design the products and share them for wider audience with help of new social technologies.
During recent ten years the concept of learning objects has received a remarkable attention and enthusiasm in educational and e-learning communities (e.g. Wiley, 2000; Churchill, 2005; Jonassen and Churchill, 2004; Lukasiak et al., 2005). However, researchers and educators have had difficulties in sharing definition for the learning object (c.f. Wiley, 2000; Wiley and Edwards, 2002; Cocharane, 2005; Churchill, 2008). The question also remains how to define a learning object to serve a specific instructional model or learning goals.

For developing the model on design-oriented learning where students are co-developing (c.f. Linux phenomenon) together digital representations of real physical objects, the activity theory has provided us a conceptual framework to define the learning object. According to activity theory, learning and action are in a close interaction and learning as well as knowledge emerges from action. The three central factors: subject, object and tool are all essential here. The subject comprises the social arrangement whereby the learners participate in the action (Roth & Lee, 2007; Jonassen, 2000.) The learners can act alone or in a group, although deeper learning results can be achieved when the learners, teacher and other members of the community construct their understanding together (Krajcik & Blumenfeld, 2006).

Then the learners can develop their understanding, based of their own interests in different knowledge areas and at the same time take responsibility for the division of the expertise with other members of the community (Bielaczyc & Collins, 1999). In order to approach a real object, the learners like experts in any domain field have a special benefit from physical and cognitive tools (Kim & Reeves, 2007). These tools can augment physical and cognitive activity and therefore serve in a special position in distributed human cognition.

New technology has provided and provides new means for organizing people’s joint efforts for developing artefacts and practices, and is all the time providing new forms of mediation (Paavola, Engeström & Hakkarainen, in press). In designing the learning objects, it is possible to construct representations of different kinds (e.g. video clip, audio, drawing, map, picture or textual information) by using students' possessed technologies (e.g. mobile phones). The socially shared tools provide new possibilities for working with the knowledge related to the physical, conceptual and cultural artifacts so that these personally constructed insights may in also become learning objects for the others, also for purposes outside the educational institution.

2  

A proposed model for design-oriented education

The instructional model developed by a research group lead by Professor Jorma Enkenberg in the University of Eastern Finland, is based on distributed cognition, object-oriented learning, learning by designing, and collaboration. The emphasis is on authentic, idea-centered activities and collaborative knowledge development bounded with the objects and tools that represent the phenomenon. The goal is to align the learning paths with the practices of professional or scientific communities, and by that way enhance students' skills to develop knowledge further together in a meaningful, and transparent way (co-development).

Based on before mentioned theoretical points of views the instructional model has been built on the following theoretical principles:

1. Anchoring learning process on learners' ideas, thoughts, conceptions and interpretations about the research questions to be investigated (epistemological principle),
2. Working with the objects that represent the phenomenon and in applying physical and cognitive tools (ontological principle),
3. Developing knowledge by collaborative designing (learning principle),
4. Using learners' possessed technologies in collecting empirical data (technological principle),
5. Putting emphasis on affording learning resources, guiding and supporting the learning process (teacher's agency) and
6. Addicting and orienting learners' by driven questions and whole-tasks (instructional perspective).

The process of the learning and its environment are described in figure 1 below.
The model has been tested and validated in many cases and with several learners’ groups. An example of learning object, co-developed in the framework of the pedagogical model, can be found on YouTube, (http://www.youtube.com/watch?v=gVKeTflC5Qg), (translated into English). In this case the learning object has been entirely produced by primary school children in a small village school in Finland. This example demonstrates in a nice manner how the young children worked with their own driving question in continuous transfer from one space to another, interacted with experts and use different technologies to exercise choice, collaboration and took responsibility for their own learning. With nearly 10 000 views, this learning object highlights how the ideas of the learners can and should be a part of construction of continuously growing knowledge and expertise around shared objects in across spaces.
3 References


Towards the design of learning scenarios combining activities across multiple spaces

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Abstract. Recent technological advances enable the design of innovative blended learning scenarios combining physical and virtual spaces through mobile and interactive devices and applications. One of the aspects that need to be explicitly considered when designing these scenarios is the physical spatial location where the activities occur. In this context, this extended abstract discusses the following question: Can we help teachers/designers/practitioners define the characteristics of the spatial locations intervening in their learning activities and the technology that link them? 4SPPIceS and ISiS are two conceptual models that propose including the physical space as an explicit element when designing blended learning activities. The abstract discusses their main considerations and differences.

Keywords: Educational design, blended learning, virtual spaces, physical spaces.

AcrossSpaces2011 EC-TEL Workshop Extended Abstract

In the last few years, the inclusion of interactive and portable devices in education has opened up new opportunities for learning. The pervasive and interconnected capabilities of these technologies enable the design of innovative learning scenarios combining activities occurring at a variety of physical spatial locations, in and beyond the classroom and inside virtual spaces. In these blended learning scenarios the activities are integrated through a data flow that is transferred from one space to another through different technologies to facilitate a coherent and fluid learning process. Both the space characteristics and the technologies available in a particular learning situation have a direct impact on how the links or transitions between spaces are produced. In this context, the space becomes a key factor to be considered in the design of innovative activities [1].

Recent approaches in the field of Mobile Learning consider the context as part of the design process [2, 3]. Context is defined as an artefact continuously created by people interacting with other people in their surroundings [4]. While context is something abstract and dynamic built up through interactions between people and between people and technology, for us, the space is the planned environment where the activity is going to take place. These physical characteristics and also the technologies available in that space, condition the way interactions occur when
planning and enacting the activity. This abstract compares and discusses two different models, 4SPPIces and ISiS, which introduce this idea of the space as an element to be explicitly considered in the design of innovative collaborative learning practices.

**4SPPIces** [5] combines 4 factors: (1) the Pedagogical method (what learners and teachers should perform), the Participants (who participate in the learning activity), the Space (where the activity takes place) and the History (what is likely to be varied during the activity enactment) that requires a flexible management. Each of the factors is composed by a set of facets that guide practitioners and systems developers in the design of complex structured collaborative practices in which participants with different roles interact, according to a particular learning flow, in activities occurring at different spatial locations. This model can be used as a descriptive conceptual model for stimulating discussions between practitioners and system developers when addressing the design of innovative collaborative activities involving multiple spaces. It can also be useful as a template for practitioners to reflect about the elements that a blended learning activity should consider. The 4SPPIces tool (http://193.145.50.226/4SPPIces_model/) can help in both situations. This tool prompts questions related to each of the factors in the model for guiding the design of the collaborative blended learning activities and the definition of the technologies involved.

**ISiS (Intentions, Strategies, and interactional Situations)** [6] proposes a specific identification of the intentional, strategic, tactical and operational dimensions of a learning scenario. The **Intention level** describes the designer’s intentions, closely linked to the knowledge context which defines targeted knowledge items (competencies, abilities, conceptions or misconceptions, etc.). The **Strategy level** is related to teaching methods, in order to reach goals linked to the intentions formulated at Intention level, the designer opts for the strategy (at pedagogical or didactical level) he considers to be the most appropriate. The **Interactional Situation level** represents the tactical level, i.e. the proposed solution to implement the formulated intentions and strategies. Each “interactional situation” is defined as a set of interactions with a specific set of roles, tools, resources, locations, according to the situational context. The **situational context** is defined at an abstract level, which means that only typical elements are listed (i.e.: word processor, mind map...). Physical spaces are represented by the item locations, which are typical abstract locations: classroom, home, Internet connected location… The graphical authoring environment based on the ISiS model is ScenEdit [7]. This tool assists teachers in the design of learning scenarios. Currently, ScenEdit offers some patterns for the different levels (intentions, strategies, interactional situations) elaborated from best practices identified in the literature and communities of practice in order to favour sharing and re-using practices among practitioners.

