Web3D – a Tool for Modern Education in Biology

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Abstract-Web3D or virtual reality on the web used interactive, immersive three-dimensional worlds, not to be mistaken with video clips. We write here about our experiences and suggestions on this attractive technique, which we use and develop for more than ten years. Our field of work is natural science e.g. biology.

Keywords- Web3D; web virtual reality; biology; medicine; physics

I. INTRODUCTION

The young generation is faced today with many sources of information, sometimes too rich to be digested “in time”. In addition young people are not keen to accept any more the traditional ways of teaching that emerged before the age of computers, internet and mobile phones. Many studies show that in young generation the interest for experimental sciences is much lower as it was some decades ago. So we need new educational tools that provide modern means of teaching and understanding the science. Cleverly used computer – aided education with the help of educational games and virtual reality worlds provides here a significant step forward.

In addition the world is becoming more and more globally connected. Europe and Asia (especially China) experience today a much more intensive exchange of knowledge and information as it was the case some years ago. Since the cultural history of these countries is very different, it is necessary to devise tools that make the cooperation easier and lead to less “culture shocks” that often appear when people that have grown up in different cultures meet and need to work together on the same project. New software tools that combine art, education and science and are tightly connected with “the real world” can be of great help here.

II. BACKGROUND

Combining Science with Art.

As we are studying the diversity of living beings, often some associations pass through our minds. Why not to catch them and to help us remember and understand better what we are studying? Why not to work on two levels simultaneously: the one level being the scientific and the other the artistic, the latter expressing our thoughts that are still not shaped formally enough to become the matter of the scientific research? It is easier to combine this with the help of nice pictures (fig.1) in the virtual reality world (VR) as in the real one. In the same VR world you can study the VR models of diverse animals and plants while the other models around you reflect through their shape, colour and animation or video the interesting associations stimulating yours and students’ imagination. Scientists, teachers and artists do not work just in their offices. Their creative ideas accompany them also in their free time when they take photographs, make art works or record video. So a tool combining their “professional” work with their “private art work in free time” gives rise to new ideas and stimulates the motivation. We want to describe in outline some interesting software tools and tell how we are designing and producing the educational games in the virtual reality. These educational games teach about some hot topics in the nature around us – like water pollution or radiation originating from cell phones, sun, microwave ovens etc.
Figure 1. Beautiful patterns are a popular decorative element, they stimulate our imagination and help us to obtain fresh ideas. So why not to use them as a starting point in communication?

The web links that these pictures contain do not point to the descriptions of objects as shown on the pictures, but the pictures stimulate us to follow up the association we get when looking at the picture, deciding to select it as the "right one".

The upper collection of pictures is about the forest and garden, while below dominate the “wall impressions”.

Such an arrangement of the links is definitely useless in order to reach a precise goal, but it may become a kind of a computer game or computer relaxation - the start of comparing and discussing the ways of thinking of friends from different places and cultures. So also the pictures shown here are taken from different places on the world - Slovenia, China and Italy.
III. BIODIVERSITY AND “RANDOM PATTERNS”

Biodiversity means the diversity of living beings. There are so many species of the animals and plants around us that even no specialist can know them all. It is like the field full of different flowers or forest full of different leaves. For us such “random” patterns have always presented a challenge. It seems that we have inherited the love for the semi-ordered or unordered patterns – noise in other words. Thousands of flowers on the field or leaves in the forest are for us both beautiful and challenging. We tend to find some pattern - some solution in this seemingly unordered world. Maybe the origin of this lies in the old times when our ancestors were searching for some edible plant or animal that might be hiding there. Or it was necessary to spot a wild animal that was hidden in the forest canopy. The ability to do this was of vital importance to man and so it simply had to be also interesting for him. It has been challenging to our brain to filter it out from the noise surrounding it. We also like to play games based on the uncertainty of random numbers - like throwing the cube. The biodiversity attracts us maybe also because it is so variable that it seemingly resembles a noise pattern. So why not to use this passion to learn and explore the structure of living organisms and their evolution? One can use different “noisy” patterns to compose music (fig.2). Or let the computer produce a random pattern of simple objects of different shapes and textures in the virtual reality. The user can point to the objects which he finds interesting and also the ones that he finds disturbing. So he influences the evolution of the model. As the model gets more defined in its shape, the user needs to help in the creation of the systems of organs, like the skeleton, the way of moving, the sensory system etc. So a new “living being” is created both by the random process and the influence of the user. The computer simulation helps the user to test the efficiency of the new organism in the ecosystem. For example, if the way of moving of the organism is not in accordance with its sensory system (e.g. the eyes or tactile organs are on the back) such an organism gets bad survival chances. Why not to combine such a study with interesting associations and art inventions as well as with the computer games? But the goal here is not to play in the first hand. We want to study, learn and explore while enjoying our work. This is the fundamental concept of the tools and initiatives that we describe in this chapter. It helps us to follow the ways of biodiversity, the structures and functions of the living beings but in a way to keep afloat also our intuition and art feeling to get new ideas during the study instead of becoming sleepy because of studying boring lists facts.
IV. TOWARDS A TOOL FOR EXPLORING MODERN EDUCATION, ART AND SCIENCE

Background

Present biology education sources are mainly textbooks and the study of living material like observing and dissecting animals or plants. Books are very practical if you have them and they are not too many. On the other hand, if a student doesn’t have the appropriate textbook he typically visits internet to learn about the topics he is interested in. In contrast to books, which are practical because they do not need any special rendering equipment, one needs a computer to visit internet and authoring of rich and attractive high quality internet content might be technically more difficult than writing a book. Today we are confronted with enormous inflow of information we have to digest daily. The classical style of a textbook becomes obsolete when simply uploaded as a website on the web server – because it requires too much time to read. A good web page should explain in minutes something what would require hours of study from a classical book. However, when we find the relevant information, we often turn back to the classical book style to read the details slowly and clearly. The key to such an enhancement of the speed of learning are the interactive illustrations, animations and web3D worlds with relative little text, but a lot of expression. For example, biological structures and processes are especially suited for such a representation because they all occur in space. Technology now enables us to use a rich variety of web3D tools. The first to appear was VRML (Virtual Reality Modelling Language) – ref.

