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LEARNING AND E-MATERIALS

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Abstract: This paper addresses the use of e-materials in learning. Under pressure from the public, which is becoming increasingly conversant with IT, schools and also other non-formal types of learning are changing into e-classrooms and e-learning. Among parents and teachers, too, there is a widespread opinion that e-learning is more motivating and is more effective. On the other hand, a mass of research shows that e-materials are more effective only in specific areas, where a multimedia approach is needed, for instance in ophthalmic surgery, while everywhere else they are comparable to traditional teaching and learning in terms of both effectiveness and motivation. The paper also highlights the methodological problems of measuring motivation and learning success. Finally it presents e-material which was created taking into account the results of research in this field.

Zusammenfassung: Im Beitrag wird die Benutzung von E-Materialien im Unterricht problematisiert. Der Druck der immer mehr informatisierter werdenden Öffentlichkeit macht die Schule - und auch andere Arten des nicht-formalen Lernens - zu E-Klassenzimmern und zum E-Lernen. Auch unter den Lehrern und Eltern ist die Meinung verbreitet, dass die Lernenden durch das E-Lernen motivierter werden und dass diese Unterrichtsart effektiver ist. Demgegenüber beweisen zahlreiche Forschungen jedoch, dass E-Materialien nur in spezifischen Bereichen effektiver sind, nämlich in jenen, wo der Einsatz von Multimedia notwendig ist, wie z. B. in der Augenchirurgie. In allen anderen Bereichen sind sie mit dem traditionellen Unterricht und Lernen sowohl hinsichtlich der Effizienz als auch hinsichtlich der Motivation vergleichbar. Des Weiteren werden auch die methodologischen Probleme der Motivations- und Lerneffizienzmessung herausgestellt. Am Ende des Beitrags werden die E-Materialien vorgestellt, die unter der Berücksichtigung der in diesem Bereich gewonnenen Forschungsergebnisse entstanden sind.

Key words: e-learning, e-material, motivation, effectiveness

1. Introduction

Under the influence of new technologies, the environment in which we learn and work is constantly changing. Being an informed and active member of society requires that the individual manages his own learning, that he himself is capable of selecting what is for him relevant study material, of formulating questions, linking and generalising, seeking solutions to problems and developing approaches and confidence regarding a range of different technologies. If this is the knowledge, understanding and skills that we set and expect from students, what then is the role of the computer and e-materials here? It is no doubt already clear enough that use of a computer in itself will not improve learning. This is proven by the technologies that are now in decline (television, video, overhead projectors etc.), but which in their time were hailed as revolutionary achievements, which would completely change learning and teaching. Experience shows that each new technology can be a great aid and appropriate tool with which we can do the same thing in a different way. Yet access to technology or the technology itself is not yet sufficient to change and improve learning. Thus computer-assisted learning should be guided by what students can do with the programme and not what the programme enables. It is therefore the teacher who is responsible for the successful and rational use of computers in learning, yet responsibility for the results achieved should be transferred to a greater extent to the students themselves. All this represents the preconditions for developing lifelong learning, which is not only pursued in schools and other organised forms, but in diverse environments and at different times, spontaneously and through internal motivation. The objective that should be achieved by the school is habituating students to work with computers and developing skills and knowledge that enable the use of information and communication technology in learning. This should serve to make learning simpler, more interesting, more effective and more independent.

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In the use and introduction of computers in schools and learning, alongside the argument about modern technology, which has penetrated into almost all activities of modern society, we also need to take into account the opinions held by parents and teachers regarding the effectiveness of computer technology in teaching.

The opinion has spread among parents and teachers that computer-supported teaching has an effect on learning success. Positive secondary effects are also apparent. A full 86% of European teachers take the view that using ICT in lessons makes students more motivated, especially those at grade school level (Balanskat, Blamike, Kefala 2006). Here they stress that students can work in line with their learning style, and this is especially important for children with special needs. In computer-assisted learning, students become more independent and responsible for their own work and learning, while there is also an increase in cooperation among schoolmates (e-mail, chat rooms etc.). There is also probably some truth in the argument that today's students live in a world that is rich in visual information, and learning material presented to them in that way is more comfortable and more motivating.

