LIVING MACHINERY
Advantages of Webble Technologies for Teaching and Learning

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Abstract: Webble technology is the most recent form of Meme Media following Richard Dawkins' seminal ideas about memetics and relying on Yuzuru Tanaka's interpretation of the Meme concept in the form of IntelligentPad. The reach of Webble technologies is demonstrated by means of a particular Web-based interactive laboratory. It arises the question how this novel technology is perceived and what impact it has on teaching and learning. This paper describes how to apply different learning methods to use the Webble technology for varying learning goals.

1 INTRODUCTION

As Johann Nepomuk Nestroy said, the progress has the peculiarity to look much bigger than it really is. One should have these words in mind when praising the advantages of technology for purposes of teaching and learning.

The authors facing a rather appealing technology are trying to find out the proper advantages which may be drawn from this technology when invoked for teaching and learning purposes. Emphasis is narrow-mindedly put on those details which properly distinguish the new technology from others currently in use. Do teachers really identify the added value of the new possibilities? Do learners perceive and appreciate the differences? To answer those questions, the authors have to briefly introduce the essentials of the technology first.

Webble technology is the most recent form of Meme Media systems following Richard Dawkins' "Meme" ideas (Dawkins, 1976) and relying on Yuzuru Tanaka's interpretation of the Meme concept in the form of IntelligentPad (Tanaka, 2003). It provides wide opportunities for people to reuse, to re-edit, and to redistribute software components published on the Web. The authors have developed a Web-based interactive laboratory based on the Webble technology to provide widely reusable learning or teaching environments. To build a prototype the authors used solar technology as general learning topic and therefore as concrete technical object a solar "biker", which is a model of a bicycle powered by a solar cell.

On the one hand solar technology is a prominent topic in the societal discourse because it is seen as a promising alternative to nuclear power. On the other hand solar technology provides an excellent opportunity for interdisciplinary learning in school education as it is an objective which can be analyzed through the perspective of chemistry, physics, mechanics. As known from a huge amount of empirical studies the progress in using digital technology in school is rarely cutting-edge (Windschitl and Sahl, 2002). Any software for school contexts has to take the computer literacy of students as well as their teachers into account and hence provide a multifunctional, easy to use system which allows an entertaining experience at one time (Zhao and Frank, 2003).

The metaphor "Living Machinery" points out that a virtual laboratory should not be sterile and static but a dynamic and vivid place to meet, to experiment and to communicate. In a biological sense these machines in the laboratory can grow through the user's interaction and became hereby "Living Machinery". In a technical sense these machines are extensible and reducible and therefore non-static but in a way "alive".

2 MEME MEDIA TECHNOLOGY

Meme Media technology is a software technology developed by Yuzuru Tanaka (Tanaka, 2003). The Meme Media technology accelerates the reuse and the

redistribution of the knowledge resources on computers like documents or application tools.

2.1 Meme Media Architecture

In order to realise Meme Media on computer systems, we need to have a system which supports the representation of various kinds of computing resources such as texts, images, documents, and tools. Those media should provide the functionality to recombine, decompose, and duplicate resources by their users.

Meme Media architecture proposed by Tanaka is based on object-oriented component architecture and wrapper architecture. In the Meme Media system, any type of knowledge resources is wrapped as a graphic object. All media objects provide standard user-interfaces and operations such as moving, resizing, and copying. Through these standard operations, users may define child-parent relationships between objects to set up both graphical dependencies and functional linkages. Composite media objects are always decomposable and re-editable by users.

Each media object provides a list of interfaces which maintains its state of the data, called slots. From the users' point of view, a slot works as a connection jack of a media object just like AV-system components. Users can functionally connect each child object to one of the slots of its parent object. Only a single connection can be defined between child and parent objects. Connected objects form a tree structure (Figure 1).
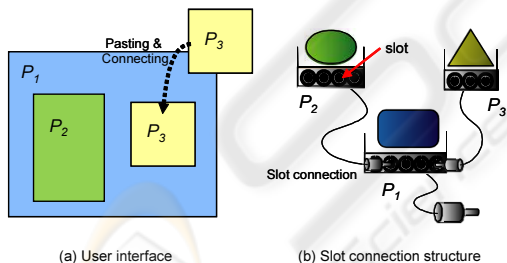

Figure 1: A composite media object and its structure in IntelligentPad.

Each media object has its Model-View-Control architecture, and communicates with other objects through standard messages; "set", "gimme", and "update". A "set" message and a "gimme" message are used to access a single slot of its parent object, and a "update" message is used to propagate changes of state to a child object. In their default definitions, a "set" message sends its parameter value to its recipient slot, while a "gimme" message requests a value from its recipient slot.