Photography, video, HDV and Web3D

Computer virtual reality, filming and photography – three different technologies, but now more and more connected. I was lucky to photograph for 30 years, shoot video for 20 years and do computer virtual reality for 10 years.
mention this because I always wanted to join the photography and video with “modern” technologies of the time. So my way of creation has been influenced by the technology that was available to me. For example, with virtual reality worlds on the web ten years ago one had to take care that objects with not too many polygons were published on the server and the file sizes of the textures (images on the models’ surfaces) was small enough. The idea of broadcasting the video on the web was more or less unrealistic. So at that time modern (and still alive!) VRML – Virtual Reality Modeling Language was very practical because e.g. to produce a sphere one only needs to write the name “Sphere”, add its location in space, the radius and optionally the texture description and so with less than 50 bytes you publish on the web a nice sphere with many polygons that are not downloaded through the internet, but created on the fly at the user’s platform. The more advanced VRML node is called the “Extrusion” which is defined by its “spine ” and “cross sections”. We modeled this way for example the human middle ear, which is less than 100KB large (Fig.3). The VRML worlds of that time as you can see e.g. on Bioanim (2006) are instructive, but they lack the richness of good graphics which we experience in professional films and computer games. So the next step (fortunately connected with the increased internet speed nowadays) is to make the web3D look more professional. We decided to do this in the Macromedia (now Adobe) Director (Macromedia 2006)–ref with the virtual reality capabilities which include not only nice graphics but also Havok physics simulation engine. Because VRML plugin has not become popular and there are rumors that also Java is not used on all computers, we chose to publish on the web mainly HTML and Flash content as well as video and allow the users then to download the Director virtual reality worlds to use them later on offline or online.

Figure 3. The VRML model of the human middle and inner ear. The models are the extrusions what makes them very small in the file size.

There is a significant difference between video and internet: Video is typically just to watch and internet is interactive. We expect to go to cinema or to watch TV and not to do anything else except getting the information and eating popcorn during the show. On the other hand internet is an interactive experience, like going to a library and searching for books there. So according to this definition, internet is more a tool to work while TV and film is more for relaxing or “relaxed learning”. Of course also the opposite can happen, but most of us expect to relax when watching video. The authors need to know this habit of their audience well; otherwise
they might disseminate their products to the wrong target audience. A combination of entertainment and education is called edutainment. Basically any modern education needs to be interesting; too, otherwise it is only a data bank or just an obsolete way of education. We today expect to become motivated for some topics by our teacher and the teachers who do not succeed here, lose much of the impact of their lesson. Edutainment can be very variable in the regard of the percentage education: entertainment. So one would immediately think that edutainment with a high percentage of entertainment and just a bit of education is naturally more attractive as if composed the opposite way. But it is in fact the expectance of the user which is crucial here. So a software tool that makes easier the study of the living cell structure and function is quite different from a computer game one uses to play and then learn at the same time a bit of the cytology. The advantage of the virtual reality (VR) is that it appears in space where we can walk or fly and is completely interactive. So a lot of textual or spoken explanations regarding the cell structure and function become unnecessary since the user already sees it and interacts with it. VR worlds can also have very nice and detailed pictures on the surface of their models. These pictures are called textures (fig.4). Imagine a plane in the VR space bearing the texture which is the picture of the living cell structure. As you travel in the space above this picture, it helps you to learn this way: The cell nucleus pops up like a volcano when you are above it, the same happens with mitochondrion etc. So it is much easier to remember the names of the cell organelles if they “emerge out of the picture” when you study them. However, good pictures are also very large (10MB or more per picture) because they need to retain high definition also when the user is inspecting the picture from a very close distance. So the virtual reality worlds with many pictures (textures) become huge in file size and therefore more appropriate for local use. Their web variants have smaller textures, stimulating us to download the detailed version to our computer.

Figure 4. Maybe the most rudimentary of influencing the picture in the 3D world. The picture above (the photography of a stone relief in grass) is the texture put on a polygonal mesh in Macromedia Director. The mesh is created “on the fly” what means that it is not imported into the world as a model, but instead the coordinates of the vertices are given and the model is built and refreshed while we are moving with our avatar around in the virtual world. The avatar here is the blue shark, just the same as shown in fig.4 and the deformation shown here is a “growing volcano”. So it is possible to make any desired deformation on the model that is covered by the picture - e.g. pointing out some interesting details on the image as we approach their locations. Such a tool can have both educational and artistic values.
As I bought my first HDV (high definition video) camera a year ago, it was a real discovery to me! High definition video is a kind of marriage of the video with photography. Before it appeared, we had used to say: “Video is nicer because it effortlessly captures the action and sound, but photography has a much better resolution and so it is better for recording details and expressing moments frozen in time”. With HDV suddenly both issues become technically possible during the same act of shooting. An image captured during playback of a HDV is good enough to be used also as a good web photograph. Officially it has the same resolution as had my first digital photo camera, but when I compare the photos, it is clear that the ones captured from the HDV are far better. So it is not just the formally declared resolution that is important, but also the way the picture is internally processed in the camera. There is also another interesting phenomenon that I noticed during the summer holidays. A big ship was passing quite far away from the coast. I filmed it with HDV and then also made some photos with the same video camera, but in the photo modus. After I inspected the photographs and video I tried to read out the name of the ship. Although the resolution of the still image was twice the HDV video camera resolution, I could read the name of the ship on the video, but not on the still photos! The continuously changing picture of the video gives our brain more information as the fixed image, in spite of the fact that the fixed photograph has a better resolution! Especially for documentaries HDV is of great value. We just primarily shoot the video. If we have opportunity, we use also the still digital camera to make good photos. But in case the target is gone, we have already captured useful photos in the previously recorded HDV.

