Ybl Journal of Built Environment, Volume 10. Issue 1. (2025)
10.12700/jbe-2025-0015

VISUAL ELEMENTS IN DIGITAL TEACHING MATERIALS

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Abstract: *The visual elements used also play an important role in the effectiveness of the learning process, which is designed for independent learning and requires a high degree of self-regulation. One of the foundations of the importance of learner engagement is the use of appropriate visual elements. If the learner not only reads the information, but also provides an explanation of the information by means of a figure, picture or series of pictures, then comprehension and memory are supported by the use of the visual channel in addition to the verbal channel, which demonstrably increases the learning effectiveness.*
In my research, I investigated the results of two learning activities based on the rules of digital content development, using two different learning materials in terms of the images and pictures presented: learning material featuring real-world images resulted in better learning outcomes than material with only simple drawings. Learning material, which began with simple visuals and later introduced real-world images, proved more effective than using real-world visuals from the start. The aim of this paper is to present the results of the research and the resulting recommendations for instructional design.

Keywords: *visual elements, digital content development, cognitive load, working memory*

1. INTRODUCTION

Thinking about the teaching-learning process is dominated by the need to make the most efficient use of the opportunities offered by technology in education [1]. Information and communication technology (ICT) tools have been used for more than 20 years to support learning in different areas of life. We learn and are forced to learn throughout our lives (life long learning) and, in all areas (life wide learning), as previously acquired knowledge quickly becomes obsolete due to rapidly changing social, economic and technological developments [2].

In recent years, the use of ict tools in education has become more widespread than ever before, not only as a necessity created by the challenges of the times, but also as a necessity due to the epidemic situation. Previous research has already shown that the inclusion of digital tools in everyday learning increases learner motivation [3, 4] In order to improve teaching-learning, methodological solutions have been focused on how digital tools can be used to increase learning effectiveness, to support targeted competence development [5] and to support independent learning according to the needs and characteristics of the learner.

In the design of education, the aim is to create digital educational content containing up-to-date knowledge in a way that serves the development of competences that meet the needs of the 21st century labour market and supports all elements of effective and efficient independent learning processes.

2. FUNCTIONS OF THE VISUAL ELEMENTS

The creation of learning material on e-learning platforms does not only mean the logical combination of well-understood texts. Visual elements and visual communication also play a significant role in the effectiveness of the learning process, which requires a high degree of self-regulation and is designed for independent learning [6]. Murphy [7] emphasises the importance of learner engagement, which is based on the use of appropriate visual elements. If the learner not only reads the information, but its explanation is complemented by a figure, picture or series of pictures, then comprehension and memory are supported by using the visual channel in addition to the verbal channel, which increases learning effectiveness.

János Ollé et al. define the functions of visual elements as follows:

1. decoration: aesthetics (even humour),
2. visualisation: realistic presentation,
3. evocation: recalling previous knowledge, making connections,

4. interpretation, explanation: e.g. showing cause and effect relationships,
5. organising: showing logical connections,
6. representing relational relationships, e.g. with diagrams,
7. representing transformations or changes over time or space [8].

When designing aesthetic presentation as a decorative feature, it should be borne in mind that a visual element that is not related to the content of the knowledge to be acquired and is merely decorative can motivate the learner to learn the material - a beautiful, aesthetic screen page in itself makes the learner feel good - but a poorly chosen decoration can also distract attention from the subject to be learned.

It is also important to aim for a realistic presentation with visual elements, because the visual elements used in teaching materials have an important role to play in "creating" the context in which the knowledge contained in the content is applied, simulating a real-life situation. This puts the knowledge into the context of everyday life and the professional environment, thus laying the foundations for later recognition in real-life situations.

Well-chosen visual elements are an excellent tool for bringing out existing knowledge. They can be used to point out links to what has been learned, even with little text on the curriculum page, and thus help to put new knowledge into a system, in line with the expectation of a constructivist learning environment that fosters problem solving [9]. The recall of prior knowledge related to the content of the learning material and the support of the interpretation of the material by visual elements also play a significant role in maintaining the attention of the learner.