Each model defines the space from different perspectives. Both differentiate between the virtual and physical spaces. In 4SPPIces, physical spaces are defined by a set of areas associated to a particular task and composed by physical electronic and non-electronic components. The components are defined by their affordance (how it is used), their arrangement (how they are located) and their mobility (portable or fixed). Both virtual and physical spaces are connected through the components of the physical space. In ISiS, the situational context is characterized by a set of variables such as resources and tools that support the activities (documents, videos, digital or
not digital tools and resources, services), locations where activities can take place and roles which can be distributed to the participants (teacher, tutor, student, pupil…).

When designing scenarios with 4SPPIces, the space is an intrinsic factor involved in the design that is related to the other factors in order to achieve a coherent learning process. In short, 4SPPIces makes designers consider the relationships between the Space and the Participants through their location, and between the Space and the Pedagogical method through the activity. The extended model of the 4SPPIces Space factor for specifying physical learning spaces [1], defines the physical environments as the set of the spaces involved in an educational scenario with the artefacts that characterize them and their linkages. Hence, the space is more than the location where the activities occur. In ISiS, each component of the interactional situation (iS), and of the situational context is independent from another. Table 1 shows a summary of the different components of the two models emphasizing how virtual and physical spaces are treated in each.

<table>
<thead>
<tr>
<th>4SPPIces</th>
<th>ISiS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participants</strong></td>
<td><strong>Participants</strong>: specifies the potential number of people to be involved in the activity and the actual number finally participating, their profile and their spatial location in each activity.</td>
</tr>
<tr>
<td><strong>Space</strong></td>
<td><strong>Space</strong>: defines the space where a learning activity occurs and the elements that compose it.</td>
</tr>
<tr>
<td><strong>Virtual Space</strong></td>
<td><strong>Virtual spaces</strong>: where participants manipulate virtual elements not necessarily located at the same place.</td>
</tr>
<tr>
<td><strong>Physical Space</strong></td>
<td><strong>Physical spaces</strong>: where the participants directly manipulate the elements of the space. Defined by areas and components with a particular <strong>affordance, arrangement and mobility</strong> properties.</td>
</tr>
</tbody>
</table>

**Discussion**

Both 4SPPIces and ISiS are descriptive models that represent an ongoing work for inspiring researchers and practitioners in the design of new collaborative blended educational scenarios. First, we contend that practitioners, system developers and researchers can use these models as conceptual means to discuss about the needs and challenges of the future blended learning experiences with an emphasis in collaboration. Second, the two approaches include the definition of the space as an element in the design of scenarios combining virtual and physical spaces. This linkage between spaces is conditioned by the technologies supporting the different activities. Consequently, the definition of the space proposed in 4SPPIces and ISiS can be seen as a first approach for making practitioners reflect about new activities involving multiple inter-related spaces. One way to support this second point is to propose authoring tools in the line of the 4SPPIces tool and ScenEdit for facilitating collaboration between practitioners and system developers in the design of activities involving multiple spaces.

As next steps, we aim to explore how existing works such as [2, 8, 9, 10], which
have experimented combinations of activities occurring at different spaces, address the linkage between virtual and physical spaces. Describing these experiences with the two models we could get a deeper understanding about how the space is treated in each one, identify in which situations would suit better using one approach or the other, or a combination of both, and who is the most appropriate audience for each model.

Acknowledgments

This work has been partially funded by the Spanish Learn 3 project (TIN2008-05163/TSI) and by Stellar European network of excellence.

References

Group formation in learning flow activities across virtual and physical spaces

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Abstract. One of the main challenges in Computer-Supported Collaborative Learning is group formation according to different types of policies that depend on the pedagogical method or/and the students' profiles, and the communication of the resulting group formation to the students and the flow engines that orchestrate the collaborative learning processes. This challenge is even more demanding when the learning flows are not only supported by computers but they also integrate activities taking place in physical spaces without the assistance of computing devices. In this extended abstract we propose to combine previous contributions towards the development of an integrated solution for supporting group management across IMS Learning Design compliant virtual learning environments and activities in the physical space, such as the classroom or the playground.

Keywords: Collaborative Learning Flow Patterns, virtual spaces, physical spaces, group formation, physical devices, managing system.

1 AcrossSpaces2011 EC-TEL Workshop extended abstract

Collaborative Learning Flow Patterns (CLFP) formulate best practices in scripted Computer-Supported Collaborative Learning (CSCL). These patterns propose specific structures for learning flows describing sequences of (collaborative) learning activities and grouping aspects that potentially lead to a set of educational benefits. For example, to achieve positive interdependence and individual accountability in an educational context where the task to solve is divisible, the Jigsaw CLFP suggest as an effective learning flow to form groups whose members study individually only a part of the task. Then, the students having worked on the same sub-task form expert groups to collaboratively analyze such sub-task. Finally, the initial groups join, having a member expert in each sub-task, so as to solve a global task that requires of a partial solution associated to every sub-task. Collage is an authoring tool that enables teachers to create their own flows of activities based on CLFPs [1]. As a result of the authoring, Collage generates an IMS Learning Design (IMS LD) computationally represented file. This file can be interpreted by virtual learning environments including a learning flow engine compliant with the IMS LD specification [2]. When accessing the virtual learning environments using a computer students can see which activity is the following one they should complete as part of a longer flow and with whom they should collaboratively work in the activity (i.e. which group they belong to).
Visualizing the group formation in virtual learning environments is still a relevant problem in broadly used learning management systems such as Moodle, whose support for group management and visualization is limited [3]. However, this problem is even more challenging when part of the activities in a learning flow are not supported by computers, but take place in a physical space such as in a traditional classroom without computers [4], in several different physical spaces such as a museum or a campus [5] or in an augmented classroom with interactive furniture [6].

For face-to-face educational situations in learning spaces without computers and when it is not possible to use mobile devices indicating group formation (because of cost reasons, software compatibility, avoidance of attention distraction, children that are not allowed to use mobile phones, etc.), we have proposed a low-cost solution based on the use of wearable personal devices (Fig. 1b) [7]. These devices show color signals by the teacher using a central manager to compose groups (Fig. 1a). Students know to which group they belong to according to the colors visualized in their personal devices so as to join and work face-to-face on a specific activity. See [7] for more details about the devices.