Cell-Tissue-Body Project

Our web3D project named “Cell-Tissue-Body” explains with VRML worlds some of the biological structures and functions that are difficult to understand from the textbooks only. The project was supported by the Ministry of Education in Slovenia (2000) and is now accepted as one of the official learning tools for biology in Slovene secondary and primary schools. The project is available for free in Slovene, English and Chinese language.

As we were producing the software package we were working together with teachers to obtain their feedback in order to make our product better. First of all they asked not only to produce web3D worlds, but to paint also the illustrations like the illustrations of classical textbooks. In other words, there appeared the need to enable a smooth transition from the classical textbook style to the web-textbook and finally web3D worlds. So we added also the illustrated atlas in Adobe PDF format which could be printed on paper and displayed also with traditional projectors. This resulted from the fact that in Slovene schools the computers and the projector are typically located together in a special room (“computer room”).

In one of the first phases of the project we were exploring the major requirements for a project bringing virtual reality worlds into the classroom. We asked the teachers and students about their needs. Teachers wanted that the project does not only contain the interactive computer software, but printable transparencies as well. Regarding the content it was decided to primarily explain topics that are difficult to understand from the textbooks only. For example, to investigate the structure and function of the living cell, one needs special equipment (microscope) and then the microscope images have to be further explained in order to understand them. There is a common practice in schools to use video equipment to record microscope images. This represents the starting point for spatial visualization (fig.5). The digitized (microscope) image is undergoes treatment with an image editing program so that the structural entities come to different images. Then the picture is reassembled into a dynamic HTML web page so that user that glides with the mouse over some structural detail instantly gets information about it: the detail becomes highlighted while other elements are shown in gray.
Figure 5. The picture of a mitochondrion on the left, its drawing (middle) and its virtual reality model (right). The noise on the left picture is eliminated on the drawing, while the 3D model tells us about the real form of the mitochondrion. It is modelled in VRML using the so called LOD (level of detail) function. This means that when our camera is far away the mitochondrion looks like a simple cylinder with the outer more permeable membrane (shown here as a patchwork) and the inner membrane. As we approach the mitochondrion, it “opens” (in fact being replaced by another model that is partly open) and we see the invaginations inside which bear the enzyme complexes for the respiratory cycle.

Figure 6. Comparison of a 2D drawing and its corresponding virtual reality world. The object are the different morphologies of the taste buds in our tongue. The drawing on the left is simple, expressive and immediately illustrates the difference between three kinds of taste buds. Excellent to retrieve just the fact – in this case the shape difference. On the other hand, the virtual reality world on the right seems to be more complicated at the first glance. The “hose” with arrows denotes a typical itinerary through this world with our camera. Although the shapes are not so clear and straightforward as on the drawing left, they (because they are 3D models) give a richer impression. If you are diving “inside” you are likely to remember better the different taste bud morphologies.

Understanding the taste receptors (fig.6), bioelectricity and the potentials on the synaptic membrane is often difficult for students. We provide here some animations and simulations that help to understand at the first glance what happens on the excitable biological membrane. First we made a simulation where the student gets two compartments containing two kinds of
ionic solutions. Initially the compartments are separated by a membrane not permeable to any ions. If this membrane is made a semi-permeable that lets through larger ions, but not the smaller ones, an equilibrium soon takes place where the diffusion forced get balanced with the electric forces – the smaller ions would diffuse through the semi-permeable membrane out of the compartment, but they are attracted back by the electrical forces of larger ions which cannot diffuse through the membrane. The bioelectrical potential builds across the membrane. In this phase the user can add channels to the membrane. Opening such a channel depolarizes the membrane, but after the channel gets closed again, the resting potential is re-established. So the student plays producing bioelectric spikes and learns about the postsynaptic and action potentials. He can place on the membrane also the ion pump which pumps the ions thorough the membrane against their concentration gradient thus increasing the resting membrane potential. After gaining the understanding of the processes on the molecular level we advance to the cellular level to study the mechanism of the synaptic connection between two cells. There is provided the “classical” illustrated material and animations describing the neuronal synapse with the presynaptic cell which contains synaptic vesicles that contain the synaptic transmitter molecules. The electrical depolarization is the trigger which makes the vesicle membrane to fuse with the outer cell membrane and the transmitter molecules enter the synaptic cleft. The transmitter diffuses rapidly and some of its molecules hit the receptor molecules of the membrane channels on the postsynaptic membrane. We provided a VRML world where the user can virtually travel with a transmitter molecule through the membrane channel. He triggers the process by clicking with the mouse on the pre-synaptic cell. The transmitter molecules are released and reach the membrane channel of the postsynaptic membrane. The activation gate opens, and sodium ions pass through the channel into the cell interior. We also follow their path, go through the channel and come out in the interior of the cell. We see how the channel “trembles” as it rapidly goes very fast from its open and closed states for several times and finally, as the transmitter molecules diffuse away, the gate. We modeled the channel, which is composed of several subunits, so that we first created one subunit from extrusions only and then copied the remaining units as instances of the first one. The functionality was achieved through VRML script. The whole VRML world is less than 80KB large. We produced two versions: one to be observed with VRML plugin and the other one to be observed without any plugin by the help of the Shout3D applets.

