

INSTRUCTIONAL DESIGN OF KNOWLEDGE NUGGETS

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Abstract

Throughout their careers, all students experience the same set of learning routines within the same time frame and following the same pedagogical approach based on identical materials. In contrast, Knowledge Nuggets provide students with different opportunities to achieve specific learning outcomes through self-directed learning activities. An individual student's skill inventory could improve the full individualization of the Knowledge Nugget delivery at the start of each class. Knowledge Nuggets are considered learning materials organized within small, defined topics. This granularity makes the content easier to consume at an individual pace. Depending on their scope and size, these Knowledge Nuggets can vary. The level does not indicate the amount of content or the shared knowledge's difficulty but how the learning is prepared and conveyed.

The simplest way (level 1) to share knowledge is only to provide text within a document. The next higher level 2 includes a slideshow explained in more detail by playing an audio podcast - so the combination of visual with audio should attend two senses in parallel. The slides contain images or diagrams in addition to keywords. Video tutorials are the most advanced ways to share knowledge. This type of tutoring allows instructors to visually illustrate content to minimize complexity by combining text, speech, images, and animation. With level 3 (video tutorials), it is possible to address more senses simultaneously.

However, all three levels offer the same characteristics: practicality, reproducibility, and manageable time. These characteristics are of great relevance to be accepted as training methods in any educational program. The progressive redistribution of dimensions occurs in elaboration, the use of technology, and the cognitive load. The paper aims to determine why the different levels are essential for the overall picture and how the measurement of learning success can be measured.

Keywords: *Knowledge nuggets, knowledge sharing, cognitive load.*

1. Introduction

Digitalization is proceeding in the economy and society, and the educational sector is experiencing far-reaching changes. Higher educational institutions are increasingly opening up towards the potential of digitization. With it comes the expectation that research and administration, and instruction will improve quality and become more professional. Although the overall concept and degree of implementation can vary from institution to institution, digitization also requires structural preconditions and technological implementations and comes with its challenges. (Gilch et al., 2019)

With the Corona pandemic causing massive restrictions on public life since spring 2020 and in-person lectures being banned, digital instruction is coming to the fore. To continue sustaining education, the short-term development and use of digital teaching formats are essential.

One approach to share knowledge is by providing Knowledge Nuggets (Ploder et al., 2020), created for self-directed learning. Knowledge Nuggets are digitally prepared learning materials that are organized within small thematic categories. (Knowledge Nuggets are deeply related to E-Learning.) The learning content can be provided in different ways. For example, as a video, a slideshow, a web page, or a podcast. (Bailey et al., 2006; Shaw et al., 2014)

These Knowledge Nuggets differ based on an individual's cognitive ability to elaborate/ process them and, therefore, be classified into different levels. The term cognitive ability also includes the concept of cognitive load. A higher stress level indicates a more complicated and unpleasant perception of information intake (Sweller, 1994). This paper focuses on elaborating the factors to define these levels, separate them from each other and thus have to be considered for planning differentiated Knowledge Nuggets. The initial idea was to start with three different levels respectively Knowledge Nuggets based on their relevance and frequency of use in higher education. In section 3, the explanation and all the factors are described.

After the first section with a brief introduction, section 2 outlines the authors' literature review and framing and the primary resources. The research focused in general on the thematic area of designing digital learning content. The literature sources were used to identify the relevant factors for developing knowledge nuggets and differentiating the different levels by design. The determining factors were then

specified in more detail in the Instructional Design and integrated into an overall framework in section 3. Section 4 continues by describing opportunities for testing the three design levels to determine which level offers the highest potential. In the end, a review of limitations is given in section 5.

2. Theoretical background

This section represents a precise analysis of the current state of research and selects suitable approaches to identify studies and other sources comparing instructional design principles for Knowledge Nuggets. The authors elaborated a systematic literature review. As a guideline, the NHS Centre for Reviews and Dissemination (2009) approach was adapted to this work's requirements. The selected phases are outlined in table 1.