In this document we propose to integrate the color signal manager with virtual learning environments and authoring tools, such as those compliant with IMS LD, so as to enable coordinated flows of activities across virtual and physical spaces. This integration will enable teachers to configure the group formation just once. Then, the students will receive signals in the wearable devices or group formation visualizations in the PCs depending on the space where each activity takes place. For example, a learning flow based on the Jigsaw CLFP can be planned so that it is carried out partially in the classroom and partly at home as follows. The individual and the expert phases, in which students work in subtasks, can take place in the classroom. Expert group formation can be indicated using the personal signal devices. Besides, the final phase of the Jigsaw in which groups formed by students having worked on different subtasks can be done from the distance, at home, using a virtual learning environment that shows to each Jigsaw group the tools (e.g., a wiki and a chat) and resources (e.g., the description of the global task) that they must use to complete the activity. The group formation shown at home will be consistent to what happened in the classroom if the configuration of the groups follows the initial design planned by the teacher and according to any change performed during the actual deployment of the activity in the classroom.
A possible implementation is to extend the InstanceCollage tool [8] with the signal manager and the CLFP-intrinsic constrains manager for group formation [9]. [9] also discusses alternative approaches for group formation technologies that could be considered for being connected to the wearable personal devices. InstanceCollage enables the instantiation of CLFP-based full-fledged designs by assigning the specific persons that will be associated to each group and deploying it in enacting systems, which in this case will be IMS LD players and the personal signal devices. The CLFP-intrinsic constraints manager for group formation allows re-organizing the planned group distribution on the fly according to unpredictable circumstances arising from the context (the extrinsic constraints, [10]) without violating the CLFP principles (or intrinsic constraints) that make the design effective (e.g., Jigsaw groups must always be composed of at least one member from every previously joint expert group). This dissociation between extrinsic and intrinsic constraints set the basis for flexibly facing the group management at runtime in a virtual learning environment or during an activity in a physical space using the wearable personal devices (see Fig. 2).

![Fig. 2. CLFP intrinsic constraints group formation manager (see [9])](image)

This extended abstract proposes a solution towards the orchestration of collaborative learning flow activities that occur in different virtual and physical
spaces. Its contribution is focused on proposing an integrated solution that facilitates a coherent group formation, management and visualization along spaces. In the workshop, a scenario showing how the operational system could be used for a concrete learning activity will be presented. Other related aspects for discussion are how the characteristics of the multiple spaces may influence the design of learning flows, the design of the wearable devices, if the proposed solution solve different flexibility issues that may appear in educational scenarios, and how the task descriptions, the distribution of resources and the flow of information between activities can be also easily orchestrated in physical spaces (the classroom and beyond) and across physical and virtual spaces.

Acknowledgments

This work has been partially funded by the Spanish Learn 3 project (TIN2008-05163/TSI). The authors would like to thank other members of the GTI group at the Universitat Pompeu Fabra for their contributions and ideas.

References

Orchestration Framework for Learning Activities in Augmented Reality Environments

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Abstract. In this paper we show how Augmented Reality (AR) technology restricted to the use of mobiles or PCs, can be used to develop learning activities with the minimum level of orchestration required by meaningful learning sequences. We use Popcode as programming language to deploy orchestrated learning activities specified with an AR framework.

Keywords: Augmented reality, virtual learning environments, orchestration of learning activities.

1 Introduction

In a world where people require instant information to take fast decisions, where learning is a process to be carried out through the whole life and where people have easy access to IT technology, it is a market necessity to provide access to information at any time and in any place. Augmented Reality (AR) is a technology that makes it possible enhancing our senses (vision, aural and tactile) with virtual or naturally invisible information superimposed on top of the virtual world by digital means [1], [2], [3].

Augmented Reality technology has been around since the early 1990s, originally requiring specialized equipment to provide fully immersive AR experiences [1], [2], dealing with complex mechanisms to superimpose digital data based on user perspective [1]. With the integration of GPS, electronic compass, gyroscopes to the basic connectivity capabilities originally provided the mobile phones, we have in our pocket a hardware device with the basic features required for AR applications.

In the field of education, the 2010 Horizon Report [4] predicts that AR will gain a widespread usage and have a large impact on teaching and learning in the next few years. Indeed, there are already some interesting learning essays done in this direction [5], [6], [7]. There are great expectations about the impact of AR technology on digital natives’ motivation. The expectations are due to AR capabilities to overlay data onto the real world and to interact with users in ubiquitous environments. The 2010 Horizon Report [4] projects the use of this technology for simulating dynamic processes, learning and assessment.
During the last years, a variety of frameworks have been developed to build AR applications. Layar [8] and Junaio [9] are the most popular AR browsers used for developing applications on smart phones. ARToolKit [10], an open-source library, provides marker-based AR that it is also widely used for developers. Popcode [11] provides a way for describing and delivering AR content using a specification based on XML, more elaborated programming can be done using a scripting language.

In our opinion, a step beyond the simple correspondence of real location with digital information is necessary to make AR technology useful in the education field, with features for interactivity, collaboration, orchestration of activities, adaptive learning among others. In this work, we present a development that points out in this direction: the specification of sequences of augmented learning activities (Section 3). We base our development on the AR and scripting features of Popcode (Section 2). Finally, in Section 4 we present our conclusions.

2 Features of Popcode

Popcode [11] is a toolkit developed at Cambridge University that is both simple and powerful enough to develop AR applications. Popocode has two families of features that will allow us to build learning applications fully integrated into augmented reality. The first family includes inherent mechanisms of AR toolkits:

1. It can be trained to recognize a real image.
2. A digital object (text, picture, audio, video, URL) can be associated to the real image.

The second set of features is similar to those of event driven scripting languages:

1. Associate a set of attributes to a given object. For instance, a unique identifier, a position, a scale, a visibility property.
2. Define simple actions: set or modify an object’s attributes; move objects (rotation, translation); identify the occurrence of events; associate an action to an event.

Program execution consists in deploying concurrently all objects defined, waiting for an event to occur over a visible object. When an event is triggered, systems modify objects attributes according to event definition.

3 Orchestration of Learning Activities

Popcode has a limited expressivity power as scripting language. Nevertheless, its features as event-driven language along with its mechanisms to modify the visibility of objects can be used to deploy sequences of learning activities on an augmented reality environment.

In an AR environment, we define a learning sequence as a set of learning activities: $A_1, \ldots, A_k$. For example, a learning sequence could be composed by three activities: introduction, exploration and assessment. Each learning activity uses a set of digital objects denoted as $d_1, \ldots, d_n$. Each digital object "d" has associated a set of attributes: $d<a_1=val_1, \ldots, a_p=val_p>$ denoting object properties such as identification, position, size,
visibility. The key aspect for orchestration of learning activities is the right handling of the visibility attribute.

Each learning activity is composed by frames. Each frame represents the subset of digital objects superposed over a real image that are visible for the learner in a given moment. The set of frames of a learning sequence are denoted as: \( F = \{ F_1, \ldots, F_{m_1}, \ldots, F_k, \ldots, F_{m_k} \} \). Each frame contains all the system’s objects (visible and hidden) with the value of its attributes. A transition \( \tau \) from frame \( F_i \) to \( F_j \) occurs when an event “\( e_x \)” acts over a visible digital object \( d_{ik} \), we denote it as \( \tau = < d_{ik}, e_x, F_j > \). \( e_x \) will produce changes on visibility properties of system’s digital objects. \( F_j \) will be considered \( F_i \)'s successor. Notice that \( F_i \) will have as many successors as different combination of event-object might act over it. The learning activity flow graph \( G = \langle F, E \rangle \) will be built with frames as vertex and events as edges among the frames. \( G \) captures all the possible interaction paths a final user might have with the application.