To learn about the more complex relationships in the nervous system we chose the field cricket as the model animal. In contrast to humans or mammals, the nervous system of insects contains much less cells and is easier to study and to understand. There has been done much research on the processing of acoustical information in insects, especially crickets. The acoustical communication is necessary for the survival of the cricket as a species. The male emits the chirping sound and the female finds the male so that it locates the sound source. Scientists studied this behavior so that they put a female cricket on a rotating sphere of about 50cm diameter. There were loudspeakers next to the sphere emitting the male sound and the female was running towards them. The sphere was rotated by several motors so that the animal always stayed on the top of it (the cricket’s position was monitored by the video camera which supplied information to the computer controlling the motors). With the animal running in the same place during the whole experiment the neural mechanism of searching for the sound source was studied. This technique was refined so far that it was even possible to record the electrical activity of nerve cells in the running animal.

Our visualization also starts showing the cricket walking on the virtual ball. As we approach to the animal, its body gradually opens (the level-of-detail function replaces the closed model with the open one) and the nervous system is revealed. The selected nerve cells are modeled with their colors changing as they conduct the nerve impulses. In the next virtual world the user approaches the prothoracic ganglion – one of the most important centers processing of the acoustical information. There he can adjust with sliders the intensity of the incoming neural information input and observe the way how the omega cells process this information.

Another example of one of our functional models is the structure and function of the human eye. First a simplified model of the eye is shown which opens as we approach it to reveal its main structural parts: cornea, lens, choroid and retina. The path of the light through the eye is shown as a semitransparent cone that connects the object we are looking at and its inverse picture on the
retina. Now the user has two possibilities – to learn about the color vision or to experiment why we sometimes need glasses to correct our sight.

The virtual world where one learns about the color vision is composed of a source of light, the object we are looking at and the model of the eye. The intensity of the light can be varied with a slider. At low light intensity we see with rods. These receptor cells are relatively very sensitive to light but they do not enable color vision. We visualized this fact by “sending” black-and-white pictures of the object from the retina to the visual nerve. When the user increases the light intensity, the other receptor cells - cones in the eye become active. Now we see colors. This is shown in the model as you could guess, by sending color pictures from the retina to the optic nerve.

In the other virtual world the student can deform the round shape of the eye and so study why there is sometimes the need to wear glasses. He has three buttons that elongate, shorten or restore the original shape of the eye and two sliders which control the focal distance of the eye lens and the lens - object distance, respectively. The inverted image of the object is projected to the retina. When the user changes with the first slider the distance of the object, he has to change accordingly also the focal distance of the lens to restore the sharp image back on the retina surface. This goes so far as the eye keeps its original shape. However, when the eye gets deformed, it is no more possible to adjust the vision properly. The student has to click on the model of the right “contact lens” to apply it to the eye and he can then correct the sight of his deformed model.

Rgaming and Lake pollution projects

Rgames (fig.7) are educational games explaining the hazards that can be provoked by radiation, impairing the living cell and hence also our organisms. This is the entering point to teach about the function and structure of our genetic and cellular system and the possible dangers arising in this respect. We use the web technologies like web3D, Havok physical simulations and DHTML to produce spontaneously attractive teaching material and electronic interactive “textbooks” covering selected topics that are taught in the secondary and primary schools in Europe and are difficult to learn from only paper textbooks.
the lower right image fires a projectile – the photon modelled as a sphere with spines – it may hit the DNA base and make it vibrate. The vibration reflects the instability of the real DNA when hit by a photon of great energy like UV or gamma waves.

The middle picture shows the integration of video in the virtual reality world. It is possible to play video and one can clip it with a clipping mask like the butterfly shape here.

We created a web portal explaining some of the themes that are now much discussed by young people and difficult to teach only with written or spoken explanation. We concentrated on the themes connected with the living cell and its genetics like radiation – from natural (visible or invisible) sunlight to other radiation sources (radioactivity). The living organisms face radiation from the early times of the evolution of life on Earth. Radiation harms as well as benefits for the living beings. It is also an excellent starting point to play, explore and learn in the virtual reality environment.

We made the experiments’ designs according to the suggestions of experts in physics and biology and we accepted the pedagogical theories of expansive learning and constructivism, where student learns as he constructs things.

First we made our models with Z-Brush modeler, then added animations in Discreet Plasma and finally ported the functional models into the Adobe Director, where the final product was assembled and further programmed. In Director we programmed the code related to the virtual reality world, while the educational game engine itself was done in Macromedia Flash and then ported to Director. So it was possible to produce in addition to the virtual reality Director world also a “planar” Flash version of our game that is running well also on older computers that children or some schools sometimes still have. This Flash – Director combination enhances also the collaboration between pupils. They can write their Flash code – a simple game for example. After playing it in Flash planar environment they can plug it into our Director code (with models and 3D world already available there) and instantly they get a real virtual reality game. So their motivation for learning natural sciences gets enhanced.

In the virtual simulation/play about the lake pollution the user can experiment how to manage and clean the polluted lake without previous knowledge of biology and ecology. However, if you want to be successful in playing the game, you need to gain knowledge about the biology and ecology of clean and polluted lakes.

The virtual environment is represented by the model of the lake which has inflow of fresh water, outflow of lake water and the lake depth is divided into three levels: shallow, medium and deep. Plants can only grow in the shallow part of the lake, deeper there is no light for them even in the unpolluted lake. The deep part of the lake contains cold water which almost never mixes and is vulnerable to accumulation of toxic agents of pollution as well as potentially toxic sediments. The border around the lake contains a virtual farmland (the source of organic pollution), a factory (the source of chemical pollution) and a cleaning plant.

The user can use several vehicles (avatars) to travel in the virtual reality world. The vehicles take forms of animals (e.g. a tadpole for swimming in water), or a dragonfly for flying in the air. The parts of the vehicles can be animated (the tadpole moves its tail in order to show swimming and the dragonfly flaps its wings to simulate flying). The user controls the flying or swimming of a vehicle with the keyboard keys.