Table 1. Search terms used in the systematic literature review.

Phase No.	Phase	Steps
1	Planning the review	Purpose of the literature review Developing the review protocol
2	Conducting the review	Searching the literature and assessing studies for relevance Assessing and grading studies for validity (quality) Extracting data from the selected studies Synthesizing data from the selected studies
3	Reporting	Documentation and interpretation of the results

Phase 1 starts with the definition of the framework for the analysis and is followed by the formalization of the review protocol, which determines the methods used to perform the review. To formulate a search strategy and create this framework, gaining familiarity with a deep understanding of the study field through relevant contributions and discussions is needed. Through topic-related preliminary research, carried out through the Google Scholar database and a general internet search, it was possible to determine the first state of knowledge for the topic to be worked on. Fundamental studies found at this stage were directly incorporated into the collection. Ongoing the systematic literature review process, the Google Scholar database was used as a basis for identifying qualified sources. The further specialization by including relevant search terms refined after the initial search helped to focus the analysis's scope. The summarized list of all used search terms is represented in table 2.

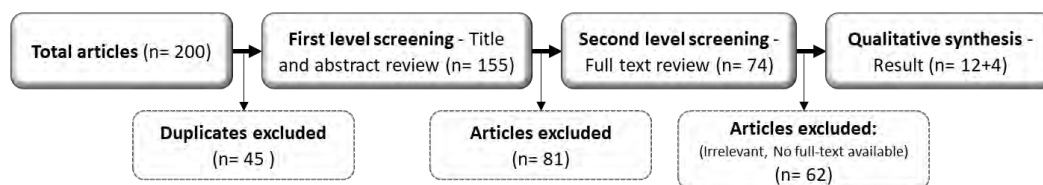
Table 2. Search terms for the systematic literature review.

Keywords	
Design of video; cognitive load; learning performance; multimedia learning	Signaling; multimedia learning
Learning from text and video; instructional design; multimedia learning	Emotional design; multimedia learning

Besides these mentioned criteria, a further characteristic was established regarding the publication period and the full-text availability. To focus on the most recent research on this topic, only full-text accessible articles from 2014 are included. The items were sorted in the relevance ranking of Google Scholar. A limit of the first 50 references was set to be reviewed if the search results in an excessively high number of hits.

Based on this entire collection of different criteria and the research protocol development, proceed to phase 2, illustrated in figure 1. Generally, in phase 2, searching the literature is executed. More precisely, it identifies potential studies and assesses the quality of these ongoing in the procedure. If the database search matches the outlined requirements and the search terms, validation is initially required by removing all presented duplicates. All references that had the identical title and author and published within the same year were excluded—moving on to the stage “First level screening”, by reading just the title and abstract of the candidate studies and then deciding whether to include or exclude the study. In this way, studies that are not related to the topic can be removed. Whether to include an article, the full document was retrieved (Second level screening). The result represented as a pool of 16 studies is ready for the data extraction and quality assessment and can be synthesized to finalized.

Figure 1. Study selection.



In the final stage in phase 3, the last documentation and the interpretation of the findings is carried out. Table 3 shows illustrate all selected relevant literature with title, Authors, and names.

Table 3. Overview Literature.

