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KNOWLEDGE NUGGETS INSTRUCTIONAL DESIGN V2.0 AND TESTING STRATEGY

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Abstract

Currently, the education sector is undergoing profound changes and, in parallel, making digital teaching formats essential. One of these upcoming formats is the so-called "Knowledge Nugget". Knowledge Nuggets are digital learning materials that are designed for self-directed learning. They are organized within small, defined topics and vary depending on their scopes and sizes. Differentiation goes along with the way learning material is prepared and conveyed but does not provide information about the amount of content or the shared knowledge's difficulty. Based on a paper at END2021, the next step sheds light on general design aspects to reduce the extrinsic cognitive load during learning. Hence, it is necessary to which kind of Knowledge Nuggets has been prepared and how the different nuggets are structured. How the information is prepared must be taken into account not to harm the students in their learning process. This paper aims to further develop the previous form of instructional design, adding general design factors and providing a well-planned testing strategy to verify the explained model.

Keywords: *Knowledge nuggets, testing design, self directed learning, cognitive load, online teaching.*

1. Introduction

Teaching and learning have changed not only since the world started dealing with the Corona pandemic but also plays a significant role in everybody's life. That is because since classes were shifted to the digital environment due to the pandemic, the ongoing discourse on the value of traditional teaching methods reignited around the questions: " Do these teaching methods still reflect the spirit of the times?" and "Do they encourage learning?". Digital teaching, for example, loses value through traditional teaching methods, such as face-to-face teaching, as social interaction between teachers and learners via a video conferencing system is challenging to establish. A new teaching method that enables fast and sustainable information intake in the digital and analog world, suitable for today's fast and global world, is the design of so-called Knowledge Nuggets.

Knowledge Nuggets are self-contained didactical materials divided into small topics and prepared for self-directed learning. Usually, they are designed in a multimodal and creative way to enable students to consume knowledge easily and with satisfaction. Knowledge Nuggets can be created in various ways and thus differ in scope, size, and presentation. (Ploder et al., 2021). Knowledge Nuggets are therefore conducive for teaching students essential content in a proper amount of time through an original design. Although there are many creative ways to design Knowledge Nuggets, certain principles should be followed to ensure their success which is presented in this paper.

The theoretical background is outlined, with a brief introduction and the underlying literature. This study's focus is to define further and extend the elaborated Instructional Design provided in the paper “Instructional Design of Knowledge Nuggets” (Ploder et al., 2021). Knowledge Nuggets should not exclusively include the mentioned factors within the provided framework but should be expanded by general design principles.

This new adapted framework, Instructional Design 2.0, is presented in section three. Section four illustrates a possible procedure to verify this framework and the effect of its factors in an empirical setting. This procedure can be tested by running an empirical study. In the final section, five limitations are highlighted, and possibilities for further research are suggested.

2. Theoretical background

From March 2021 to April 2021, a literature review using Google Scholar and other scientific databases was executed to identify qualified publications. Following the guidelines of writing a literature

review by Snyder (2019), a deep understanding of the study field through relevant contributions and discussion was established. Keyword search terms included “multimedia learning AND design principles AND extraneous load”, “Learning from text and video AND instructional design AND multimedia learning,” and “Self Directed Learning AND Cognitive Load AND Online Teaching”. This search identified around 300 contributions. After duplicates were removed, the titles and abstracts of all remaining hits were screened for potentially relevant impacts. The full texts were read and critically appraised; 18 papers matched all criteria and were included for analysis.

2.1. Online teaching

Online teaching has gained increasing attention due to a fundamental transformation of traditional knowledge transfer, from books with text and images to computer-based multimodal media such as narrated animations, instructional videos, hypertext with printed text and illustrations. At this point, digital competence, in particular, becomes relevant to use digital media as productively as possible (Ehlers, 2020). Online environments allow many innovative approaches to support learning, but the challenge is deciding how best to use them by applying the instructional design. The cognitive load theory (Sweller & Chandler, 1991), which emerged in the 1990s and is constantly evolving, relates to the instructional design of online learning and will be used for measurement.

2.2. Self-directed learning

Digitalization in higher education institutions is leading to significant changes, and new skills in self-directed learning have become essential. Ehlers (2020) calls these "Future Skills". One skill mentioned by Ehlers and should be fulfilled by students is self-competence, including independent motivation and planning of learning content. Additionally, students should have the ability to manage their own time to organize the learning content successfully. Thereby, students have a great deal of personal responsibility to benefit from the learning content in the best possible way (Douglass & Morris, 2014). Students should work through the topics independently using the materials provided. To make this possible, it is necessary to clearly define the content of the Knowledge Nuggets and organize it in small chunks. The tasks must be comprehensible and fit in with the learning material (Ehlers, 2020).