2. Motivation and e-materials

In the context of learning and school, motivation has a number of meanings. For many teachers *motivation* represents firstly *introductory motivation* as a motivational stimulus in the introductory stage of the lesson, in order to gain the attention of the students, and such motivation falls more within learning strategies (Juriševič, Pučko 2006). The broader meaning of *motivation* as a psychological construct in the context of school and learning is too lax, however, so in this discussion motivation should be understood more narrowly, as *learning motivation.* This represents an amalgamation of different factors (interests, attributes, self-image, learning objectives etc.) which activate and guide learning towards the desired goal. Owing to the unexplained meaning of motivation, discussion and research of the motivational values of e-materials are often superficial, since they do not distinguish between *learning motivation* as an interweave of internal and external *motivation*, and learning strategy, which encourages the student to learn and through which the student will also effectively achieve his learning objectives. Thus students can be motivated simply by the actual learning strategy or medium used in learning, regardless of the other factors of the motivational pattern, which include the substance and objectives of learning. In this light we may also highlight the definitions of the relations between motivation, learning processes and learning achievements given by Rheinberg (Juriševič, Pučko 2006), which are determined by three factors: the duration and frequency of learning activities, the form of providing learning activities and the functional disposition of the student during learning activities. All this to a large extent is determined by the learning strategy or learning medium. With e-material this is the computer and the programme that guides the student through the learning material. For this reason an increase in learning motivation, as shown by many studies on the use of e-materials in learning, means primarily motivation towards learning with a computer and less towards broader learning motivation, in which the learning objectives are encapsulated.

What does the variety of research on motivation for learning with a computer and for e-material prove? Much of the research has shown that learning with a computer motivates students, but not all of it. Research on the influence of internal (intrinsic) motivation on e-learning (Martens, Gulikers, Bastiaens 2004) determined that students with high internal motivation do not achieve better learning results, which runs counter to the established conviction regarding the high correlation between internal motivation and attained knowledge. Analysis of the activity of students, which was itself possible to conduct by means of a computer, showed that more motivated students do not work harder or immerse themselves more than less motivated students, but owing to greater curiosity their activity is spread wider. Computers were used more for research than for learning.

Clark (2005) found that computer-assisted lessons are more attractive for students in part because learning is thereby presented to them as less arduous, and more like fun and games. The effect, however, is frequently the opposite. Use of a computer translates into less learning than the students would gain with a live teacher. The initial enthusiasm owing to the attractiveness of the medium, accessibility of content, navigating between various chapters, leaping ahead or going back through content, simple checking or even point-ticking of knowledge, all this soon wears thin once learning needs to be seriously addressed. Research has even shown a negative correlation between motivation for learning by means of computers and learning achievements. Thus better motivated students had poorer results in tests of knowledge. Researchers explain this negative correlation in terms of a reduction in the mental effort that more motivated students are prepared to invest in learning, since their expectation is precisely that learning with a computer requires less mental effort. We therefore need to differentiate between motivation for work with a computer and motivation for learning on its own.

Frequently enough this high motivation to work with computers is used for learning less popular subject matters. Zahorec and Haškova (2007) report on a successful programme for learning more difficult physics content. The initial activities, which were spurred solely by motivation to work with a computer, changed after the introductory part into the optimal psychological state of the student during learning, which is described as a concept of rapture, where students are immersed in work, they forget about time and are not aware of the effort or of anything else not connected to the actual activity (Juriševič, Pučko 2006).

Undoubtedly the motivation to learn and work with computers is founded on the interactive dimension and on the multirepresentational dimension, or the concurrent higher number of sensory modalities with which the computer communicates with the student. Research by Mayer and Moreno (Mayer and Moreno 2002) points to a saturation with information of different modalities, which has negative effects on learning, but clearly it has positive effects at least on the initial motivation to learn. Colourful pictures, animations with sound and interactive animations where the student can change certain parameters are strong motivational factors.

Thatcher (2006) assures us that attention is one of the factors of motivation in learning through computer animation. Moving objects continuously stimulate us to observe. Computer animation of moving molecules at the same time motivated medical students to learn less popular subject matters, and presented in a more understandable way complicated biochemical mechanisms. Although the results of studies comparing learning by means of computers and animations with traditional learning from textbooks vary, students are more inclined towards a combination of computer and textbook, while they see an advantage of the computer in the shorter learning time. Increasing the interest in studying is most commonly the reason for using animation. Fisk (2008) concludes that it is precisely the movement, the dynamic of the pictures that should later influence the internal motivation to learn.