2.2 Webble Technology

The most recent version of IntelligentPad is extended as a Web-top system called Webble (Kuwahara and Tanaka, 2009), which allows us to directly publish and combine media objects in the Web. The Webble means Web Pebbles, where "Pebble" is short for "Pad Enhanced Building Block Lifelike Entity". In the Webble system, each media object has 2D vector graphics and its view is called "webble". Each webble can be embedded into a local coordinate system of another webble to define a child-parent relationship between them. It is possible to create Web-based compound documents including dynamic graphic components represented as composite webbles. Because the Webble system is implemented by using Microsoft Silverlight, it is available in major Web browsers only by installing the Silverlight plugin. The Webble system brings in more flexible representations of media objects and more seamless integration with the current Web technologies. Our Solar Biker Laboratory uses the Webble system as the basic technology.

3 SOLAR BIKER CASE STUDY

The Solar Biker project has been inspired by some real toy kits originally developed for educational purposes by Peter Thron et al. in Ilmenau, Germany. The general intention of the authors is to digitalise a series of similar toy kits and produce Web-based laboratories providing useful content for learning at school. The teacher composes a target application like a complex machine from the atomic components in the lab. To rebuild it on their own requires knowing and applying the laws of physics, mechanics and electricity. The Solar Biker Laboratory is a prototypical example. Because the virtual laboratory is based on the Webble technology, it allows the easy distribution and the reuse of both components and composite results.

The system should also encourage users who are intrinsically motivated and knowledge seeking to learn something about certain topics, e.g. like visitors of a museum. Solar technology is a highly discussed topic in the public. People in western cultures are very aware of energy-related topics, e.g. in Europe as you can see in the results of the Eurobarometer (TNS Opinion & Social, 2009). Therefore it is assumed that people are interested to deal with environmental topics like solar technology and that they are moreover intrinsically motivated to deal with solar technology.

But there is a big gap between environmental awareness and the understanding of basic phenomena like solar technologies or climate change. Bell (1994)

and Peters and Heinrichs (2008) stated people often do not understand the underlying scientific coherences. We will offer with our "Living Machinery" an approach to deal with relevant social and science based topics in an playful but knowledge based manner.

3.1 System Overview

The interface of the Web-based virtual laboratory basically consists of four main parts: repository, workspace, help desk, and administration panel. Figure 2 shows a snapshot of the current user interface of the Solar Biker Laboratory. The repository lists up available components as icons. Users can instantiate a component by dragging out an icon from the repository and drop it onto the workspace. In the workspace, users can perform standard webble operations such as moving and pasting to compose a solar biker. The help desk displays basic information such as a description about the functionality of each component is displayed. Here, learners can put in some keywords in the input field on the help desk to retrieve appropriate help documents. The administration panel can be used for loading and saving composite components.
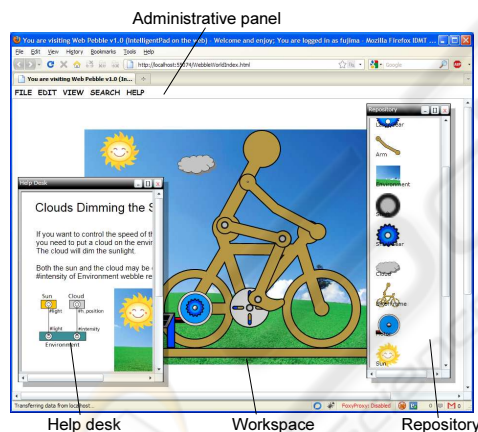

Figure 2: A basic layout of our virtual laboratory Web site.

Learners have to pick out the necessary components from the repository and combine them correctly in order to compose a solar biker. If this is successful, learners can complete to build a leg animation for bike riding. Through this system, users can study, for example, how to supply electric power to a motor through a solar cell or how to construct a leg movement by combining some basic components.

3.2 Components

In order to realise the construction kit for a solar biker, we implemented the necessary component parts as webbles. The component set includes all necessary components which form the body of a solar biker such as a body frame, arms, and legs; and mechanical parts like motors, gears, and solar cells. Some components represent some sort of environmental conditions such as a sun and clouds.

Each webble publishes the necessary information as slots. They include some values used for customising the behavior of a webble and visual attributes such as the position of a webble. By transferring these slot values among composite webbles, various behaviors of a solar biker including movement of the legs are realised. For example, a motor webble has the slot "powerInput" for receiving electric power and the slot "rotateAngle" for sending the rotation angle of its shaft to other webbles.
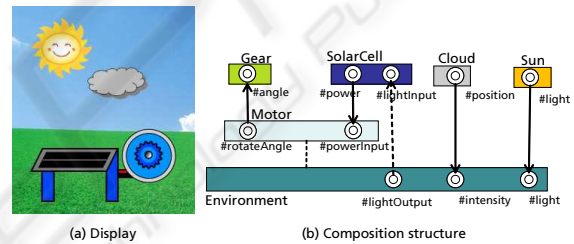

Figure 3: An example composition of components.