3. Instructional Design 2.0

In the Instructional Design of Knowledge Nuggets (Ploder et al., 2021), three different levels of Knowledge Nuggets were named: (i) text within a document, (ii) slideshow with an added audio podcast, and (iii) video tutorials, and the factors which distinguished the three different levels were identified. By combining visual content with audio, two senses are addressed in parallel. The slideshow contains graphics or diagrams that are explained by additional keywords, and in video tutorials, the visual senses are additionally discussed by animations. However, it is essential to note that all Knowledge Nuggets share the relationship to practice, reproducibility, and a manageable processing time, which are particularly relevant in the field of education (Ploder et al., 2021).

Collective findings extend the basis from the systematic literature review in this paper. Some general design factors help to reduce the extrinsic cognitive load during learning. Hence, how the information is prepared and how the different nuggets are structured should be considered. Certain multimedia learning factors are implemented in the structure of those Knowledge Nuggets to improve the success. Table 1 shows an overview of all crucial factors, including the design principles. The highlighted design principles are discussed in detail in the following paragraphs. A detailed description of the first four factors can be found in (Ploder et al., 2021).

Amount of provided information - The following graph in figure 1 outlines the most distinct factors organized into three categories to illustrate their shift among the three levels. The y-axis represents the amount of information provided, and the amount of information does not vary from one level to another. The textual share represents the number of words written. However, there is no differentiation between continuous text, bullet points, and headings. The pictural amount applies to the visual elements used for the individual level. Correspondingly, the auditive share refers to how audio files or a podcast supplements the level. In conclusion, this overview explains how the levels differ and indicates that this may significantly change the learning experience.

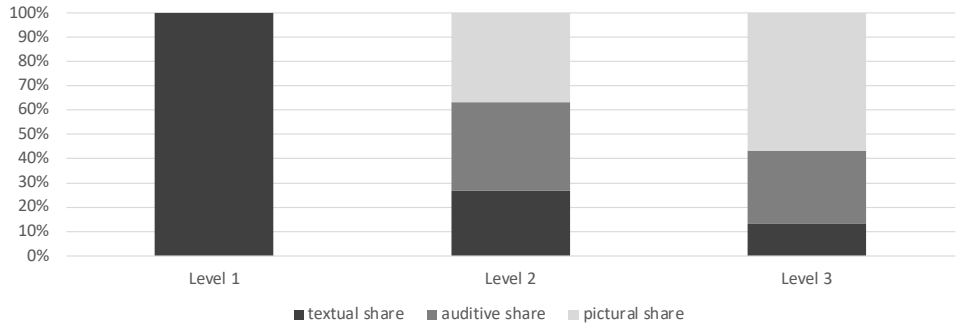
Signaling - One example of these design principles is signaling. The signaling principle states that people learn better when highlighting important content (Mayer, 2001; Richter, Scheiter & Eitel, 2016). These signals do not contain new content but show the learner what content is essential and relates to (Mayer, 2002).

Table 1. Relevant factors for the Instructional Design.

Factors	Level 1	Level 2	Level 3
Visual Elements		Static images	Dynamic images/animations
Recipient engagement	Self-regulated	Self-regulated	Controlled
Language Style	Formal Style	Conversational style	Conversational style
Sensory Modalities	Visual sense	Auditory + visual senses	Auditory + visual senses
Visual Elements		Static images	Dynamic images/animations
Recipient engagement	Self-regulated	Self-regulated	Controlled
Amount of provided information	Textual share	Textual, auditive + pictural share	Textual, auditive + pictural share
Signaling	Font formatting + structured headings	Font formatting, static graphics + stronger linguistic emphasis	Font formatting, dynamic images + stronger linguistic emphasis
Split attention effect		Spatial contiguity + Temporal contiguity	Spatial contiguity + Temporal contiguity
Coherence principle	Avoid irrelevant text fragments	Avoid irrelevant text fragments, visual and auditory elements	Avoid unrelated text fragments, visual and aural elements
Length and Quantity	Divide the text into short chapters, avoid long sentences	Appropriate time and amount (approx. 6 minutes)	Proper time and amount (approx. 6 minutes)

The aim of highlighting relevant information is to reduce the extrinsic cognitive load of the learners (Mayer, 2008). This principle can be applied at all three levels but in different ways. Based on Mayer (2008), signaling can emphasize specific words when creating texts. That can be done by another font formatting, for example, choosing a different font size or writing in bold or italic. The listed techniques can be incorporated in all three levels. In addition, structuring individual text sections with thematic headings can influence the processing of the subsequent text (Niegemann et al., 2008) and thus achieve advantages.