The whole world contains Havok physics simulation and is collision sensitive where desired (for example the avatar always collides but its whiskers never collide).

There is possible to “fire missiles” from any vehicle. When the missile hits a relevant target, some action is evoked as the result. For example, when underwater, a water plant starts to grow there in order to help to make cleaner water. But if the user fired the missile too deep, where there is no light, then also no plants can grow and so firing the missile was ineffective.

The objects – sources of pollution like the farmland or the factory – produce pollution. Pollution is modelled as quantum spheres of “pollution units” which are produced by the polluting agent and enter the lake. If heavy enough they might fall on the bottom and increase the degree of pollution. On the
other hand, the water cleaning plant produces “cleaning spheres” that destroy the pollution spheres when colliding with them. So everybody sees the degree of pollution or cleaning at a glance. There is available a set of monitors that show to the user what is happening in the system. Because acting in the 3D world needs a lot of attention, the “default” message display is simply very well seen 3D extruded text which appears on the top of the vehicle and slowly floats up and away. Typically it displays a short message. Since the text contains many polygons and slows the performance of the system significantly, there are allowed only two lines of it. But the user can decrease the size of the 3D window and to bring to view additional screens - “oscilloscopes”, showing the history of the game. Two oscilloscopes show the degrees of lake pollution and its resources, respectively; the other two show the resources and health of the user.

CISCI (Cinema and Science) project

The project CISCI (Cinema and Science) – ref is an undertaking to help to raise interest and to improve public understanding of science primarily in the young generation. The primary target groups are teachers and their pupils. CISCI combines the most popular media among the young generation, namely movies and the Internet, to help to raise the attractiveness of science, to counteract the widely spread misconceptions arising from pseudo-science as well as to raise the pupils’ awareness and sensibility of gender-biased representations of science and scientists shown in movies.

CISCI sets up a web-based platform containing scientifically relevant and interesting video clips about 1 to 3 minutes long from popular movies or documentaries together with didactical scientific explanations and analyses. This includes also pseudo-scientific themes, gender-specific issues, and public ethical and risk concerns related to science and scientific achievements. These video clips are supplemented on the CISCI-platform with multimedia, interactivity, communication features, search functions, availability of the video tapes or DVD’s for the corresponding movies, and an online-journal about science aspects in movies. The contents of the CISCI-platform are available in at least 6 European languages and implemented in and disseminated through the central CISCI-platform, the websites of the involved partners and additionally through already existing popular educational websites.

Movies as well as the Internet belong to the most effective media consumed by European citizens. In the CISCI-project these two widespread media most popular in the young generation are combined targeted at pupils at schools in order
• to help to raise the attractiveness of science
• to counteract the widely spread misconceptions arising from pseudo-science
• to raise awareness and sensibility of gender-biased representation of science and scientists
• to discuss in public ethical and risk concerns related to science and scientific achievements

The purpose of CISCI is aimed at enhancing science teaching in schools across Europe complementing formal curricula. The primary target groups are teachers and their pupils. CISCI uses an innovative approach by combining the most popular media among the young generation namely movies and the Internet with the following objectives:
1. To raise the interest and attractiveness of science in the young generation
2. To take popular movies and documentary films as a vehicle to present scientific concepts and laws to pupils
3. To help pupils to learn to distinguish between pseudo-sciences presented in popular movies and scientific laws and ideas
4. To motivate pupils to think critically about science information presented in popular movies
5. To help pupils to learn where the borderline between verified and untested science lies
6. To overcome gender-stereotyped representations of science and scientists and encourage especially female students to engage with scientific careers
7. To address public ethical and risk concerns related to science and scientific achievements
8. To attain the widest possible dissemination of the CISCI using the possibilities of the Internet

CISCI sets up a web-based platform containing scientifically relevant and interesting video clips about 1 to 3 minutes long from existing popular movies and documentaries together with didactic scientific explanations and analyses including pseudo-scientific views, gender-specific issues, and public ethical and risk concerns related to science and scientific achievements related to science and scientific achievements. These clips are supplemented on the CISCI-platform with documentaries, multimedia, availability of the video tapes or DVDs of the corresponding movies, interactivity, communication features, search functions and an online-journal about science aspects in movies. The dissemination are carried with the help of the CISCI-platform, the websites of the involved partners and additionally through already existing popular educational platforms amounting to totally at least about 20 different European educational platforms and websites. With the help of these dissemination activities at least 100.000 users in 9 European countries are reached. Production of an offline DVD (or several) as material for use in schools with limited bandwidth or even for private households.

The average age of European scientists is growing continuously because of demoscopic reasons as well as the careers choice of the young generation. However, for the European research area and the connected affluent society it is of utmost importance that a sufficient number of qualified persons leaving the educational sector in the area of science and technology exist. The vocational choice is most notably stamped by opinion forming factors and experiences in the primary and secondary educational sector. However, recent analyses reveal that the falling interest among young people for science studies and careers can be attributed in large part to the lack of appeal of study courses at school. Science is perceived as uninteresting and difficult, and so it is not surprising that young people acquire a negative attitude towards it. More than half of the Europeans (59.5%) think that first of all, science lessons at school are not appealing enough.5 Especially the raise of the number of female researchers and female scientists has been pointed out as a primary task of EU-policies. New analyses show that the decreasing interest in scientific studies and careers is partially due to the insufficient attractiveness of scientific school subjects as well as to the missing scientific “role-models” especially for girls.