Figure 3 shows an example composite webble forming a part of a solar biker. From the users' point of view, the composite webble is displayed like Figure 3 (a). On the other hand, internally the composition structure can be represented as Figure 3 (b). Here, rectangles represent webbles and double circles represent slots. Additionally, solid arrows show slot connections and their directions of data flow. Dashed arrows indicate data transfer without slot connections.

In Figure 3, a gear webble and a solar cell webble are combined as a motor webble, and the motor webble is pasted on an environment webble as its child. A sun webble and a cloud webble are also connected to the environment webble. The solar cell receives light through the environmental webble, and supplies electric power to the motor webble. When the motor receives electric power, it rotates the gear by transferring rotation angle. The learner's movement of the cloud webble horizontally changes the value of the intensity slot because the cloud's horizontal position slot is connected with the intensity slot. Therefore, the intensity of the light, which is supplied to the solar cell, is changed, and the motor's rotation speed is also changed.

Thus, learners can combine the available components through direct manipulation of webbles to compose toys. Through the construction process, learners can acquire which component should be combined and how components interact with each other.

3.3 Help System

Even the most recent and advanced help systems (Salazar and Macias, 2009) tend to be implemented as a static document which includes some texts, images, sounds, or videos. Learners can only read, watch, and listen to them. The current compound document technologies such as HTML and Flash provide many opportunities to implement interactive documents which include directly manipulable objects. However, it is difficult to extract parts of such objects and reuse them in the users' environment for other purposes.
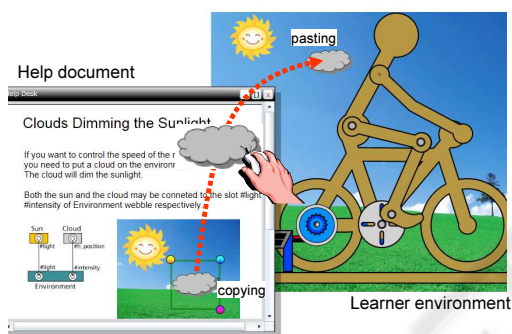

Figure 4: Copying a component in a help document and pasting it onto the workspace.

By using the Webble technology it is possible to advance existing help systems. Figure 4 shows an example of such a help system. Referring to the figure, a learner opens a help page that explains how clouds have an effect on the sun and how clouds should be connected to an environment webble. The Webble technology allows us to embed "Living Machinery" on such documents as well. Teachers or system administrators can create such documents just by combining working webbles with some text webbles or image webbles, and can store them in the system.

The help document in Figure 4 includes some text descriptions, a working composite webble, and a figure showing the composition structure. The learner may get some information from the text and the figure. However, for a learner who cannot understand the text description well, the embedded working webble might become a good alternative. Learners can not only manipulate the embedded webble directly by using the help document but can also make a copy of the cloud, and paste it on the environment webble in his workspace to confirm the function of the cloud.

4 PEDAGOGICAL AND DIDACTICAL ADVANTAGES

The Webble system could be used to create different learning scenarios. There is no need for much technical competence, so also teachers who have no advanced computer programming skills could easily appropriate it. The great advantages in comparison to other existing e-learning platforms are

- first of all the ease of use
- second, the flexibility of learning methods.

In the following chapter we will discuss these advantages with regard to the virtual environment laboratory described earlier.

4.1 Ease of Use

Technology in school needs to be easy to use, especially for teachers (Buzhardt and Heitzman-Powell, 2005) but also for learners. Hereby the Webble technology provides within the virtual laboratory a toolbox for teachers, through which different topics and tasks can be edited as learning scenario and on the other side a construction kit for learners to explore the given tasks or learning environments.

Ease of use, as the extent to which a novice user or a novice learner can manage an e-learning system with a rather low amount of practice and training and as the extend to which a more skilled user can manage the e-learning system with a minimum of effort, is one of the most influencing factors for the consumer acceptance (Leong, 2003).

The teachers can use the webble technology to create e-learning scenarios in the same way a child would use building blocks to create certain physical objects like Lego. The functionality of the webbles enables their usage without any programming skills. Every webble can work on its own or as a part of a complex system. For example the options of a gear webble (on its own) are restricted but due to the fact that this component stores all the information about its possible course of actions it can be easily put on another webble and work together without further effort. Therefore the teacher can for example merely arrange the required webbles for a given task even without programming them or programming them with a simple relation setting through the user interface (like a child-parent relation).