The existence of an empirical contradiction between the effectiveness of animation in learning and enthusiasm on the one hand and its usefulness as expressed by students on the other, is shown by McGregor, Griffeth, Wheat and Byrd (2008). Research on the effectiveness of animation points to mixed results, while students are enthusiastic about animations. What is the reason for these contradictions? A group of American researchers first focused on animation as a counter to the static image. In this comparison animation has two properties which the static picture lacks, these being trajectory (time sequencing) and movement. In this way animation represents one of the sub-masses of visual learning aids and depends theoretically on the theory of learning as a processing of information, something also argued by Gagne. Why and what kind of effect animation has on motivation to learn is not researched in detail, but we know that animations have an effect on motivation and that repetition of experience confirms the link between animation and learning.

The question of how a high motivation to learn with the computer (motivation towards media and technology) can be used in learning and teaching is also addressed by a group of Canadian researchers (Upitis et al. 2008). How motivation to learn by means of computers can be changed or used to motivate for learning and understanding concepts, and what kind of role the teacher should play in this, are set up as primary questions for future research.

In an awareness of the effect of learning strategy and media as an external factor of motivation, in Ireland attempts were made to proceed from internal motivation, where the student himself is a source of information for his own motivation (Cocea, Weibelzahel 2008). A definition was given for three developmental directions in which research on motivation and e-learning is currently being conducted. The first is the motivational planner, the second is based on the ARCS model (attention, relevance, confidence, satisfaction) and the third is based on the socio-cognitive theory of learning. Motivational planning includes practical strategies and tactics used in respect of the student's motivational state. In assessing this, three parameters are used: effort, confidence and independence. Motivational planning should be in correlation to planning of content. The ARCS (attention, relevance, confidence, satisfaction) model is used as a principle in planning learning interventions with increased motivation and also as a model for assessing the motivational state of the student during interaction with e-materials. The model was developed by J. Keller of Florida State University in the USA. Attention is the most important factor of the model. It relates to establishing and maintaining attention during the learning process, and this is achieved through various forms of e-learning, for instance simulation, knowledge testing, discussion and other. Relevance means that the subject matter being learned is such that the student accepts it as useful and beneficial for further learning or for future work. Confidence stems from relevance. Motivation raises confidence in the fact that the student will master the study unit in its entirety and in a reasonable time. Excessively extensive and demanding study units reduce confidence and thereby motivation. The final factor is satisfaction. A student who has successfully completed the study unit experiences satisfaction, which contributes to motivation for further learning. External recognition such as prizes, written commendations, praise from teachers and similar also contribute to satisfaction with the work done.

The third direction based on the social and cognitive theory of learning emphasises the importance of self-sufficiency and self-management in e-learning. Self-sufficiency relates to the student's belief in his own ability to tackle certain tasks at a given level, while self-management relates to the ability to control and balance one's own behaviour. Self-image has therefore been shown to be an equal factor to the student's actual ability and as an important motivational factor.

Particularly in primary education, some fascinating research has been conducted on the effects of introducing an imaginary animated person – an agent who appears in study units as a guide and commentator (Clark 2005). There is a widespread opinion among teachers that such "agents" would supposedly increase the motivation to learn and in general make learning easier. Here also, however, empirical studies do not back up these views. Research results indicate that the "agents" are a hindrance, because they interfere too much with thought processes and the flow of learning. On the other hand, research that supposedly shows a greater level of motivation with the introduction of an animated "agent", is methodologically disputable. Just as in the research on the effects of multimedia on learning, where a new method was introduced along with new media, here too the same mistake is repeated; it is not the effect of the "agent" that is being measured, but the "agent" and different media at the same time.

3. Effectiveness of e-materials

Clark (2005) analysed a large amount of research on the effects of computers on learning and teaching, and attempted to respond to some of the widespread and almost generally accepted opinions on the success of using computers in teaching and learning. He condensed the following views on computer-assisted learning.

- Learning with e-materials is more successful compared to "live" lessons or other media.

- Video, simulation and the combination of graphic and audio presentation used in this render learning easier.