Given the specification of a learning sequence as its learning activity graph, a Popcode program can be written following the rules:

**R1:** For each digital object \( d < a_1 = \text{val}_1, \ldots, a_p = \text{val}_p > \), a Popcode object must be defined. Its general form is: \(< \text{object id} = d \ldots a_p = \text{val}_p > \ldots \langle /\text{object} \rangle \). At least one Popcode object must be visible.

**R2:** For each transition \( \tau = < d_{ik}, e_x, F_j > \) where the \( F_j \)'s visible digital objects are renamed as: \( d_1, \ldots, d_n \), and its visible digital objects are renamed as: \( d_{n+1}, \ldots, d_m \). The Popcode object “\( d_{ik} \)” will include the event “\( e_x \)” as follows:

\[
<\text{object id} = d_{ik} \ldots a_p = \text{val}_p > \\
<\text{event type} = x> \\
<\text{set object} = d_1 \quad \text{what} = \text{"visible" to=} \text{"true"} /> \\
\ldots \\
<\text{set object} = d_n \quad \text{what} = \text{"visible" to=} \text{"true"} /> \\
<\text{set object} = d_{n+1} \quad \text{what} = \text{"visible" to=} \text{"false"} /> \\
\ldots \\
<\text{set object} = d_m \quad \text{what} = \text{"visible" to=} \text{"false"} /> \\
</\text{event}> \\
\ldots \\
</\text{object}>
\]

Fig. 1 shows three consecutive stages of a sequence of learning. The whole sequence is composed of 8 frames specifying introduction, exploration and assessment learning activities. Each snapshot corresponds to a frame: \( F_3, F_{3+1}, F_{3+2} \). \( F_3 \) has visible only the digital object: “test”. Once the event: “click-on-object” is produced, “test” remains visible at frame \( F_{3+1} \) and four new objects -the question and its possible answers- become visible.

The framework has been used on two different research studies. Sixty-nine students participated in the first study using an AR learning environment specified with our framework. A quantitative analysis showed that students had a strong motivation for the augmented reality learning activities. The attention and satisfaction motivational factors were the highest rated. A second research study was carried out with 33 participants that were trained to specify sequences of learning activities using
our framework. 70% of instructors were able to specify a sequence of three learning activities.

4 Conclusions

In this paper, we have presented a framework for augmented reality learning environments. The framework provides a structured way to specify learning sequences that can be mapped to the Popcode language. The visibility property of objects allows Popcode engine to orchestrate the learning activities.

The simplicity of the framework proposed will be useful in the development of an authoring tool for instructors with reduced computer skills.

Fig. 1. The Birth of Venus (Boticelli). Assessment activity in an AR learning environment.

References

Bottling the magic dust: an infrastructure for mixed-mode teaching and learning

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Abstract. There is a lack of clarity about what good teaching means in practice which makes it hard to provide technological support. Conversation Theory and Positioning Theory provide a basis for analyzing this. Building on these insights a new system is described, based on Apache Wookie and Apache Rave (both incubating). Forthcoming pilots, based on scenarios, are outlined.

Keywords: widget, Wookie, rave, scenario, conversation theory, positioning theory, IMS LD.

1 Diagnosing the problem

In face to face learning today there are highly developed and standardized curricula and expensively developed learning materials (particularly in the form of text books). There are also increasingly sophisticated frameworks for lesson planning (which are often compulsory). Nevertheless the results obtained by teachers are seen to vary greatly, as shown by the efforts by government agencies to reward “great teaching”, and to take action against “bad teachers” [1]. However, in education policy and training there is often little idea of what this corresponds to in classroom practice, and the difference between teachers is frequently ascribed to vague concepts such as inspiration, experience or personality. This lack of clarity may (or may not) be problematic in presential learning, but when we seek to use technology to facilitate these processes it is potentially disastrous, because we can only implement that which we make explicit. The danger is that as technologists we find ourselves in the position of implementing systems which attempt to bottle an unspecified magic dust which ‘great’ teachers deploy in transforming curricula into marvelous learning experiences. In attempting to make sense of this we make use of two theoretical frameworks.

The first of these is Pask and Scott’s Conversation Theory, which was adapted by Laurillard [2], and was applied by Britain and Liber to develop a framework for the evaluation of VLEs. According to this model “The process of learning is supported by the creation of interactive ‘micro-worlds’ (learning activities) in which the student can actively engage in practice that enhances and reinforces the ideas that have been formulated through discussion. The model emphasizes that these activities should be
created and adapted on the basis of the conceptual dialogue, rather than pre-set in advance.” [3]

This is problematic for approaches based on learning design and learning patterns, because they take as their starting point the separation into a design process and a runtime process [4]. This is not necessarily a mortal blow to learning design approaches, as it corresponds closely to the traditional phases of curriculum design and lesson planning (design time) and the teaching process (runtime). However, in a face to face class the teacher has considerable freedom in creating and changing activities, while the range of activities available with computers is more constrained.

The second framework is Harré's positioning theory. As we have discussed previously [5], Harré sees role as being conditioned by social structure (e.g. I am a teacher, you are a student; I am a scribe, you are a facilitator), while positioning is identified as the emergent effect of particular normative conditions, particular communicative acts and particular narratives (e.g. something terrible has happened to me, you are sympathizing; I care about your opinion, you are considering your position). An analysis of the exchanges of communicative acts, and evolving or switching narratives, can provide insight into way in which teachers modulate the learning activities within a conversational framework. In the classroom teachers can modulate the activities through a verbal intervention, and they can also introduce new learning resources which they have to hand (for example, a map on the wall, or a drawing on the blackboard).

2 Computer support for activities in mixed-mode teaching

It is possible to conceive of how computers could provide similar support for 'micro-worlds' and their modulation through positioning, but to achieve this tools need to be as 'to hand' as chalk and duster, and switching between them needs to be as agile as it is in the classroom. If they are not, then we run the risk that teachers will be unwilling to use them because a) they generate an organizational overhead, and b) because they occupy time which could have been used for more agile interactions. We now describe an infrastructure which enables us to address this challenge.

In our earlier work implementing IMS LD runtime we were confronted by the problem of providing services which were both generic (enabling a UOL to be exchanged between systems) and specific (providing instances of services to particular learners during runs). To achieve this we developed a W3C widget server called Wookie, now available as Apache Wookie (incubating) [6], as described in [7]. As far as educators are concerned the principal capabilities of Wookie are that it enables them to:

- deliver multi user services (e.g. forum, chat, vote) as well as simulations, and dynamic content to any platform with a Wookie plug-in
- curate and deploy a collection of services
- easily publish a new or changed service to a group of learners
- contribute to a single service (e.g. a forum) from different platforms.
These capabilities opened up exciting opportunities beyond the IMS LD context for which they were developed.

3 The iTEC infrastructure

Integration of Wookie is not normally a major task on a Web based platform, and Wookie services can currently be consumed in iTEC using Moodle, Liferay and dotLRN. By means of IMS Basic Learning Tools Interoperability the list can be extended to include Blackboard and other compliant platforms. Work is underway to support mobile devices, and other appliances could in future also be supported, the only limitation being that they support some kind of browser.

Our intention is that these shared services will be available across a wide range of devices in the classroom (e.g. computers, white boards, phones, tablets, etc.) with the teacher choosing the mode of delivery which is most to hand. The services which are made available can be curated on the server which is used in a particular institution or district or state, thus providing a means of managing the choice which teachers are exposed to. Current work in iTEC will provide an enhanced infrastructure for this.