No	Title	DOI	Year
1	A meta-analysis of how signaling affects learning with media	https://doi.org/10.1016/j.edurev.2017.11.001	2018
2	Assessing the effects of different multimedia materials on emotions and learning performance for visual and verbal style learners	https://doi.org/10.1016/j.compedu.2012.05.006	2012
3	Benefits of emotional design in multimedia instruction	https://doi.org/10.1016/j.learninstruc.2014.02.004	2014
4	Cognitive load in multimedia learning environments: A systematic review	https://doi.org/10.1016/j.compedu.2019.103618	2019
5	Cognitive load theory and multimedia learning, task characteristics and learning engagement: The Current State of the Art	https://doi.org/10.1016/j.chb.2010.05.003	2011
6	Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content	https://doi.org/10.1187/cbe.16-03-0125	2016
7	Effects of different video lecture types on sustained attention, emotion, cognitive load, and learning performance	https://doi.org/10.1016/j.compedu.2014.08.015	2015
8	Emotional design in multimedia learning: Differentiation on relevant design features and their effects on emotions and learning	https://doi.org/10.1016/j.chb.2014.11.009	2015
9	Emotional design in multimedia learning: Effects of shape and color on affect and learning	https://doi.org/10.1016/j.learninstruc.2013.02.006	2014
10	How multimedia can improve learning and instruction	https://doi.org/10.1017/9781108235631.019	2019
11	Instructional animation versus static pictures: A meta-analysis	https://doi.org/10.1016/j.learninstruc.2007.09.013	2007
12	Learning from Examples: Instructional Principles from the Worked Examples Research	https://doi.org/10.3102/00346543070002181	2000
13	Learning from the text, video, or subtitles: A comparative analysis	https://doi.org/10.1016/j.compedu.2020.104034	2021
14	Signaling text-picture relations in multimedia learning: A comprehensive meta-analysis	https://doi.org/10.1016/j.edurev.2015.12.003	2016
15	Thirty years of research on online learning	https://doi.org/10.1002/acp.3482	2018
16	Trends and issues in multimedia learning research in 1996–2016: A bibliometric analysis	https://doi.org/10.1016/j.edurev.2019.100282	2019

3. Instructional design

In this section, the collected findings from the systematic literature review provide a framework for planning differentiated Knowledge Nuggets by design. The three levels which correspond with the given literature can be named: (i) text within a document, (ii) slideshow with an added audio podcast, and (iii) video tutorials, the various principles and techniques were applied, and factors identified. The designed model depicted in table 4 provides an overview of the relevant characteristics to obtain the desired Knowledge Nugget at a certain level. All the factors and their expressions in explained in the following subsections. It is worth mentioning that all levels are assumed to provide the same quality and the same amount of knowledge.

Table 4. 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 - One of the factors that differentiate the Knowledge Nuggets and, therefore, the levels from one another are visual elements. In general, visual features are considered to be, e.g., graphics, images, diagrams, and animations (Li et al., 2019) on top of text. Since visual elements do not support a pure continuous text, it strongly differs among the other levels. For instance, slideshows, compared to level 1, often contain a variety of static visual elements, such as diagrams and images. However, according to Lewalter (1997), static images can sometimes cause misinterpretations and result in an inaccurate understanding or prospect. Moreover, misinterpretations may increase a participant's cognitive load.

Besides static graphics, dynamic images like animations are familiar. According to Rieber and Kini (1991), an animation is formed by a series of fast-changing computer screen visuals that create the impression of motion to a viewer. These are primarily used for video productions, representing level 3. However, it should be noted that animations do not represent permanent information but a current capture

(Hegarty, 2004). The risk of misinterpreting images can be decreased by (using) animations, as they facilitate procedural explanations that can lower an individual's cognitive load. To visualize the same complex process differently, multiple static graphics would be required. (Höffler & Leutner, 2007)

Recipient engagement - A further factor that distinguishes each level is the active regulation of Knowledge Nuggets by the recipient. Examples include repeating or skipping information and regulating the speed of information intake. Regarding videos, the transmission of information is preferably controlled by the sender since the receiver does not influence the rate of animations or the speaker's performance speed. Repeating or skipping information in a controlled way is more difficult in this case since videos usually do not have well-defined section headings/ delineated sections. A slideshow including an integrated podcast, on the other hand, is more comfortable to regulate as the individual slides structure the presentation. The recipient proceeds with the presentation autonomously by browsing through the slides and can initiate the voice-over of each slide independently. In comparison to videos and slideshows, processing texts can be controlled by the recipients to a much greater extent. The reader has the opportunity to reread sentences or paragraphs, skip parts, and adjust his reading pace to his needs. Thus, the learning process is even more personalized. (Merkt et al., 2011; Tarchi et al., 2021)