Figure 1. Differentiation of Knowledge Nuggets.



Important information can also be emphasized with the help of static or dynamic graphics (Richter et al., 2016). When learning content addresses auditory senses, the principle can be applied through stronger linguistic emphasis of critical terms. However, this type of signaling can only be applied in levels 2 and 3.

Split attention effect - The integration of related content or information from disparate sources can impair students' learning, the so-called split attention effect. In this case, the recipient must divide their attention between the contents and cognitively relate them. Divided attention and the mental work of bringing them together increase the cognitive load and consequently should be avoided (Chandler & Sweller, 1992).

Concrete examples are Spatial contiguity and the Temporal contiguity principles (Mayer, 2002). Both can only be applied in levels 2 and 3. The two principles assume that the formation of connections between ideas, events, or other elements depends on their spatial or temporal proximity. According to the Spatial contiguity principle, people learn better when words and images are presented close and not far apart (Mayer, 2018). Thus, it is advisable to place text close to related graphics.

In contrast, the temporal contiguity principle implies simultaneously presenting language and graphics. In this way, words and images enter the working memory simultaneously. That makes it easier to integrate the information into working memory instead of presenting them separately. (Mayer, 2018)

Coherence principle - Another principle that should be considered when designing Knowledge Nuggets related to the amount of content of a nugget is the coherence principle. Following this principle can also help minimize the extrinsic load. The coherence principle aims only to use visual and auditory elements essential for the context and thus for knowledge when designing nuggets. That avoids irrelevant information, such as text fragments, illustrations, or audio tracks, inhibiting learning. "Less is more" can be used as a guideline (Clark & Mayer, 2011; Mayer, 2005).

Length and Quantity - A key role when designing Knowledge Nuggets of any kind is played by the factors "length of the nugget" and related to this, "the amount of content". A Knowledge Nugget should enable learners to adopt the critical content quickly. The learners' capacity to adapt is limited, and an overload of information or learning units that are too long inhibits their adoption. For this reason, the length of the Knowledge Nugget should be limited, and the amount of information should be chosen wisely. When designing a Knowledge Nugget, it helps to ask the question: "What information is important for the recipient and how can it be conveyed in a comprehensible way?" However, there are no exact guidelines that specify an appropriate time and amount for all Knowledge Nuggets, as it depends on the type of Knowledge Nugget. In general, however, a length of approx. six minutes is recommended as the most appropriate time for instructional videos (Brame, 2016) since videos too long reduce the student's engagement, whereas short videos are more captivating. For the slideshows, a similar length is aimed. When structuring texts, especially the quantity should be kept in mind. It is advisable to divide the text into short chapters to simplify reading.

Furthermore, a chapter can be divided into smaller paragraphs. In addition, long sentences should be avoided, as they are more challenging to read. Generally, a sentence should consist of less than 20 words.

4. Pre-study procedure

In the future, an empirical study is planned to be conducted to test the three different levels of Knowledge Nuggets. The factors and design principles mentioned in the paper are the basis for further research in this field. With the help of empirical research, it can be determined how the students perform, and the cognitive load will change depending on the individual level. The framework can be provided digitally on Learning Management Systems (LMSs), as shown in Table 2.

Table 2. Study procedure Agenda.

Agenda	Description
Introduction + Briefing	Study description, procedure
Demographic data + expertise query	Demographic characteristics, interest, prior knowledge
Knowledge transfer through Knowledge Nuggets	Three different levels of Knowledge Nuggets Level (Text, Slideshow, Video)
Assessment	Multiple Choice Questions
NASA Task Load Index	Measuring cognitive load

The participants are instructed to refrain from any additional aids to carry out the study and distort the results. They are advised not to use any other tools to survey or falsify the results afterward. In addition, demographic characteristics are requested to assess the sample size better. Moreover, it should be determined whether the participants have prior knowledge regarding the respective subject area. This is a relevant factor since participants with specific prior knowledge in the related topics are expected to perform better.