At present Wookie widgets have to be displayed in an existing platform. However, work is underway in the Apache Rave (incubating) project [8] to provide a lightweight container which will host collections of widgets. In future these widgets will also be able to interact with each other.

Our proposal is that a Rave container, optionally embedded across multiple platforms, can provide a sufficient variety of services, and agility in their deployment and to support the management of ‘micro-worlds’, and to facilitate the modulation of positioning between teachers and learners. The Rave container will be embeddable in other environments such as a VLE. In this way we provide an infrastructure which enables us to explore the agile configuration of learning activities and the modulation of teachers positioning of learners, within the context of systems which are governed by institutional roles and curricular requirements. When Rave becomes available this will be integrated into the system.

4 Piloting the system

The system will be piloted by teachers and learners in school classrooms across Europe as part of the wider iTEC infrastructure. This process will be facilitated by scenarios, which, in iTEC, refer an idea for a lesson or series of lessons which includes a vision, motivation, educational trends addressed, narrative, and key words. Information is also provided about the roles people carry out, the interactions (e.g. ‘formative assessment’), the technical and physical environment. This is developed into a ‘learning story’ which translates the scenario into a set of specific activities, with identification of tools and resources, and guidelines on how to prepare for or adapt a lesson. It is interesting to note how closely these elements are related to those of IMS LD, but there is a critical difference in that there is no ‘method’ in an iTEC scenario, the coordination being carried out principally by the teacher.
When a teacher decides to make use of an iTEC learning story they will be provided with tools and resources and a guide to their use. As the lesson progresses, however, not everything may go according to plan. The learners may disengage because they find the activities too complex, too simple, too boring, or too incomprehensible. When using conventional classroom resources the teacher can simply direct the learners’ attention to a new resource, and position the learners in a new conversation. But when working with computer mediated activities this is hard to achieve. There is a restricted set of activities available in each system, and making them available to learners on the fly is sometimes impossible, and seldom easy. Through the iTEC Wookie server the teacher has access to a potentially huge collection of tools and applications, which can be curated and filtered at any level, country, school or class (depending on how the system has been set up). The teacher can change any of the recommended tools from the learning story for any other tool available on the system simply by clicking on the tool, and choosing a new one. This is instantly available to all the learners who are logged onto the system, thus avoiding the problem of multiple questions of the type “Miss, I can’t find the link, what do I do now?” In this way the teacher can make use of the capabilities of computer mediated activities in the classroom, but with the ability to redirect them in the same way as she can redirect activities using traditional resources.

Two major interactive whiteboard manufacturers are partners in iTEC, and these will also be important platforms for pilot activities. Whiteboard systems are of particular interest from the perspective of this paper, because they have a well established purpose and practice in the coordination of classroom activities, and so provide an appropriate platform for researching the micro-management of activities and the modulation of positioning.

References

MiRTLE (Mixed-Reality Teaching and Learning Environment): from prototype to production and implementation

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Abstract. This position paper focuses on our efforts to implement and evaluate a Mixed Reality Teaching and Learning Environment (MiRTLE) in higher education institutions and other organisations, our current technical research to streamline and improve the utility of the system, and potential pedagogical developments for MiRTLE in the future.

Keywords: e-learning, virtual reality, mixed reality, pedagogy, institutional change.

1 Position Paper

We have previously presented our work on building a Mixed Reality Teaching & Learning Environment (MiRTLE) in a series of presentations and publications [1]. Moreover, we have suggested how we could go beyond the classroom to create much larger mixed-reality environments based on the wider university campus, with greater integration between devices and resources in the real and virtual worlds [2].

MiRTLE is a mixed reality environment that links the physical world of the classroom with a virtual world for remote learners, so permitting real and remote students to come together in a single, traditional, instructive, higher education setting. A key objective of the MiRTLE project was to provide online access to classrooms for remote students while providing education practitioners with a ‘business as usual’ environment for their teaching, so allowing institutions to increase class size, while retaining their existing practices. The environment augments existing teaching practice with the ability to foster a sense of community amongst remote students and between remote and co-located locations. The first achievement of the project was the successful demonstration of the concept of combining physical and virtual worlds into a single practical service. This was then validated in several deployment scenarios. Others have now begun to adopt MiRTLE [3], and its use has also moved beyond Higher Education to other sectors including Community Education and the K12 school system in the USA [4].

From the initial evaluations of MiRTLE at the University of Essex, a number of valuable issues were highlighted that have implications for future uses of this technology. It particularly highlighted potential social issues, such as the impact on student motivation and perceptions of crowding and jostling for position in the virtual
classroom. The trial also showed that there was potential for impromptu and naturalistic social interaction between virtual and physically present students. Teachers also recognized the potential value of the product, reporting that, once students are logged on and settled, the MiRTLE environment had a minimal impact on normal patterns of teaching, and the teachers perceptions of the learning occurring in their teaching environment. An important emerging theory is that the previously described finding of spontaneous social exchanges between virtual and physically present students suggests that MiRTLE can facilitate a breaking down of the barriers between the virtual and the physical, and increase a sense of presence for all learners and teachers involved.

Emerging uses for MiRTLE lie not only in expanding class size, but also in providing a teaching tool for: geographically remote settings where it is difficult for all students to come together in a single physical environment routinely and regularly; post graduate professional education where employers would like to reduce absence from the workplace, whilst still encouraging continuing professional education; and in providing a communication tool for policy or other decision making environments where bringing together thinkers who are distant from each other, and who can ill afford the time to travel for meetings, is commercially desirable.

The key challenge now for MiRTLE is to go beyond a prototype to become an established part of the teaching and other organisational infrastructures. This presents a number of technical, pedagogical and commercial challenges.

This position paper and the accompanying presentation focuses on: (a) our efforts to implement and evaluate MiRTLE in higher education institutions and other organisations, the dilemmas and problems faced in our early implementation experiences and the solutions deployed wherever possible, (b) our current technical research to streamline and improve the utility of MiRTLE, and (c) potential pedagogical developments for MiRTLE in the future.

1.1 Implementation discoveries, issues and dilemmas

Amongst the earliest of our discoveries about the implementation of e-learning products was that it is difficult to secure buy-in, and organisational access/co-operation even where one believes that the product is absolutely right for a given organisation. A single articulate, and indeed authoritative champion may not be sufficient. What is necessary is to reach individuals with either purchasing authority or those who are orchestrating the relevant organisational policies with which ones product chimes.

• With MiRTLE a particular hurdle to overcome were preconceptions held by individuals and organisations of perceived similarity to other products in the market place, making them reticent to consider it further.

• Another profound barrier to implementation was the issue of selling a product built upon an open source platform. In this instance our solution has been to give our customers our prototype MiRTLE system, requiring them only to pay for the hardware necessary for their bespoke installation and for our support. Nevertheless we have learned a great deal about the need for a long-term view when developing a product, which may ultimately have a commercial endpoint.

Having gained access to an organisation, overcoming technical implementation problems within existing institutional IT structures was our next implementation challenge. We have found that the key to resolving this was to work in an
implementation and evaluation partnership, prevented fear of change and competitive
behaviours that risk stalling the implementation.