Interpretation, organisation, relational connections, visual representation of processes related to the subject matter are key learning supports. Appropriate use of diagrams, clear highlighting, well-spaced spacing, etc., promotes clarity and thus understanding. Consistent notation, colours and clear indication of clickable elements increase the sense of security for learners. In self-study materials, it is also important to keep the learner informed of his/her progress in the material. The correct visual display of markers and navigation elements on the screen can not only inform the learner, but also help him or her to navigate the learning page independently and, if the interface allows it, to return to any page. Parminder Walia, in his March 2020 paper published on eLearning Industry, summarised the components of effectiveness in seven points, which include easy-to-use navigation, visual appeal, visual consistency, easy-to-understand content layout, appropriate colours and font size [10].

János Ollé et al. emphasise that the structure, organization and structuring of the text also affect the visual channel [8]. Studying the impact of visual elements on the learning process, researchers have found that their use affects the load on working memory. In addition to short-term memory, working memory is responsible for filtering and organising information, as well as for linking and integrating it with existing knowledge. Overload caused by redundant or poorly presented visual elements can significantly reduce the receptive capacity of the visual channel.

The visual sources of cognitive load for learners can be summarised as follows, based on Clark and Mayer [11]:

- Lack of or low degree of adjacency, where the figures and their captions are not displayed directly next to each other on the screen, but are spaced apart, making it difficult for the learner to interpret them.
- Modal redundancy, redundancy effect: the simultaneous use of several media (text, image, sound) leads to overloading of the visual channel.
- Coherence effect: the use of visual elements that are not related to the educational purpose or content overloads memory.

In digital learning materials, the principles outlined above should be followed to ensure that visual elements are used that are appropriate to the subject matter and support the learning process. Drawings and photographs are used for different reasons: drawings can be used to highlight certain details that are relevant to the subject, while other parts can be rendered neutral, thus guiding the learner's attention. Photographs are usually taken of a real element or situation, rather than a model, so that they can illustrate what is being taught in a real-life situation in a real environment.

3. THE METHODS OF THE RESEARCH

The research is a multi-sample curriculum experiment, in which two versions (K5, K6) of the curriculum were developed for the same educational content. Both are optimised for problem solving, but differ in the elements related to each hypothesis. Baseline and final states were measured by questionnaires and knowledge tests, and data on the learning process with the experimental learning materials were provided by the MOODLE interface. The MOODLE H5P plug-in provides an interactive presentation of the course content, the input questionnaire and the final questionnaire are implemented using the MOODLE test function, and the glossary of terms used to interpret the course content is also included in the MOODLE applications.

The knowledge content of the experimental curriculum is adapted to the curricular content of construction training, based on a real-life situation. The problem situation is an event that fortunately does not occur often, but it does occur in the practice of construction. This real-life situation is woven through the selected curriculum content as a case study, motivating due to its real-life nature and supporting student engagement (see Ollé et al., 2016).

At the beginning of the teaching materials, a situation is presented in which a slab formwork is torn off during a concrete pouring in January. Then, the stakeholders involved in the problem and their position and responsibilities in relation to the accident will be described. The trainee will then be taken through the construction practice, from the conditions for starting work on the slab formwork to the general rules of formwork installation, reinforcing steel installation and concreting. The manuscript is based on university curricula, but can also be adapted to the curriculum of secondary education [12].

The experimental curricula differ in the way they are structured and presented, while the content of the knowledge presented is the same and the questions for reflection in the curricula are the same. In the K5 curriculum, I have tried to include images of the real environment of use in addition to the textual representation of the knowledge (Figure 1). Thus, this version of the curriculum fulfils the principles that emphasise the realism of the visual elements in the curriculum, the presentation of the application of the knowledge in a real situation and environment.