- It is adapted to students through various learning styles.

- It facilitates a constructivistic and inquiry based approach to learning.

In relation to the first assertion he found that much of the research was poorly planned. Usually pedagogical research compares the results of experimental and control groups, and these must be equated in as many criteria as possible. The main criticism of such research is that alongside new media (ICT), a new and different method of teaching was introduced. So the groups were not equated in terms of the teaching method. This of course renders the validity of such research questionable. In order to better understand and grasp the effect of multimedia on learning, researchers must differentiate between the media, method and sensory modality (visual and aural perceptions, smell and touch).

Major meta-research on the effect of multimedia on learning, in which a comparison was made between 650 research studies of “live” learning and multimedia distance learning, showed that there were no differences.

Teaching methods are not only specific for multimedia. “Live teaching” or e-materials can be organised according to the same method. A time saving has, however, been shown. Methodically well prepared e-materials shorten learning time. The other advantages that the studies ascribe to computer-assisted learning are primarily greater economy, accessibility, time savings for teachers and students and similar. Just like “live lessons”, the success of computer-assisted lessons depends on several factors. Saat and Bakar (2005) isolated four important factors: software and hardware, the role of the teacher, the readiness (maturity) of the students and the physical environment.

Within the programmed content (software), an important factor of influence on learning was the actual sensory modality, or how the transfer of information from the medium to the student was organised. Multimedia lessons are by definition characterised by the simultaneous use of several modalities, images are supported by sound, texts are written and read, voice accompanies video, graphs and diagrams are coloured, animations are included and so forth. Research by Mayer and Moreno (Mayer and Moreno 2002) points to a saturation with information of different modalities, which has negative effects on learning. Excessive information overloads the working memory. For this reason information should be given in various ways, and not the same information in different sensory modalities. If the text is written, it is not necessary for us to hear it, while the effectiveness of learning is increased by a combination of text and pictorial material or a combination of pictorial material and narration. What is more effective is learning with text that does not include additional material, that does not extend into features of interest or anecdotes and details, but follows the basic idea – the story. A personal approach from the teacher is important in successful teaching. There is therefore no need to always have a live teacher but a clip of a good lecture is more effective than only reading text from the same lecture.

Animation is a typical and desired exponent of the use of multimedia, since it generally uses several modalities. One American research study (McGregor, Griffeth, Wheat and Byrd 2008) has shown that animation is only effective for cognitively more complicated content, and in less complicated content it has the same effect as a static image. The effectiveness of animation is enhanced by simultaneous narration (reading accompanying text). Some studies confirm the effective use of time in animation-assisted learning. Those being tested who had learned by means of animation more rapidly constructed the appropriate model or solved the assignment. In a Canadian study (Upitis et al. 2008) computer animation contributed to better spatial conceptualisation. Even better results were achieved through a combination of activities with three-dimensional objects and computer animation. Good results in the use of animation are also reported by Marbach-Ad, Rotbain and Stavy (2007). They compared the teaching of molecular genetics in the classical way, by means of illustrations, and by means of computer animation. Good results in the use of computer animation compared to video in teaching ophthalmic surgery are reported by Prinz, Bolz and Findl (2005). As for spatial conceptualisation, however, they identified differences between the genders. Using computer animation, women progressed further than men in the same test group. Fairly mixed results in testing knowledge following the use of a study unit that contained text, static images, video and simulation compared to the control group are reported by Pane, Corbett and John (1996). The mere use of computer animation and simulation does not guarantee greater learning success. Well prepared learning material with images and text should equally be effective and of course much cheaper. Yet video and simulation draw students’ attention and they become involved with it for long periods, which should in the long term also contribute to greater learning success. Thus animation contributes to the effectiveness of learning only if it is closely tied to learning objectives (Fisk 2008). Animated learning material should therefore be carefully prepared and target-oriented to specific learning objectives and specific users. Even the most colourful and perfect animations that do not incorporate the learning objective do not contribute to learning. A good example of this is Mister Clippy in the older Microsoft Office programme. Although it was superbly animated, the majority of users dismissed it as interference in using the programme. The effectiveness of animation for learning is in fact partly dependent on the prior knowledge and abilities of students. Fisk states that students with poorer prior knowledge often gain more from animation than students with good prior knowledge. For this reason animations are supposedly appropriate especially for the general public and popular presentation of natural science and medical processes. Like other teaching aids, however, computer animations can lead to erroneous perceptions and consequently to miss-concepts (Falvo 2008). The interpretation of animation also depends on the student's prior knowledge, for if this is limited then the interpretation of the animation is also limited. Another factor that influences the interpretation is the level of cognitive development. Students at a lower level of formal thinking or in the transition from concrete to formal thinking often accept animation as a copy of reality without the necessary degree of abstraction.