The e-learning system has to deal as mentioned above with both more skilled users and novice users. A novice user could be very pleased with a restricted user prompting through a help system. A skilled user on the other side could pretty soon be tired or bored

with that restricted user prompting. The help system can control which elements are put together in which order, so a failure analysis can take place. The user will get a very individual feedback concerning concrete failures during a task and will receive the required assistance to solve the task.

4.2 The Flexibility Concerning Didactical Methods of Learning

Overall the advantages for using the Webble system are based on the flexibility concerning didactical methods of learning. For the teacher it is very easy to implement an optional instructional method to support the intended learning outcome. In the following chapters three different types of learning approaches and their possible implementation in the Webble system will be described.

4.2.1 Discovery Learning

It was Piaget who argued that people construct new knowledge through processes of accommodation and assimilation on the basis of their experiences (Piaget, 2003). As one result the learning theory of constructivism emerged. This approach of discovery learning focuses on the learner as an active individual which should be engaged in knowledge acquisition. Learning is seen as constructive process on the basis of experiences (Loyens and Gijbels, 2008).

There are different instructional methods to foster this kind of learning. The concept of discovery learning for example assumes the necessity of active examination and self-determinant exploration of objects of the social and objective environment to foster sustainable learning. Discovery learning has the potential to motivate students intrinsically, because of the focus on self-determination (Deci and Ryan, 1985). Exploration is one of the learning styles, which are inherent from birth. The teacher has to offer space for self-acting engagement with different objects and topics (Bruner, 1961), which will be given through the Webble technology. Hence important properties of the virtual environmental lab are the possibility to freely discover the learning environment and possible actions within it. It is possible to change or recreate objects consisting of different webbles through a process of trial and error. Learning through experiences is also enhanced through the cooperation with other students. Therefore the Webble system provides the possibility to exchange results as webbles via Internet with other users.

4.2.2 Playful Learning

Learning through playing is another learning style, inherent from birth. Great advantages of playful learning are also seen in the potential for intrinsic motivation. Playing is an action that takes place for its own sake. A player experiences playing as a rewarding activity that includes feelings like enjoyment or suspense (Huizinga, 2006). Playing is mostly attended by deep concentration on the content and the voluntary investment of time. These are characteristics each teacher would decide as being very important for learning.

There are different options for students using the virtual laboratory as a playful learning platform. First of all it provides the possibility of just playing around. Therefore the solar biker provides a multifunctional virtual playground. Students can stick different components together, either to explore the manifold possibilities or to reach certain internal goals. Learning based on playing without certain goals gives the learner a wide range of possible actions to discover, practice and experience (Mitgutsch, 2008).

Students without intrinsic motivation would maybe soon loose the desire to play. In this case it could be a promising alternative to bring in the dimension of competition. Within the Webble system it is easily possible to change the players experience completely and put in the aspect of competition and strict rules. For example there can be a tournament between different groups of students to reach a given goal first or the teacher can apply a high score for the optimal implementation of given machines in a given environment – digital game-based learning (Prensky, 2001).

4.2.3 Guided Learning

There is also a main research area dealing with discovery learning, which mainly shows that in some cases guided learning is more effective for learners (Kirschner et al., 2006). That's why an e-learning environment should be capable to react on difficulties of the learner and offer the chance for the teacher to implement guided learning strategies. The first point is linked with the help function. The importance of the help function's usability and the implementation in the Webble system is described above.

The second point refers to strategies of direct instructional guidance. This means that teachers provide every topic-relevant information for learners and support a learning strategy. To add a focused learning goal, working examples and steps to reach the learning goal can be very fruitful for novice learners, which otherwise would be confused or lost because of the

manifold possibilities of the virtual laboratory environment.

5 CONCLUSIONS

Inspired and driven by the idea of Memes and based on former work about IntelligentPad and the Webble technology, the authors developed a prototype of a virtual and interactive laboratory, namely the "solar biker". The virtual solar biker supports learning as well as teaching, because the underlying Web application monitors the learning progress of the user and provides individual help. Furthermore the solar biker can be used for collaborative work, for example the user can send the work results as "living machines" via e-mail to others. We outlined three different didactic methods to illustrate how the solar biker can be flexibly embedded in different learning situations depending on previous knowledge, motivation, or learning goals.

We regard the empirical evaluation as the main next step. The empirical evaluation will be conducted as formative evaluation, integrating the perspective of students as well as teachers. The "Living Machinery" follows the meme media philosophy and supports a creative way to produce, reuse, and reedit knowledge in a social and communicative manner. The leading research question for the empirical evaluation is: do the two target groups appreciate the new character of that "Living Machinery"?

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