Managing user concerns and expectations and evaluating user experiences is a
challenge that we have only limited experience in, to date, but one that we fully
expect has the power to stall projects. Users ranging from IT support workers, through
to teachers and students are all united by their own fear of change and in some
instances irrational fears of technology. The management of this is probably
something that should be shared between providers and purchasers. Product providers
must give sufficient and reassuring training, but product purchasers must take
responsibility for managing local user concerns and anxieties, drawing on the above
training.

1.2 Technical research to streamline and improve the utility of MiRTLE

In parallel to our early implementation activities, we have continued to think about
our product conceptually and to explore technical developments to streamline and
improve the utility of MiRTLE:

- In developing MiRTLE on different virtual world platforms we have had to come
to terms with the fact that there is currently no clear market leader in the
development of virtual worlds. As a consequence any developer is faced with a
potentially confusing array of different features and tools to choose from. So far
we have developed MiRTLE using the Open Wonderland toolkit as this best
supported the key technical features required by MiRTLE. However, we have
also created test implementations using both SecondLife and RealXtend, and we
are currently investigating the use of a number of other commercial platforms.
The ultimate aim is to produce a commercial grade reliable environment for wide
spread usage.

- Streamlining the installation and setup phases is critical to the widespread
adoption of MiRTLE. We have developed a number of online tools to simplify
the configuration and setup of MiRTLE. This includes tools for configuring the
video feed and the shared desktop used by the teacher. This also removes a
number of the technical barriers for technicians, whose anxieties may be one of
the sources of resistance to implementation.

- To date the MiRTLE classroom has required the teaching room to be specifically
tailored to use the system i.e. large display screens, speakers and a microphone.
This can be a barrier to the more widespread use of the system. Moreover we
recognise that it is vitally important that MiRTLE provides no additional hurdles
to the teacher, who will already be preoccupied with the job of teaching, and
possibly anxious about using technology. If overloaded with further technical
complexities in the classroom, these key stakeholders may quickly become
resistant to implementation. To alleviate these issues, we have created a
‘portable’ version of MiRTLE, which is based on a wheeled trolley that can
easily be moved between classrooms, and only requires a single network and
power connection. This portable version requires no setup by the teacher. They
just need to start it using a single power button and the system is then designed t o
automatically launch and be ready for use.

- Two further development considerations have been to (a) overcome MiRTLE’s
current requirement for students to have a high-specification computer, and (b) to
increase the number of people who can participate in a live session. We have
been investigating ways to capture and stream MiRTLE to individuals using only
a web browser. This allows lower-specification computers to be used and
potentially supports a larger number of participants.
1.3 Pedagogical developments for MiRTLE

From a pedagogical perspective we want to go beyond the use of MiRTLE for the simple delivery of lectures, and explore other pedagogies that can further exploit the affordances of the mixed-reality environment. Our thoughts to date include:

- Creating more reference sites for different educational uses.
- Linking MiRTLE installations to explore richer collaboration and co-creation scenarios.
- Integrating MiRTLE into our research testbed – the iClassroom.

1.4 Next Steps

Finally, our development thinking has also touched upon how we might incorporate some of our ideas into future research work on mixed-reality and smart classroom environments. This will primarily be in our newly created iClassroom [5], which provides a rich testbed for exploring the use of a range of technologies, from pervasive computing, through to multi-modal user interfaces. All of this is within the context of the University of Essex Digital Lifestyles Centre, which is a member of the European Network of Living Laboratories.

References


Augmented reality at the primary school: a pilot study on a Natural Sciences course

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Abstract. This paper presents a pilot study conducted on third grade students where a series of AR contents about Natural Sciences have been used as a teaching tool. The developed educational resources cover the following topics: skeletal apparatus, water cycle, frog metamorphosis, solar system, senses and plant development. The main objective of the application is to help the students to learn complex concepts that present a difficult understanding. The AR application combines 3D models and animations, mini games and quizzes. An evaluation of the educational contents was made from the point of view of two different parameters: academic achievement and satisfaction. Results show a positive impact on academic achievement and a high satisfaction for participant students.

Keywords: augmented reality, academic achievement, satisfaction.

1 Introduction and related work

As the Horizon Report 2011 [1] states, augmented reality (AR) is a capability that has been around for decades, that is reaching a maturity level that could mean a time to adoption of around two or three years. However, there are limited references to quantitative results on the application of this technology in real educational scenarios. Majority of these results are based on expensive and exotic hardware that make these previous experiences of limited application [2, 3, 4]. However, simpler and cheaper AR configurations are also a feasible alternative in educational settings. For example, with respect to the immersive nature of the visualization display, there are interesting considerations regarding using desktop AR (visualization in the monitor screen). Liarokapis and Anderson [5] note that participant undergraduate students preferred monitor-based augmentation compared to head mounted display (HMD) based augmentation which they found distracting and difficult to use. Sometimes, benefits of AR in educational contexts are linked only to promote motivation and engagement among students. For example, Juan et al. [6] developed an AR game for learning
words. Thirty-two children played the AR game (using an HMD display) and the equivalent real game. When comparing results of the two games, they did not find significant differences between the two games except for one question: 81% of the children preferred the AR game.

Active or passive interaction with AR contents is an important element of study, especially in the context of primary education. Kerawalla et al. [7] conducted a study to compare the use of AR, using the virtual mirror interface (desktop AR using an interactive whiteboard (IWB) as display) with traditional teaching methods to teach 10 year olds about the interrelationships between earth, sun and moon. Their analysis of teacher–child dialogue revealed that children using AR were less engaged than those using traditional resources, perhaps due to their passive relation with AR contents. Freitas & Campos [8] conducted a study on the design and evaluation of augmented reality for teaching 2nd grade-level concepts like means of transportation, types of animals and similar semantic categories using an interface similar to the virtual mirror used by Kerawalla et al. [7]. Results suggested that AR is effective in maintaining high levels of motivation among children, and also has a positive impact on the students’ learning experience, especially among weaker students, showing some contradiction with Kerawalla’s results.

2 Didactic contents

The developed AR system consists of an AR engine and six AR applications about the skeletal apparatus, water cycle, frog metamorphosis, solar system, senses and plant development. This work tries to provide additional experience in the application of AR technology in an educational context similar to [7, 8], following the approach of the virtual mirror paradigm previously described, and using AR as a tool to support teacher’s explanations, making emphasis in the analysis of the impact on users through academic achievement, usability / satisfaction and motivation.

Each AR application provides four learning activities. In figure 1, four screenshots of the skeletal apparatus application are shown. It will be used to describe them:
1. “Game”, is a kind of archaeological excavation that appears over an AR marker. Game objective is to place a set of bones, which someone has dug up, into its original place. The way to do this is by selecting the bone that user wants to place and then pick on the correct silhouette part.
2. “Visualization”, shows a human skeleton over the AR marker. It also shows the most important bone names using arrows and text. By using AR, the application lets the user observe every skeleton bone from every angle, which can facilitate teacher explanation and student understanding.
3. “Consultation”, lets teacher to ask their students about the lesson. The teacher asks the students for a bone and then, the student has to select it on the correct skeleton position.
4. “Quiz” helps the students to self-assess their learning. System asks the user for ten bones, and she/he has to locate them in the skeleton. So, different sounds are played when the user is right or fails.
3 Evaluation and conclusions

Academic achievement has been evaluated using a quasi-experimental design scheme based on interrupted time series. The group under study consisted of 21 students, 12 boys and 9 girls, of third grade of primary education. For the experience the first ten thematic units of a Natural Science subject were analyzed. AR was used by the teacher to support his/her explanations. Students used the application by turns on the interactive whiteboard. Thematic units 6 and 7 used the AR contents. Teachers considered all units of similar difficulty.