It is true that computers enable the use of various media and a combination of media, and this enables the adaptation of material to students and teachers. Here the focus of research interest was on the level of adaptation of computers and programmes to students' learning styles. Precisely this – individualised study units – was the major expectation regarding the use of computers in learning. Yet this, too, lacks any unambiguous evidence. Today's results show that study units adapted to different learning styles do not lead directly to more effective learning. Of course here, too, the problems are primarily methodological. Just the determining or identification of the student's cognitive style is difficult, and it is even harder to adapt methods and content to the individual style. Furthermore the validity of determining the cognitive style is questionable, since for the most part it is based on self-assessment.

The research results are surprising. Students who selected their learning style or their favourite method of learning and who also took part in such learning, did not achieve better results than the control group. One clear difference among the students is of course intelligence. Although it is possible in individual areas to improve results and teach certain strategies in solving problems, there is still no evidence of the effects of such success on general successfulness in solving problems.

Moreover adaptation to students – individualisation – which is frequently stressed as an advantage in using computers, is questionable, difficult and expensive. Many e-materials are closed, and do not enable free linking and combining. Independent searching and combining different media requires skills and procedural knowledge on the use of computers and computer programmes, which teachers and students frequently lack. This kind of preparation and linking are also time-consuming.

What is still more promising is adaptation of e-materials to students' prior knowledge. Students with less knowledge need more structured guidance in order to avoid new information overload owing to a lack of knowledge. On the other hand, students with better prior knowledge can be more independent in their learning. Excessively structured study units are an impediment for more demanding students.

There is also an entrenched view, at least in respect of teachers' work, that the most effective learning experience is one where the student directs his own learning or solves problems in the least structured environment or with the least support possible. This assumption about the success of discovery learning has also been tested out many times, but there is still no convincing evidence of its greater value over well structured and well led "live" lessons. Here, too, there is a problem with overloading the working memory. Less capable students use up a considerable amount of their mental capacity just on organisation, seeking strategies and other procedural knowledge, and therefore less on actual understanding and grasping specific concepts.

Sufficiently open discovery learning using e-materials and a constructivistic approach are only appropriate for students with a good knowledge of science skills (knowing the nature of science) and computer skills. In contrast to this, excessively closed material, which precisely determines the learning path, restricts the more capable students. This gives rise to an opposite effect to that among less capable students, for whom such help raises their learning success.

Bonyard and Underware (2008) have found that there are also difficulties with individualisation owing to the differing understanding of this concept among different actors (teachers-students-parents), and that in using computers there are generational and social differences, which modern schools should supposedly neutralise through enhanced use of modern ICT. They also point out discrepancies in educational phases and the use of computers. Verification and assessment lay far behind the provision of new content.

4. What are e-materials

E-materials should be didactically planned, accessible and understandable materials furnished with multimedia and interactive elements for independent learning or for teaching.

In defining e-materials in the broader sense, which covers all materials in e-form, we used the classification and descriptions drawn up by the Commission for Evaluation of E-materials at the Ministry of Education and Sport (MES 2005).

E-learning materials comprise: **building blocks, study units, study courses.**

Building blocks may be pictures, video clips, text, animation, audio recordings, simulations, software-supported presentation of content or something else. They appear as independent files. Building blocks are characterised by not having any independent pedagogical function. They only acquire this when they are arranged under didactic principles into a rational system in which each building block has a certain pedagogical function (motivation, introduction, construction of concept, assessment etc.).

Building blocks organised in this way, and to which are added learning objectives, give rise to the **study unit**. The study unit, which represents a complete whole, is also defined through the user. The building blocks can therefore be organised into a study unit such that they enable independent learning and are adapted and aimed at students, or in such a way that they are aimed at teachers. The first case is characterised by greater interactiveness (dialogue between the user and computer), and in the second case the interaction is directed away from the computer and more into a dialogue between students and teacher, while the computer is merely a means for using e-materials. E-learning units aimed at students also represent proper **e-learning**, which is defined precisely through interactiveness.