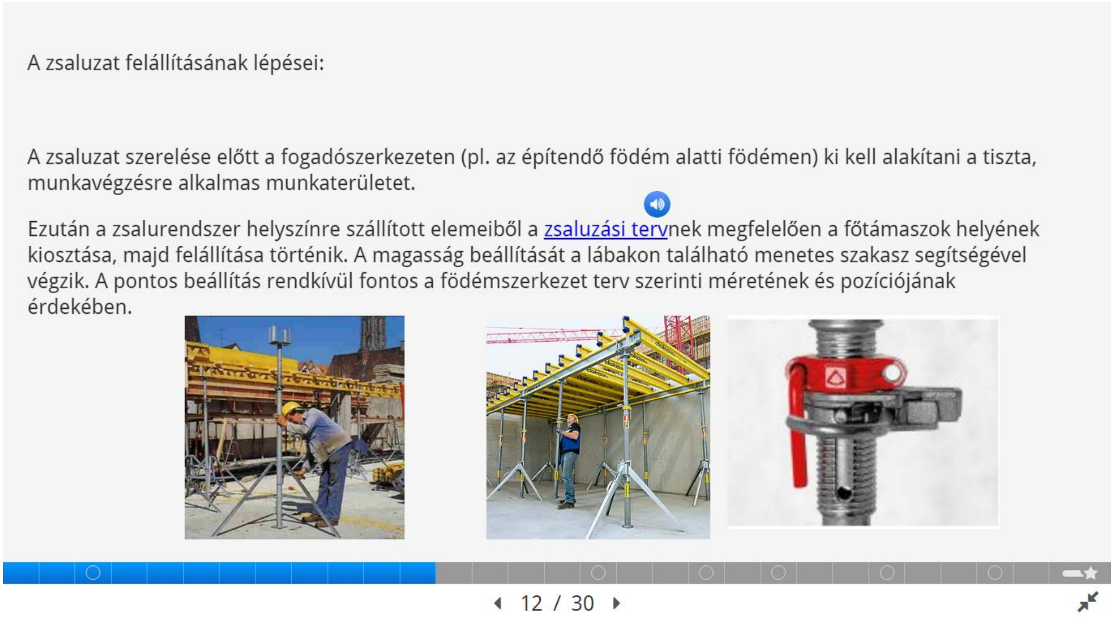

Figure 1 screenshot from the K5 version

The K6 version was designed to enable the individual to relate the information learned to the practice of implementation by means of pictures of the real environment corresponding to the problem situation, after having been supported and conveyed by simple diagrams and drawings (Figure 2). Therefore, simple diagrams and drawings are used in the initial pages of the curriculum to illustrate and complement the text, and as the learning process progresses, elements and operations from the K5 version of the real environment of the construction site are introduced. In this way, the learner comes to understand the knowledge in a unique and generalised way, in the process of putting it into its context of application.

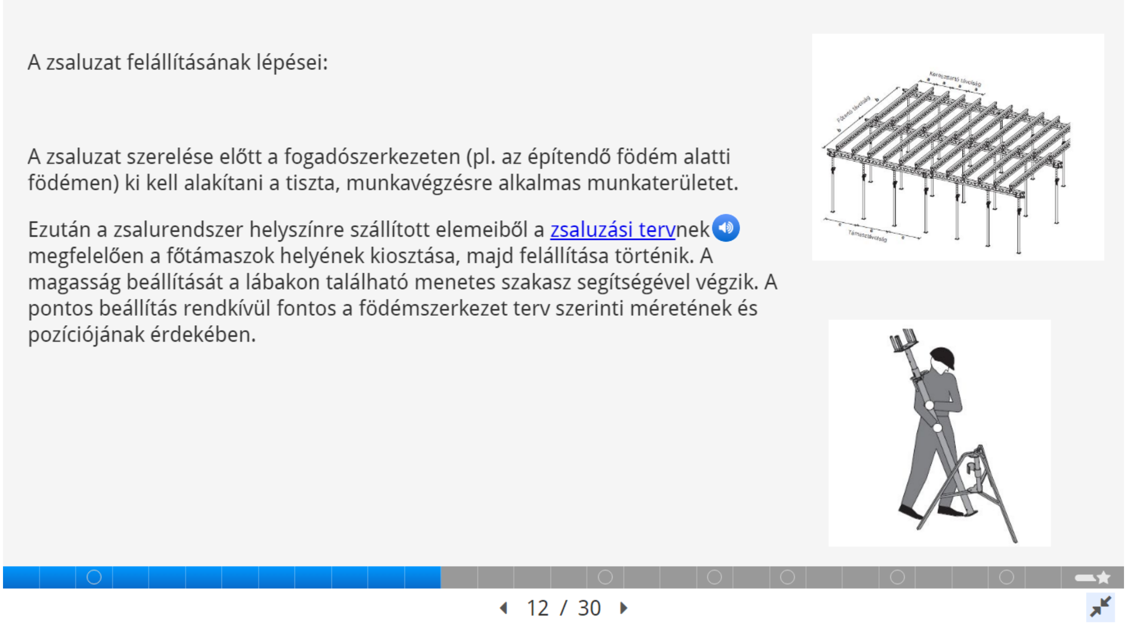

Figure 2 screenshot from the K6 version

Non-probability sampling was used, in line with the possibilities and the subject of the research, as a representative sample would not have been viable given the subject-specific nature of the curriculum and the availability of potential respondents. For learning with the curricula, I targeted the survey at adults who were enrolled in or had completed a technical or university course in construction science. The sample was 68 university students from Faculty of Architecture from 2 universities (ÓE, BME)
randomly divided in the order of application. The research was conducted between January and June 2022.