In the third section, the knowledge is transferred with Knowledge Nuggets. The test persons are randomly assigned a certain level of Knowledge Nuggets. In the empirical study, a text, a slideshow, or a learning video on the same topic is provided for every participant.

With the help of a questionnaire, the recorded knowledge is checked. With multiple-choice questions, comprehension and reproducibility are evaluated. Subsequently, the participants' stress levels can be measured using the Nasa Task Load Index (Hart, 1988).

5. Future research and limitations

The study procedure presented in table 2 can be tested within an empirical pre-study for further research, and the process can be tested with selected participants. Moreover, a more extensive study can be conducted based on these findings to get a more detailed view. Before interpreting the study, some limiting factors should be taken into account. As no empirical research has been conducted yet, the findings from this article are derived exclusively from underlying literature. Therefore, the instructional design should be tested in practice to get a more detailed result.

References

Baddeley, A. (1992). Working memory. Science, 255(5044), 556–559. https://doi.org/10.1126/science.1736359

Brame, C. J. (2016). Compelling Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content. CBE life sciences education, 15(4), 1–6. https://doi.org/10.1187/cbe.16-03-0125

Chandler, P. & Sweller, J. (1992). The Split-Attention Effect as a Factor in the Design of Instruction. British Journal of Educational Psychology, 62(2), 233–246. https://doi.org/10.1111/j.2044-8279.1992.tb01017.x

Clark, R. C. & Mayer, R. E. (2011). e-Learning and the Science of Instruction. San Francisco, CA, USA: Pfeiffer. https://doi.org/10.1002/9781118255971

Douglass, C. & Morris, S. R. (2014). Student perspectives on self-directed learning. Journal of the Scholarship of Teaching and Learning. https://doi.org/10.14434/josotl.v14i1.3202

Ehlers, U. (2020). Future Skills. Lernen der Zukunft - Hochschule der Zukunft (Research. Zukunft der Hochschulbildung). Wiesbaden: Springer VS. https://doi.org/10.1007/978-3-658-29297-3

Hart, S. G. & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In N. Meshkati & P. Hancock (Hrsg.), Human Mental Workload (Advances in Psychology, 1. Aufl., Bd. 52, S. 139–183). Elsevier. https://doi.org/10.1016/S0166-4115(08)62386-9

Mayer, R. E. (2001). Multimedia learning (1. Aufl.). Cambridge University Press. https://doi.org/10.1017/CBO9781139164603

Mayer, R. E. (2002). Multimedia learning. Psychology of Learning and Motivation, 41, 85–139. https://doi.org/10.1016/S0079-7421(02)80005-6

Mayer, R. E. (2005). Cognitive Theory of Multimedia Learning. In R. E. Mayer (Hrsg.), The Cambridge handbook of multimedia learning (Cambridge handbooks in psychology, 1. Aufl., S. 31–48). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.004

Mayer, R. E. (2008). Applying the science of learning: evidence-based principles for the design of multimedia instruction. The American psychologist, 63(8), 760–769. https://doi.org/10.1037/0003-066X.63.8.760

Mayer, R. E. (2018). Thirty years of research on online learning. Applied Cognitive Psychology, 33(2), 152–159. https://doi.org/10.1002/acp.3482

Niegemann, H. M., Domagk, S., Hessel, S., Hein, A., Hupfer, M. & Zobel, A. (2008). Kompendium multimediales Lernen (1. Aufl.). Berlin and Heidelberg: Springer Science & Business Media.

Paas, F., Renkl, A. & Sweller, J. (2003). Cognitive Load Theory and Instructional Design: Recent Developments. Educational Psychologist, 38(1), 1–4. https://doi.org/10.1207/S15326985EP3801\textunderscore

Paas, F., van Merriënboer, J. J. G. & Adam, J. J. (1994). Measurement of cognitive load in instructional research. Perceptual and motor skills, 79(1), 419–430. https://doi.org/10.2466/pms.1994.79.1.419

Ploder, C., Ehrhardt, L., Gamper, L. & Hazy, C. (2021). Instructional Design of Knowledge Nuggets. In M. Carmo (Hrsg.), Education and New Developments 2021 (S. 245–249). inScience Press.

Richter, J., Scheiter, K. & Eitel, A. (2016). Signaling text-picture relations in multimedia learning: A comprehensive meta-analysis. Educational Research Review, 17, 19–36. https://doi.org/10.1016/j.edurev.2015.12.003

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039