Language Style - Moving on to the next factor, the authors examine the influence of language style. Principally, language is another crucial component of the transmitter-retriever model and represents the primary medium through which we can share knowledge. Changing narration from a formal textbook-like style to a more personalized conversational style in multimedia instruction has shown a significant effect on learning in the past; people may know more deeply (Mayer, 2002). Mayer describes this phenomenon as the personalization principle (Mayer, 2008). Mayer believes that using conversational language instead of formal language in multimedia teaching will encourage retrievers to establish social relationships with the narrator. That leads to greater participation and effort. For instance, while explaining, make instead use of "your" alternatively to "the" when involving the retriever or the use of "I" to point the narrator's viewpoint. While the text in level 1 is only a composite of words and therefore has to be presented more formally, level 2 and level 3 can use the personalization principle. Regardless of the version, the same factual information is always transmitted. (Mayer, 2018)

Sensory Modalities - Another factor of level differentiation is the form/ expression of visual and auditory stimuli/ allures. Based on how Knowledge Nuggets are set up, the cognitive load resp. The stimuli of the participants are strained differently. According to Mayer (2001), individuals possess separate channels to process auditory/verbal and visual/pictorial information. The continuous text provided in the first level is processed in the vocal track. When consuming a slideshow, the load is divided into two channels. The spoken words and keywords on the slides are captured in the auditory/verbal channel. The static images are displayed in the visual/pictorial channel.

Regarding videos, the visual/pictorial channel is additionally claimed by animations. Referring to Mayer (2001), individuals only have limited capacity to process input material in these channels. Therefore, the channels should not be overloaded. While the cognitive load generated by texts arises from the verbal channel only, it is divided between both channels when viewing slideshows and videos. Consequently, the cognitive load is strained in different ways. That also influences the design of the considered Knowledge Nuggets. Thus, the only formatted continuous text is used in level 1. Since slideshows additionally use images and audio files for presentation, the text is limited to keywords on the slides. The unique characteristics of videos are the animations. These, in return, replace some verbal/auditory stimuli of slideshows. In conclusion, the Cognitive Load mustn't be overloaded in any of these levels. (Mayer, 2018).

To sum it up finally, this section provides an understanding of how the levels differ and indicates that this may significantly change the learning experience.

4. Future research

During the elaboration of the theoretical framework, further interesting considerations could lead to additional research soon. Creating differentiated Knowledge Nuggets should not only be based on the factors mentioned above but also on general design factors. Therefore, for an expanded approach, design aspects should be addressed and included. Moreover, the level factors identified in this paper only provide a theoretical policy regarding how levels differ from one another and how they influence the cognitive load of Knowledge Nugget recipients. To verify these factors and their effect in practical application, they can be tested by running an empirical study. Conducting such a study requires that differentiated Knowledge Nuggets are created based on the previously mentioned theoretical framework and can be provided digitally on suitable platforms, such as LMSs. Subjects may begin the learning process subsequently by retrieving the instructional materials under predetermined conditions. After performing the learning process, the stress level based on the Cognitive Load Theory can be measured using standardized scales. Questionnaires or tests are suitable for evaluating comprehension and reproducibility. The results given by these measurements may then indicate which types of levels, and thus which factors, should be utilized for learners such as students of higher education institutions to impart knowledge.

5. Limitations

When interpreting the findings of this study, some limitations need to be taken into account. First, it has to be mentioned that the literature review was restricted to some specific journals within a certain period. Another factor is that the Knowledge Nuggets instructional design is not yet validated in a practical setting. Experts can be used in the validation process to minimize this impact in the future.

Furthermore, by designing the Knowledge Nuggets, the authors decided to prepare exactly three levels of Knowledge Nuggets. That is a limiting factor because it would be possible to split the nuggets into more detailed levels. The last limiting factor is that our Knowledge Nuggets are designed for digital learning. That means that the purpose of the nuggets is to work correctly on digital screens compared to the idea of differentiation of analog and digital systems based on (Singer & Alexander, 2017).

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