In my research, I used thirteen open- and closed-ended, multiple-choice questions in the input questionnaires in order to assess the background variables, learning habits, and prior knowledge of the students necessary for the research.

The final questionnaire, like the input questionnaire, was created in MOODLE with the test extension. The test can be accessed with a password that can be found on the last page of the curriculum, and the student can complete it once.

The final questionnaire was structured as follows:

1. The first group of questions includes questions related to learning with the curriculum and questions necessary to examine the hypothesis related to the curriculum.
2. The second group of questions included questions for measuring knowledge, each of which the student sees on a separate page; free navigation between the questions is not possible - I drew the students' attention to this in advance.
3. Finally, any thoughts related to the curriculum or learning could be shared in response to an open-ended question.

The eleven questions are mostly multiple-choice type, in addition, there is one drag'n drop and one open-ended question in the questionnaire.

4. THE RESULTS

In my research, I hypothesised a difference in the effectiveness of different types of visual support materials. I formulated the following hypotheses on the impact of the design of learning materials on learning effectiveness:

H1: Significantly better learning performance can be achieved with problem-solving optimised independent learning material if it contains a majority of pictures that represent the real-world context of use in terms of information content, rather than just drawn but also contextualised pictures.

H2: Learning is more effective with problem-solving optimised independent learning material when the initial phase of the learning process is dominated by simple information graphics and the subsequent phase by pictures of the real environment, than when the learner is presented with pictures of the real environment from the beginning of the learning process.

To test the hypotheses, I used the results of the students with K5 ($N = 31$) and K6 ($N = 37$). Based on the Kolmogorov-Smirnov test, a normal distribution cannot be assumed for the majority of the data, so I performed a Wilcoxon signed rank test to test the significance of learning achievement. The Wilcoxon signed-rank test ($T = 0.00$; $Z = -4.861$; $p < 0.05$ (1 tailed); $r = 0.873$) showed that the scores after learning with the K5 curriculum were significantly higher (Mdn = 86) than before learning with the K5 curriculum (Mdn = 59). The results of the Wilcoxon signed-rank test ($T = 0.00$; $Z = -5.305$; $p < 0.05$ (1 tailed); $r = 0.872$) for the K6 learners showed that they achieved significantly higher results after learning with K6 (Mdn = 90) than before learning with K6 (Mdn = 60). Based on the pre- and post-learning results with K5, the median difference between the groups is 27, and 30 for K6.

The calculations confirmed hypothesis H1 that better learning performance can be achieved with a learning material optimised for problem solving and designed for independent learning if it contains a majority of pictures that represent the real-world context of use in terms of information content, compared to a learning material that only contains drawn pictures that are also related to the context of the problem.

Based on the calculations, hypothesis H2 was confirmed, i.e. better learning performance can be achieved with a learning material optimised for problem solving and designed for independent learning if in the initial phase of the learning process more simple information representations are included and in the subsequent phase pictures representing the real context are included, than if the learner sees pictures representing the real context from the beginning of the learning material.

5. CONCLUSIONS

In the construction of the curriculum around a real-life situation, images and pictures play a prominent role. According to the theory of cognitive load, the basic function of pictures and images is to support comprehension and to illustrate the subject matter, so in this case it is expected that these pictures and images are related to the context presented in the curriculum, but their explanatory value may vary. In my research, I tested two different solutions: in one of the experimental curricula, I edited images taken from the real context of use, and in the other version, I inserted simpler images showing the context of use at the beginning of the curriculum, and later on, photographs depicting the given situation, corresponding to the information content. In both cases, the results demonstrated that greater learning outcomes can be achieved by using these solutions when learning with problem-solving optimised curricula than when there is no targeted effort to present the elements represented by the pictures and diagrams (e.g. the parts of the formwork) in a real-life context of use. Therefore, in order to improve learning efficiency in the development of the curriculum, it is recommended to use simpler illustrations to aid comprehension in the initial phase of learning, and then to use images of the real-world environment in the later phases of learning, as in the test result of hypothesis H2.