Pupils spend a considerable amount of their leisure time watching movies by going to cinemas or by watching television, video tapes and DVDs. Therefore, it is clear that this offer of the entertainment industry has a large impact on the views and mental attitude of the young generation. The relevance of this behaviour with respect to the attitudes of science is a double-edged sword. On the positive side it can raise the interest and attractiveness of science, on the negative side it may lead to serious misunderstandings and faulty knowledge of science. Many blockbusters of the movie sector are related in some way or another to scientific subjects or undertakings. On the other side they include often elements that are related to or even pure pseudo-science or science fiction. It is one of the aims of CISCI to aid teachers in the classroom to disentangle these two aspects shown in popular movies.

It is well documented that most of the public including the young generation has only a minor interest in an understanding of science. In fact, it is even worse, because most of them cannot distinguish between science and pseudo-science, and have not a clear concept of science in their every-day lives. There may be many factors of this limited scientific literacy including social and economic conditions. However, many scientists strongly believe that the media, and in particular the entertainment industry, have a large influence with respect to the interest and attractiveness of science, and are at least partially responsible and a source of the public’s misunderstandings and faulty knowledge of science. In popular movies scientific issues are sometimes not dealt with in a correct manner, and they contain often pseudo-scientific or para-physical themes that are only partially related or even contrary to scientific processes and laws. A
wide public and also pupils who watch television or films with pseudo-scientific or para-scientific themes do not interpret all events as entertainment based upon fiction and tend to take them as real or at least within the reaches of science.

This unchallenged manner in which entertainment industry portrays pseudo-scientific and para-scientific phenomena should excite great concern in the scientific and societal communities. This fact does not only amplify the public’s scientific illiteracy, but puts at risk the public’s attitude towards science in general. As a consequence the possibility is enhanced that decision makers and opinion leaders our society could inadvertently causes serious damage to science simply through ignorance and misunderstanding. Furthermore, such influential figures can obtain aversions during school time against general and specific issues related to scientific achievements and progress influencing possibly their decisions in the scientific and technical sector in an unjustified negative manner.

The impact of popular movies with respect to the scientific literacy of the public can be enormous compared to other media and specific educational efforts. One striking example can be taken from the “Eurobarometer Survey” testing the scientific literacy in all member states of the EU. It was found that the scientific literacy remained practically the same for all subjects between the years 1992 and 2001 with a notable exception: the knowledge on dinosaurs had increased by almost 10%. This is probably due to the hype activated by the blockbuster “Jurassic Park” by Stephen Spielberg. The Internet allows the most wide-spread dissemination. However, the use of the Internet for educational purposes does not automatically guarantee a wide-spread impact. In the CISCI-project there are at least three factors that should enhance its impact for teaching sciences at school. All the relevant and necessary content, information and tools can be found on the web-based CISCI-platform, making it to the one-stop shop for movies and science thus facilitating the work of teachers. The second factor is the use of combination of the films and the Internet that are both universally enjoyed especially by the young generation. The third factor is that CISCI is available on numerous educational websites in the native languages of the involved partners being indispensable for the use in most European schools.

Some tools that we use in our work

After 10 years of experience with authoring in Virtual Reality Modeling Language (VRML) ref we have been developing a virtual reality environment in Macromedia Director. VRML and its successor X3D are extremely cleverly built environments and we are very fond of using them. They are maybe the best tools for open code based projects, but they lack the more advanced graphical and functional features that are characteristic for the computer games that our children like to play. So we also “upgraded” to Director because it has a very good virtual reality engine as well as being a professional authoring platform for multimedia. The virtual reality part of Director also contains the Havok physics simulation for rigid bodies. This means that the objects can possess the mass, velocity etc. and can be connected with springs. So the animation and simulation becomes much more elegant to create. The first step in the world creation – the virtual reality models we used to produce with another tool called Zbrush (Pixologic 2006) and Plasma (Discreet 2006) . The final textures and the functionality of the 3D world are then composed in Director. We also use Macromedia Flash environment along with Director. In Flash we often program the game engine because the Flash action script is more comfortable to author than the Director programming language and even more important – one can make the Flash game a standalone project and then (if he observes the simple rules for the interface) he can just drag and drop the Flash file into the Director. So in Director this same Flash game starts to live in the virtual reality world. The above technical description illustrates also how different members of our community can each provide some part (3D
model, nice picture or video, Flash code etc) and these parts can then be readily fused into the Director virtual reality world.

There are several kinds of virtual reality. From the most demanding, which can be used only with special computers, to the ones that can be used on an ordinary desktop or laptop played from its hard disk and “the lightest” which can be readily accessed from the internet. For example, a functional model of the human ear in VRML is only about 100KB large file size. This is because it uses the clever way of VRML programming where e.g. a cone is not defined by the coordinates of its vertices, but simply by writing the word “cone”. Our fully functional environment for the VR game Rgames (Radiation games in virtual reality, containing tens of models and lots of code) is about 20 MB large when the images (=textures) are of very low resolution. Improving the quality of images so that the pictures become nice produces the file of about 90 MB.

A good strategy is to combine all of the above techniques in a clever way.

**VRML**

VRML (VRML 2006) is the classical modeling language. Although it is now more than 10 years old (hence its name VRML97) and in the meantime declared to be dead for several times, it is still very important and used. You can use it in its classical form which is called VRML97 or in its “reincarnation” which is called X3D. The latter is now intensively developed and let’s hope it will become widely used and popular. VRML or X3D is written in plain text like HTML and has the nature of open source. You describe the models, materials and animation with simple text. So you can write only a few bytes of code to produce quite a nice scene. The problem is that VRML typically needs a browser plugin to be rendered on your platform. The plugin is small (e.g. Cortona –ref less than 2MB) and you get it of course for free. However, it can well happen that somebody who visits your web site with its VRML worlds, does not take time to download the plugin and so sees nothing of your creations. A workaround is to use the java applet like Blaxxun or Shout3D as shown on the fig.8. instead of the VRML plugin. The java applet is a part of your code and so the user sees (if he has the java enabled on his machine) your world without downloading anything. Unfortunately there are rumors that lost of users do not have java enabled and so my recommendation is to show on your web site first of all the pictures or Flash –ref animations, obtain this way the interest of the user and then invite him to look at a VRML world or to download a larger virtual world of high quality done e.g. in Adobe Director.