Study courses represent a series of study units provided with a list of contents and general objectives, as well as indicated learning paths or learning strategies. Study units prepared and equipped in this way make up an **e-textbook**.

5. Evaluating e-materials

In evaluating e-materials, especially study units and study courses, we may steer towards a judgement or assessment of the **user interface**, the **design** and **technical quality** of the product, and of course a **didactic assessment**.

For the **user interface** we assess how we can orientate ourselves around the material, how accessible it is, and contributing to this are tables of contents or diagrams and maps of concepts the materials contain; what navigation is like, how we can move around the material (forward, backward, closing and opening programmes), and this also includes an assessment of the support, whether it enables access to dictionaries, other browsers and databases of important links and so on.

The assessment of **design** and the **technical** assessment cover everything from the design and size of the text to the quality of images and animations, the distribution of graphic elements on the screen, their illustrative quality and their organisation.

The didactic assessment is similar to an assessment of classical materials. Here we assess the compliance of the content with the objectives, whether it allows different didactic approaches, the variety of learning methods, the nature of the learning support, how well equipped and appropriate assignments are for assessing, the possibility of self-assessment of knowledge, whether the programme enables progress tracking and more.

E-materials can support procedural objectives (procedural knowledge, skills and disciplines) as objectives leading to the development of concepts and declarative knowledge. More modern views of learning, including the learning of science, which follow the socio-constructivist approach, emphasise the role both of written and oral communication in the construction of meaning. Here, too, computers may help greatly. Yet communication is just one of the roles that a computer can play in lessons. In rough terms four functions have been defined, and a computer with the relevant programmes should have these in the learning process (Murphy 2003): as a tool, as a source of data, as a means of communication and as an aid in research. Good e-material of course combines all these. In planning, preparation, development and use they should incorporate certain principles deriving from the properties of modern learning and teaching:

- Learning is the building of knowledge through discovery, solving problems, thinking, creating and communicating,

- Learning is a deliberate and directed activity arising from the desire to make sense of and understand the environment and out of a desire to function in the environment.

- Learning in lessons is based on the prior knowledge of students, which is tested and faced with different ideas. This leads to new insights, which require a reorganisation of existing knowledge.

- Learning is an interactive activity and is therefore more successful if the student is interacting with the teacher, with other students, the computer or other resources.

- Content should be provided in a context that is familiar to students, from which they can identify the use of what they have learned.

- Learning is more successful if the content (concepts) are linked and interconnected.

- Learning should be integrated. It is better to embrace the whole problem, rather than divide it up into smaller units.

- Learning concepts is a spiral process. On a higher level concepts are enhanced.

- Learning requires guidance and support, and may be organised in the form of lessons guided by the teacher, or the student can be guided by a computer programme.

- Successful learning depends on the ability and orientation or motivation of the student to learn certain content.

- Learning is more effective if students reflect on their activities and consciously consolidate the methods, paths and strategies that activate learning (metacognition).

6. 3DBIOlab eye programme

The overview given above of the research, conclusions and recommendations generated from studies of the effectiveness and usefulness of e-material for learning, has served as a basis for the international project *3DBIOLAB support system for biology teaching/learning,* as part of the *Comenius Lifelong Learning Programme.* Greece and Austria are participating in the project alongside Slovenia.

In this project we are developing a computer programme for learning and teaching about the eye and brain on several levels, from primary school to university, and teaching for the third age university. The aim of the project is to create a learning aid that will to the greatest possible extent take into account the advantages offered by computer-supported learning, so the emphasis of the project is on 2D and 3D animation, spiral construction, interactive elements, synchronisation of modules, visualisation, brief accompanying text and simple navigation through the programme. We will attempt to avoid the other deficiencies and weaknesses of similar learning aids that have been identified by the afore mentioned research.

Programmes for different levels will be formulated in the same way (with the same building blocks), but the complexity of the content will increase spirally. In this paper we present the programme for the lower level of primary school (in Slovenia this is the 4th grade).