Fig. 1. Skeletal apparatus RA application.

Fig. 2: Mean scores (range from 0 to 10). In units 6 and 7, AR contents were used.
Results show that the two thematic units with best mean qualifications, match with those in which AR was used (Figure 2). Furthermore, the best results were obtained in thematic unit 7. To evaluate usability and satisfaction of students, a questionnaire with a smiley Likert scale of 5 levels was used. As shown in Table 1, satisfaction values are very high, especially in questions 3 and 5. In general, both teachers and students showed a very positive attitude toward the Augmented Reality technology, being their first contact with it. Augmented reality can be a cost-effective technology (at least desktop AR only requires to add a webcam and the proper software to an IWB setup) to provide students with attractive contents that give an added value supporting the understanding of difficult concepts.

Table 1. Satisfaction questionnaire.

<table>
<thead>
<tr>
<th>Questions</th>
<th>mean</th>
<th>std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 I believe that this material will help me to make a better examination</td>
<td>4.4</td>
<td>0.97</td>
</tr>
<tr>
<td>Q2 It has been easy to learn to use this material</td>
<td>4.4</td>
<td>0.87</td>
</tr>
<tr>
<td>Q3 I would like to use this material at home</td>
<td>4.7</td>
<td>0.70</td>
</tr>
<tr>
<td>Q4 In this class I have been more attentive than in other classes</td>
<td>3.7</td>
<td>1.02</td>
</tr>
<tr>
<td>Q5 This class has seemed to me to be useful and interesting</td>
<td>4.6</td>
<td>0.59</td>
</tr>
<tr>
<td>Q6 I would like to take more classes as those of today</td>
<td>4.4</td>
<td>1.08</td>
</tr>
<tr>
<td>Q7 It is easier to follow the teacher's explanation in a class of this type</td>
<td>4.6</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Acknowledgements

The Spanish Ministry of Science and Innovation partially supported this work (Project ref. TIN2010-21296-C02-01).

References

Architecture for Collaborative Learning Activities in Hybrid Learning Environments

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Abstract. This article describes an architecture for blended learning environments comprising the real world and its 3D virtual mirror. The architecture allows the integration of both worlds; the interchange and geolocalization of multimodal information, and also the orchestration of learning activities. We deploy over architecture a collaborative learning experience.

Keywords: blended learning environments, augmented reality, augmented virtuality, mirror worlds, 3D virtual worlds, architecture for virtual learning environments.

1 Introduction

Information and Communication Technology (ICT) tools have been used to create learning environments that improve student learning. However, the lack of social interaction in web-based environments reduces the motivation of less independent students [1]. A compromise solution is to deploy hybrid or blended environments to take the advantages from the technology affordances while retaining the benefits of face-to-face teaching [2], [3].

A technological evolution of flat-web, the 3D virtual worlds (3DVWs), comes to improve online learning by fostering students’ motivation through their immersion capabilities [4], [5]. However, 3DVWs graphics are not appealing and it is not easy to fill these worlds with complete and meaningful information. The foregoing suggests that just as the flat web, 3DVWs capabilities as learning environments could be enhanced by connecting them with other learning environments.

Real and virtual worlds are the two extreme components of Milgram’s continuum [6]. Our approach merges these two worlds and includes the other two Milgram’s components: augmented reality (i.e., the superimposition of virtual objects and information on the physical world) and augmented virtuality (i.e., the introduction of elements from the physical world into a virtual one). Virtual and real world are merged by geolocation capabilities of mobile technology. The integration of these worlds will pro-
vide learners with a richer source of information and better possibilities to contextualize situations.

In this work, we extend the architecture outlined in a previous work [7] to support collaborative hybrid learning environments (see Section 2). A learning activity was designed to promote collaboration among participants in both worlds within our architecture (see Section 3). Finally, Section 4 presents the conclusions and future work.

2 System Architecture

The system is designed to support collaborative learning experiences on a learning environment that unifies the real world and its mirror. It establishes a one-to-one correspondence among elements of the two worlds; provides mechanisms to exchange multimodal information across the spaces and supports the workflow of activities.

The architecture proposed (see Figure 1) extends Open Wonderland (OWL), a Java based open source multi-user 3D game platform. A multi-user game based architecture is composed of a server that orchestrates the distributed functionality inherent to these environments, and a set of clients used to visualize and manipulate 3DVWs. Any change in objects that populate the world is propagated from server to clients.

We extend OWL server to consider the real world as an additional client, the mobile client. The server keeps the information of the 3D virtual objects centralized, and also that of real objects. It also sends data regarding their location, appearance, and surroundings. Mirror world should geotag a minimum set of benchmark elements to guide the correspondence among the real and the virtual clients of the extended Wonderland server. The mobile phone is enhanced with a mobile client to exchange information with the extended Wonderland server. Thus, the architecture allows both augmented reality and augmented virtuality.

The exchange of information between the real and virtual world requires a Communication Module to follow the ad hoc protocol developed for our architecture; a Location Module to process the geo-location information in real time about the people in the real world and the avatars of the mirror world and a set of Multimedia Modules provided by Open Wonderland to handle image, video, text and audio (Image viewer, Video player, Text chat and Audio recorder respectively). Multimedia Modules handle multimodal information that is enhanced with geotagged information, the combination of both allows the clients to locate information in the mirror space (virtual or real). A data base with multimodal information is used by these modules. Virtual phone module provides the communication capabilities through VoIP protocol. Finally, the orchestration of activities is directed by a narrative process carried out by Non Player Characters (NPCs) that ask questions to participants, they process the answers via AIML module, an Artificial Intelligence engine. This architecture differs from that presented in [7] in how it orchestrates activities, it also extends the Multimedia Module and integrates a new module for handling communications between the two worlds. All of which forced the restructuring of the system as a layered architecture.

Participants from the real world establish connection with our platform by sending a
"login request" message through his/her mobile phone. This initial message is encapsulated into a frame from the ad hoc protocol developed for our architecture. Once the user is logged in, he/she can exchange information with the virtual world by means of sending and receiving multimedia files or making phone calls. Our ad hoc protocol implements different frame types for these purposes. To establish a phone call, our ad hoc protocol implements a special frame type to indicate the virtual phone that the user wants to speak with. Once the connection with the virtual phone is established, the user in the real world and users in the virtual world can maintain a voice conversation using VoIP technology.

Figure 1. System Architecture

3 Case Study

The proposed situated learning experience takes place on the Gran Via of Madrid and its mirror image in a 3DVW. It is designed to promote listening and speaking skills of advanced students of Spanish as second language in a collaborative environment. Students perform the activities through their avatars in the mirror world where they have access to limited information about the shows available in some theatres of the Boulevard. Meanwhile, there is a group of instructors near the chosen theatres ready to collaborate with students. Their mission is to compile information that is not available in the mirror world according to students’ requirements and send back multimodal information via telephone. The final goal is to purchase a ticket for the show preferred by the group of participants.
4 Conclusions

In this work we have presented the architecture that supports augmented reality and virtual reality joining the real world with its mirror in a 3DVW. Mirroring the words was possible thanks to the geolocation of 3D object models in the 3DVW. The architecture is in charge of keeping updated the position of participants and sends it to the other world. Exchange of multimodal information was also possible and the actions has been orchestrated by NPCs. Technology has been used to deploy a collaborative learning experience where participants in one world required help from the other world to achieve a common goal.