**C++,Java, Maya and 3DS Max**

The programming languages like C++, Java and Java script are the basics of programming. One should be aware when using them that this is very demanding work, for which you never know how long it lasts because you can encounter problems in your code which can be sometimes fixed soon, or it can last days of debugging to find the bug, which is often just a single wrong line of code… Alias Maya and 3DS Max are difficult to use for the beginners besides being expensive tools. In short, the topics of this chapter is not to discuss these highly professional tools but rather write about simpler and cheaper tools that are more suited for the “amateur” VR authors.
Z-Brush

Z-Brush (Pixologic 2006) is a 3D modeling and “2.5D” painting tool. It is very interesting and I recommend it to the artists who like to discover. Its idea is to paint originally in 3D (with high quality models with large number of polygons, materials and textures) and then convert the artwork to the 2D picture. Alternatively, there is possible to export the models in the Alias (obj) or Autocad (dxf) format (Alias 2006, Autocad 2006)–ref. In case of obj you can export the texture as well. Zbrush offers the unique user-friendly possibility to paint the textures on the 3D models. You can also import a model into Z-Brush, paint it and export it back. For modeling Zbrush offers also “3D painting” on the surface. As you draw on the model surface with your brush, you push down or elevate the surface polygons. So you can make very nice details in a short time. Alternatively you can model with “Z-spheres” (fig.9) to produce models which can then be skinned. It looks like that the Z-Brush was made by a very clever author who created the missing link between

Figure 8. Web3D visualization of the marsh called “Barje” near Ljubljana, Slovenia.
the classical 3D modeling tool like Maya or 3DSMax and the painting program like Adobe Illustrator or Photoshop. The consequence of this genial approach is also that the user interface is something much special, very nice and user friendly, but much different from the interfaces we are used to in other programs.

Figure 9. Modeling a shark for our VR world of Flash movie. We produce first a model in the Zbrush (upper left) which then gets the skin and is painted as seen on the upper right. The model is then exported into the Plasma where it receives the bone animation. This model can then be exported to Flash as an animated cartoon or as a virtual reality animated model.

Producing the terrain

Producing terrain for your virtual reality world can be achieved also without any special software. First you scan or photograph the map of the terrain you intend to model. Then paint with the same grey level the regions that have the same elevation. For example, the sea level can be painted black, the 100m above sea grey and 300m white. More grey levels means more detailed terrain. Then soften the image to obtain nicer relief and import it into the NIH Image, a free image processing program (NIH Image 2006). NIH Image can export the image as ASCII characters, which can be then with small adjustments imported into VRML as the indexed face set or the elevated grid. You have obtained the 3D relief of your terrain. Finally put on it the texture and here is the virtual reality world based on the real terrain taken from a map.

Terragen

If you do not need to reproduce an existing terrain, there is a simple and very nice tool named Terragen (Terragen 2006). It produces randomly based (fractal) landscapes with water, vegetation clouds and sun (fig.10)! The creation process can be almost automatic or finely controlled with numerous possible adjustments. For example, you can influence which parts of the terrain are covered with vegetation by defining the altitude or the steepness of the terrain as the limit for growing the vegetation. You can use Terragen to produce the background of your virtual worlds. You make several screen shots of the landscape created with Terragen, join the images into the panorama and bring this panorama as the background of the VR world. When, for example, the water level rises during an
educational game (e.g. because of the global warming), the background images are replaced by the ones containing higher and higher water level. The water simulation in Terragen is very simple and effective task.

![Fractal landscape with lake](image1.png)

![Fractal landscape with flooded water](image2.png)

Figure 10. The view of a purely virtual fractal (randomly generated) landscape with lake (above) and after being flooded with virtual water (below).

**Brand Worlds Tools**

Brand Worlds Tools (Brand Worlds Tools 2006) is a program where you can produce nice looking human beings (or optionally also other creatures) without any programming. It can be regarded as a smaller brother of the much more professional Poser (Poser 2006). The output is a Flash format file (swf) or image (jpeg or animated gif etc) file. There are several already modeled characters whose body proportions, skin, clothing and many more can be varied. You then add from the menu the kind of motion or gesticulation you prefer. Alternatively you can compose your own gesture and use it the same way as you use the factory-made ones. There is also possible to compose the 3D background surrounding, where your actors live. The user interface is a very user-friendly drag and drop system, which can be edited and fine-tuned also later on. This is a very appropriate tool for the “target population” of this chapter. Simply make your own character without knowing anything of computer programming. The things that are still missing is sound and the export to virtual reality world. You get “only a movie”, but it can consist of several layers (one for head, one for body etc).
Plants in VR worlds

Plants are beautiful and the main themes of many artworks and botanical studies. The technology of virtual reality enables us to produce them artificially in the (educational) virtual environment and to travel through their interior microstructure discovering and redefining their structure and function. The user can – through his avatar – enter the plant interior e.g. through its stomata, discover the structure of the leaves, enter the process of the photosynthesis and if he wishes so, modify it as well as modify the color of chloroplasts and color pattern of the leaves.

Also the shape of the leaves can be changed or shaped by the user. The user constructs his “own” plant, but this one becomes also the simulation of a living one that needs to perform effectively in the ecosystem. So the shape of the leaves influences its survival in heavy rain, the way the leaves are coated influences the performance when the water supply is lacking etc. There is also a user – friendly computer program that help us to make 3D plant models (Fig.11).