E-building blocks are organised as component parts of the transparencies into the headings: INTRODUCTION, ANATOMY OF THE EYE, SIMULATIONS, EXPERIMENTS, TESTS and the heading MORE ABOUT THE EYE.

Under the heading INTRODUCTION the eye is presented as an important sensory organ that enables us to observe our surroundings and identify shapes, colours, the size of objects and movement.

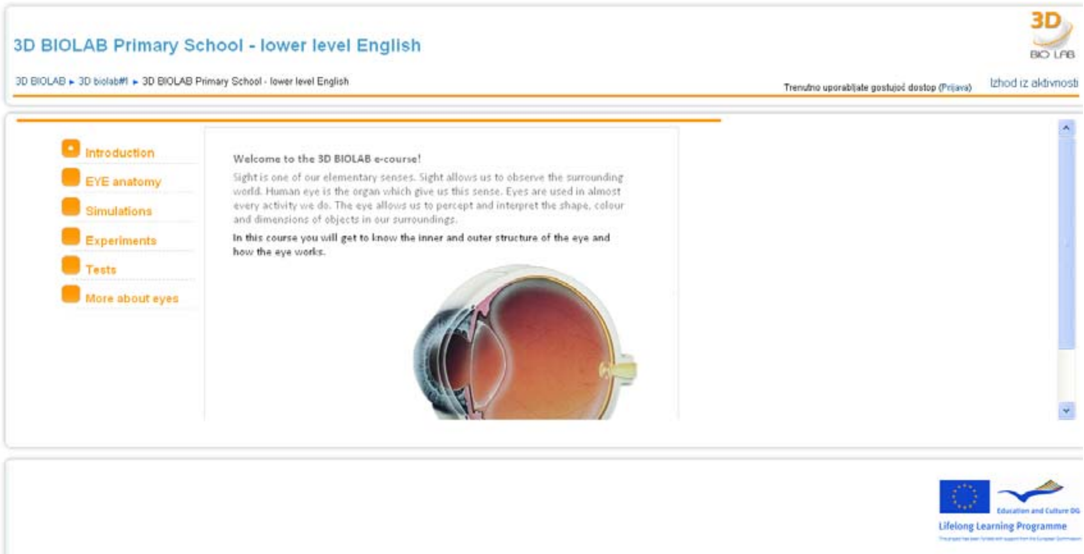

Figure 1.: *Screen image of the heading Introduction*

Under the heading ANATOMY there are three sub-headings:

- *Parts of the eye*, where a drawing shows the eye and its auxiliary parts (eyebrows, eyelashes, tear ducts and eyelids) as well as the pupil and iris. Clicking on an individual part of the eye or auxiliary part of the eye brings up a box with text describing the characteristics and role of this part of the eye.

- *3D animation* of eye structures. A 3D eye is shown with the eyeball muscles that turn the eye. Clicking on the text on the left, which describes individual parts of the eye (cornea, sclera, choroid, pupil, lens, retina, optic nerve, blind spot, vitreous body) highlights the desired part of the eye in the image. A box also appears on the right with a brief explanation of that part of the eye.

- *how the eye works.* This shows a drawing of light rays entering via the lens onto the sensitive part of the retina and the image on the retina (inverted and reduced).

Under the heading SIMULATION the computer animation shows what an image is like when it lands on the retina, and why it is reduced and inverted. It also shows short and long-sightedness, and why these conditions arise. A brief explanation also appears in a box on the right.

Under the heading EXPERIMENTS several examples of illusions are shown. Instructions are given for students themselves to determine why it is better to look with both eyes, how we can identify the blind spot, how the eye responds to higher or lower illumination and how the iris changes the size of the pupil.

Under the heading TESTS there are images and assignments for testing and consolidating knowledge. Thus for instance the left hand side shows drawings of parts of the eye, and on the right are the names of parts of the eye, and students can use the mouse to attach the names to the relevant part. This is an example of what we would call a DRAG and DROP assignment. We will also add selection-type assignments (A, B, C), assignments for filling in and YES/NO assignments.

The heading MORE ABOUT THE EYE is aimed at more demanding children. Here they can find out about conjunctivitis, what rods and cones are and what their function is in the retina, and what colour blindness is. In addition to the human eye, we can also find out how animals see the world around them and why the eyes of certain animals shine in the dark.

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