We intend to conduct a preliminary evaluation on October 2011 to determine the usefulness of our hybrid learning environment in terms of motivation, immersion into a situated learning experience, and participation in collaborative activities. Previous usability evaluations with a similar blended learning environment showed high levels of satisfaction of participants.

5 Acknowledgements

This research is supported by the following projects: “España Virtual” within the Ingenio 2010 program, subcontracted by Deimos Space. The “Comunidad de Madrid” project e-Madrid, S2009/TIC-1650 “Investigación y Desarrollo de tecnologías para el e-learning en la Comunidad de Madrid”.

6 References

Conceptualizing Virtual Research Arena Framework: 
Learning Activities across Physical and Virtual Spaces

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Abstract. In this paper, the authors present a discussion on the Virtual Research Arena (VRA) – a framework for creating awareness of educational and research activities, promoting cross-fertilization between different environments and engaging the general public. The framework is developed to be used for educational purposes in 3D Collaborative Virtual Environments (CVEs) as well as connecting physical and virtual spaces. The goal of the paper is to consolidate the results of a number of explorative studies and form a concept of the VRA, the first realization of which was evaluated in the Virtual Campus of Norwegian University of Science and Technology in Second Life virtual world.

Keywords: 3D collaborative virtual environments, 3D educational content, learning communities, Second Life.

1 Introduction and related work

Potential and possibility of 3D Collaborative Virtual Environments (CVEs) for collaborative work with various types of content is supported by a number of studies [1, 2]. Most CVEs offer advanced content manipulation, uploading, creating and sharing 3D objects and other media, such as text, graphics, sound and video. CVEs allow creating complex interactive content and using it collaboratively for various purposes. 3D CVEs enable learning communities to leave traces of their activities that become part of the shared repertoire of the community through the process of reification [3].

In addition, the opportunity to interact in a way that conveys a sense of presence, lacking in other media [4], allows using CVEs for meetings, performances and role-playing. These opportunities result in a number of benefits for establishing and supporting learning communities and in the potential for supporting cross-cultural understanding and collaboration.

In this paper, we consolidate the results of our previous studies on the use of 3D CVEs for learning to conceptualize a Virtual Research Arena (VRA) framework. We present an overview and a context of the framework as well as a discussion on its practical use. We define the VRA as a framework for creating awareness of educational and research activities, promoting cross-fertilization between different environments and engaging the general public [5].
2 Virtual Research Arena: overview and context

In our previous research, we were exploring collaborative work on 3D content in a virtual campus and virtual city context. The VRA was suggested as a part of the conceptual framework ‘Universcity’, in which we seek to integrate different aspects of city life: culture, society, education and entertainment [6]. The ‘Universcity’ framework has 4 layers that correspond to the above aspects of city life and contain specific infrastructure elements or facilities. These elements of the environment are designed using the Creative Virtual Workshop (CVW) framework [6]. The CVW provides a set of principles/approaches for collaborative work on 3D content in CVEs, including its creation, sharing, reuse, presentation and exhibition.

The VRA was proposed as a social virtual environment for supplementing the Norwegian Science Fair – a festival where science projects are presented to the general public in a simple yet attractive way. As a first realization of the VRA, a virtual science fair was erected in Second Life mirroring the one in reality and presenting 8 research projects in a virtual mode (Fig. 1).

![Fig. 1. A Virtual science fair pavilion in Second Life](image1)

Furthermore, the Virtual Science Fair was presented at the fair in real life as one of the projects. The visitors in real life could come to the pavilion and immerse themselves into the virtual extension, exploring a number of projects (Fig. 2).

![Fig. 2. A real-life pavilion presenting the Virtual Science Fair](image2)

In addition, we were using the VRA environment for a regular practical exercise in the Cooperation Technology course. Students were asked to build visualizations representing any research project and present them at a joint session by role-playing. The data was gathered from direct observation of students’ activities online, virtual artifacts, such as chat log and 3D constructions, and users’ feedback provided in a form of group essays. The methodology applied proved to be effective in this particular course and promising for other areas. The students extended their understanding of cooperation and received some practical experience in cooperating with others using different technologies, their advantages and limitations.
The study demonstrated a wide range of possible topics that can be visualized and presentation methods. In addition, the results of the study helped us to develop an experimental typology of the 3D content and visualization means in 3D CVEs.

3 Discussion and future work

The results of the work presented contribute to 3 main areas that are connected by the VRA: first, collaborative work on 3D content; second, services contained in a virtual campus; and third, community represented by virtual city. In the following, we attempt to form a concept of the VRA out of our observations, results of studies conducted and feedbacks.

Content level: On the content level the VRA introduces basic methods for facilitating 3D construction process and elaborating on 3D content. These methods are based on the typology of the 3D content and visualization means, which provides a classification of content types in 3D CVEs (text, multimedia and 3D objects) and their appropriateness for different purposes. The typology also provides a specification of the visualization means in 3D CVEs, which includes three major aspects of the presentation form of the content (aesthetics, functionality and expressed meaning) and their roles.

Service level: The Virtual Campus with a number of reconstructed buildings provides an appealing atmosphere and contains community places, tools and facilities for seminars, meetings and discussions. These tools and features that provide this support within the VRA are designed based on the principal ideas of the CVW (Fig. 3) and include a virtual workplace equipped with tutorials and tools, providing assistance for control and navigation, communication and work with content. The workplace is linked to a library with ready-to-use 3D objects, textures, scripts and other resources. A virtual stage provides support for sharing and presenting content and is equipped with corresponding facilities, such as a slide-show screen and a place for presenting 3D constructions. The stage is surrounded by a virtual gallery where constructions are stored and exhibited.

Community level: In the ‘Universcity’ framework, the Virtual Research Arena and the Virtual Campus are infrastructure elements, which represent the layer of education and research and are connected to each other (Fig. 3). This layer is considered for supporting educational/research activities and networks. Following the ‘Universcity’ strategy of integrating different aspects of community life, the VRA is linked to the three other layers (cultural, social and entertainment) by attracting international visitors and tourists, connecting research environment and the general public, creating awareness of the local and international research and entertaining the visitors.

By means of the VRA, it is possible to support ties between different communities such as students and teachers, external experts and the general public. In addition, we provide initial boundary objects and introduce shared artefacts around which the interaction and collaboration are structured. Based on the CVW framework, we are developing a virtual gallery that will serve as a community repository [7], exhibiting 3D constructions.
Conceptualization of the VRA raised a number of challenges, such as complexity of assessing and evaluating collaborative work on 3D content, sophistication and ambiguity of 3D visualizations, difficulty of establishing communities in 3D CVEs, possibilities of connecting physical and virtual spaces and events.

The future work will contain further development and evaluation of the VRA framework. We plan to use it in a new project for creativity support in educational settings involving students from different European countries during 2011-2012.

References