Doing art that needs to live in a virtual world means combining our imagination with the technical reality, it is testing our dreams in an almost real world.

![Image]

Figure 11. The PlantStudio program (PlantStudio 2006) makes possible to create 3D plant models and even lets them evolve and age in the time. As shown on the picture above, one does not model the plant from scratch as he needed in case of a general 3D modelling program. There are menus which enable us to build the plant according to the botanist’s way of thinking and terminology. The models (3D meshes with colours) can be exported in several 3D formats (e.g. VRML) or as 2D pictures or movies.

V. Future Trends

There is a very intensive work in the X3D community. Let us hope that X3D manages to become the standard of web3D and widely used. Or maybe the explosively growing multiuser platform Second Life –ref will become the most popular web3D world?
We are now in a transitional period maybe comparable to the time when people switched from handwriting to printing the books. Internet – the “new printing machine” has grown immensely in the last years. It has a great educational impact. There is educational multimedia, virtual reality and other interactive modern educational tools or products, but somehow they have not reached the impact as they should deserve. There is lacking something essential in the modern educational software. I imagine this as the situation that took place in the pioneer days of aviation. There were many curious types of airplanes, but until the brothers Wright built the first really effective plane, only a small number of people were really convinced that flight would become the No.1 way of long distance transport in some years. Maybe the present status of the educational web software is somewhere short before the crucial breakthrough. So let us “discover the plane” as the global community in the global sense as the internet is, let us join efforts in art, science and education to produce tools that through modern computer and internet technology enable much more fast and effective learning as it is possible now.

VI. CONCLUSION

How to enter the world where you intend to learn or to play? We all know the classical access to the web. You open the site you want or search with some searching engine. Ok with this, and what then? Typically you “land” in some web portal which is informative, nicely designed but not much different from a paper book with the exception of some animations. Just the right design for those who want to find information the same way as if they went to a classical library. On the other hand, if we want to creatively learn in an intuitive way, we can also try some other interface. Probably instead of text links why not to put interesting sounds or colors? Or colored pseudo - random patterns? Fractal landscapes, always different where we decide where to land and to continue our journey from that part on. So we are not guided by our logical thinking when surfing the web, but instead by our intuition. Where does us then lead such an intuition? How to establish a web site that receives the input from our intuition and then brings us to the web page that our intuition asked for? One of the way is to apply the psychological studies and produce an intelligent model, but the other is to ask the users themselves to help create the model. Simply by giving them a number of links (a link palette) at each time (fig.12). The links can also be the pseudo-random patterns (fig.1) like abstract paintings, that can be of course animated and accompanied by sound. The way many users go is tracked by the server and so later on it is possible to statistically evaluate the users’ responses in order to find out if there exist some rules which can drive some model. It were quite interesting to see if all this is just a noise or if there exist some rules, maybe also different in different cultural surroundings?
Figure 12. When we travel in a virtual reality world or in the virtual world of our mind, we typically have a goal or at least we intend to follow some path. The visualization of this path and its milestones is one of the very important tasks of the virtual reality world designer. Here are some slides from different parts of the world to illustrate the real paths in order to help us creating effective virtual ones. (The first row: Malta, Helsinki and Piraeus; second row: Great Wall, China and Wien). So we use our memories from the real world that help us learn faster in the virtual world. A clearly set guiding path in an educational virtual reality world makes easier for us to remember facts that are difficult to learn. For example, if the Great Wall towers in the VR world bear the models of mRNA, ribosome and Endoplasmic reticulum, the student could remember these cell organelles faster as when reading a classic textbook.

Flower field as a multi-user environment, this idea is definitely not new. One station or “landing place” on this world is a flower, where your avatar lands and can enjoy the landscape view and start to learn about the geology like rising and eroding of mountains or leave the view around and enter the interesting world of botany – discover the flower where you stand or deep into its internal structure down to the molecular level. Enrich the cool computer world with slides and videos of your own. Pack this high-tech slide show as the executable file and send it to the friends. Make fun by producing your or friend’s portrait in 3D model e.g. with the help of the Poser program (Poser 2006).

Computer generated models and landscapes often give a cold feeling. With simple modeling it is difficult to overcome this problem. One needs to be a good professional and excellent artist to give the virtual models the warm, personal touch. As most of us are not so
skilled, the first way to overcome the coldness is to combine the computer graphics with our “hand made” photos and videos.

In the virtual reality (VR) world you are represented by a creature that moves around and the camera, which is your eye in the VR world, follows it. I prefer to fly instead of walk since this way I can make a much better use of the 3D environment. When flying around, you can study and influence the world around you. You can be accompanied by an invisible (or visible) teacher which gives you suggestions at certain places. Of course you can (temporarily) switch to the classical web environment to get more information. You can fire “projectiles” like trees, photons or measuring devices to interfere with the world and start simulations. The objects in the world are simulated real physical objects obeying the physical laws for the rigid bodies (Havok dynamics). The objects can be also connected by invisible springs which pull certain objects together and the friction among the objects can be set as desired. For example, one can produce a simple game where the student has to hit with his projectile the model of the famous predecessor of the modern birds - Archaeopteryx that lies in a bunch together with other models of the bird like dinosaurs and more modern birds. If the hit was right (the student showed that he knows the Archaeopteryx), the friction among the models is reduced and the preset springs automatically establish the development tree of the birds. Don’t worry for the bones to get entangled – the models are surrounded by the invisible bounding spheres which makes them appear to the physics simulation engine as simple spheres. This is just one simple idea. The point here is that we shall help to establish the community of scientists, artists and teachers giving their ideas and so we together build a portal based on the VR world produced by experts themselves for the colleagues, students and broad audience.

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