However, it is also worth bearing in mind that interpreting diagrams and pictures of real-life contexts of use may be difficult for a learner with less prior knowledge, so, as Mayer [13] suggests, the relevant information should be marked for the learner. In the teaching materials for this research, I have placed this marking to aid understanding and clarity on the picture in all cases where I assumed that it might be necessary to support the learner.

6. LIMITATIONS

Because of the small sample size it would be worthwhile to continue the research with more participants and a larger sample in a (grant) funded, larger study to confirm the emerging directions.

It would also be worthwhile to examine the proposals for instructional design and content development formulated on the basis of the results of the research on other subject areas, also optimised for problem-solving. My aim was to design general specific features and to measure their effectiveness, but the scope of the present research did not allow for the simultaneous treatment of one or more non-construction topics in a similar curricular structure. Concurrent results from studies in different disciplines would provide more reliable evidence of the learning effectiveness of the solutions described in each proposal.

REFERENCES

[1] **Molnár, Gy**., (2021). Az IKT szerepe a felsőoktatás megújításában. *Magyar Tudomány 2021/11. Akadémiai Kiadó.*

[2] **Schleicher, A**. (2017). Foreword and acknowledgements. In B. Csapó, & J. Funke (Eds.), The nature of problem solving - Using research to inspire 21st century learning (pp. 3–6). OECD. https://doi.org/10.1787/9789264273955-en

[3] **Smeda, N., Dakich, E., & Sharda, N**. (2014). The effectiveness of digital storytelling in the classrooms: A comprehensive study. *Smart Learning Environments, 1, Article 6.*

[4] **Hwang, G.-J., Hung, C.-M., & Chen, N.-S.** (2014). Improving learning achievements, motivations and problem-solving skills through a peer assessment-based game development approach. *Educational Technology Research and Development, 62(2), 129–145.*

[5] **Martz, B., Hughes, J., & Braun, F. (2017).** Creativity and problem-solving: Closing the skills gap. Journal of Computer Information Systems, 57(1), 39–48.
[6] **Janurikné Soltész, E.** (2019). Digitális tananyagokban alkalmazott vizuális elemek vizsgálata. In J. T. Karlovitz (Ed.), VII. Neveléstudományi és szakmódszertani konferencia. Tartalmi összefoglalók (p. 42). International Research Institute s.r.o.
[7] **Murphy, D.** (2000). Instructional Design for Self-Learning in Distance Education. The Commonwealth of Learning. Knowledge Series.
[8] **Ollé, J., Kocsis Á., Molnár E., Sablik H., Pápai A., & Faragó B.** (2016). Oktatástervezés, digitális tartalomfejlesztés. Líceum Kiadó.
[9] **Nahalka, I.** (2002). Hogyan alakul ki a tudás a gyerekekben? Konstruktivizmus és pedagógia. Nemzeti Tankönyvkiadó.
[10] **Walia, P.** (2020, March 14). 7 tips to follow to create effective elearning course material. eLearning Industry. https://elearningindustry.com/7-tips-follow-create-effective-elearning-course-material
[11] **Clark, R. C., & Mayer, R. E.** (2011). e-Learning and the Science of Instruction. Pfeiffer.
[12] **Janurikné Soltész, E.** (2014). Építéstechnológia: Monolit szerkezetépítés: Zsaluzatok - Öntöttfalas. In J. Bisztray, O. Bokor, L. Brassnyó, E. Chovanyecz, I. Császár, P. Császár, J. Hock, M. Hajdu, E. Janurikné Soltész, A. Jámbor, L. Kapu, G. Kecskés, K. Kiss, T. Kocsis, K. Macsinka, I. Molnár, M. Osztroluczky, A. Pandula, Z. Rostás, L. Szatay, ... A. Velősy, Építéstudományi tananyag BSc képzéshez. Szent István Egyetem Ybl Miklós Építéstudományi Kar
[13] **Mayer, R. E.** (2019). Thirty years of research on online learning. In G. Davies, & P. A. Granhag (Eds.), *Applied Cognitive Psychology. 33(2), 152-159. John Wiley and Sons.*