Stanislav DERECHENNIK-jr.
Aliaksandr DUBITSKI
Sofya KHOMIUK
Antip SHULGAN
Brest State Technical University,
Brest, Republic of Belarus

CONSIDERING COGNITIVE LOAD AT DISTANT LEARNING

The hi growth of distant learning share in 2020 caused by the epidemiological reasons brought university lecturers in front of the urgent need to change the presentation approaches for the educational materials. An extremely large part of educational activities has been transferred to the online software — the special educational content management systems — and primarily to the Moodle system, as the most powerful and widespread among them. However, the interaction of students with the studied material through software requires the solution of additional design problems, and how successfully these problems are solved can have a significant impact on the effectiveness of the study.

When working with the software, the user experiences additional cognitive, visual, and motorloads. On the one hand, it is advisable to minimize such loads in order to less distract the user from the learning process. But on the other hand, reducing only the more mentally costly types of workload due to several additional typical actions (movement of the mouse pointer or clicks) as a compromise solution may be more optimal. Visual load can serve a similar purpose: for example, it can purposefully reduce the cognitive load on the user (not having to remember all the options and choices), thereby reducing learning time. An example is the concept of the WIMP (windows-icons-menus-pointer) interface, within which the commands available to the user are collected in menus and controlled by the mouse cursor [1].

The term "cognitive load" was originally introduced in cognitive psychology to illustrate the load associated with executive control of a person's short-term memory. During the assimilation of complex information, the array of data and interactions that must be processed simultaneously can either underload or overload the final volume of the user's working (short-term) memory, and in the latter case, the existing content must be processed before meaningful learning can be continued [2]. The learning process is more effective when it relies on previously known information (the so-called "existing schemes"). The more information a person has to master in a short period of time, the more difficult it is to process this information in working memory. In this regard, the difference between teaching a subject in a native language versus the intense study of the same subject in a foreign language is indicative: the cognitive load is higher in the second case, since the brain must work on translating from a foreign language, while simultaneously trying to understand new information.

Another aspect of cognitive load theory concerns understanding how many discrete pieces of information can be stored in short-term memory before information loss occurs. In usability, this principle is known as "Miller's wallet", according to which a person is comfortable navigating among no more than seven objects of the same type [3] or even less. N. Cowan refuted this theory in 2001 and experimentally proved the volume to take 4±2 elements [4].

The methodology of cognitive load is used to determine the automation (controllability) of information processing. Unlike automated processes, controlled processes involve cognitive effort. This means that additional cognitive load will impair the effectiveness of the controlled processes. Accordingly, it is assumed that automated processes will not be influenced by additional cognitive load.

Cognitive load theory provides empirically based guidelines to help redirect the learner's attention to information that is relevant to the subject matter. There are three types of cognitive load:

- *intrinsic cognitive load* is an unavoidable level of complexity associated with the material being studied. There is inherent complexity in all learning. This inevitable complexity cannot be changed, but many schemes can be broken down into separate "subschemes" that are studied in isolation and later put together and described as a whole. Particularly, Moodle provides several approaches to divide material into the number of related pages, such as *lesson* course element, which allows to create a graph-like structure of pages and small tests with conditional links between them.
- *extraneous cognitive load* is created by the form of presentation of educational information, and therefore it is easier to control it by the developer of educational materials. Since the cognitive resource is shared and limited, additional efforts to process the extraneous load generally reduce the amount of resources available to process intrinsic cognitive load and germane load (i. e., learning). Thus, especially when the intrinsic and/or germane load is high (i. e., when the problem is complex), information should be presented in such a way as to reduce the extraneous load. For example, requiring a learner to mentally integrate related sources of information that are located on different pages increases this type of load, and the opposite effect can be achieved if the learning material includes glossaries of terms which make explanation to pop-up if the appropriate highlighted word is clicked in the text. From the other side, learning material should have not to many interacting elements to avoid visual overload which increases this type of load as well.
- *germane cognitive load* is a load dedicated to handling, building and automating schemes. It was first described by Sweller, van

Merrienboer and Paas in 1998. Good example is providing students with interactive elements which involve them to self-explain the material, which may impose an additional cognitive load but it could be relevant to learning. Collaboration activities based on wiki and forum course elements may follow the same goal.

While intrinsic cognitive load is generally considered constant (although techniques can be applied to manage complexity through segmentation and sequential presentation), extraneous load and germane load are manipulable. It is assumed that extraneous load should be limited, and germane one should be stimulated. Therefore, it is relevant to search for ways to reconstruct teaching so that what would be an extraneous load was now directed to the construction of a scheme (germane load).

Finally, techniques are needed to find out whether the designer of educational materials was successful in the attempts to reduce the external cognitive load and redirect the attention of students to the cognitive processes directly related to the construction of schemes.

There are two fundamentally different approaches to measure cognitive load. Paas and van Merrienboer developed a construct known as the relative condition efficiency as an index of cognitive load, which researchers use to measure mental effort. This construct combines intelligence effort ratings with performance ratings. Following Paas and van Merrienboer, many researchers have used this and other similar constructs to measure how cognitive load relates to learning and teaching.

The ergonomics-based approach attempts to quantify the neurophysiological expression of cognitive load using standard measuring instruments. Until recently, the use of such approach was limited by the low prevalence and high cost of biometric equipment. Recently, however, a significant number of biometric sensor devices have appeared on the market for the fitness and entertainment industry. This category primarily includes optical heart rate sensors, developed for sports heart rate meters, and then spread first to fitness trackers, and then to personal digital assistants interacting with a smartphone in the form of a wristwatch (smartwatch). In addition, there are several entertainment devices that register brain activity to determine the user’s concentration, or track the direction of the gaze. All these devices have several advantages: they are sufficiently accurate, suitable for continuous monitoring, capable of transmitting data to a personal computer, and at the same time, thanks to mass production, are widely available on the market.

For example, one of the simplest and most accessible ways to assess changes in cognitive load using biometrics is to use the built-in Attention metric of the NeuroSky MindWave encephalograph, simultaneously assessing the speed of work with the material and the presence of errors in the control tests built into the educational material [6]. An increase in concentration of attention with the same or longer duration of work will indicate an incorrect balance of types of cognitive load.

LIST OF REFERENCES

1. Kostiuk, D.A., Latiy, O.O., Markina, A.A., Shamonin, V.P. (2019). *Using biometric measurements to compare graphical user interfaces.* PRIP’2019. Pattern Recognition and Information Processing (Распознавание образов и обработка информации): Материалы 14-й Международной конференции, c. 216–218.
2. Paas, F., Renkel, A., Sweller, J. (2004). *Cognitive Load Theory: Instructional Implications of the Interaction between Information Structures and Cognitive Architecture.* Instructional Science. Vol. 32, No. 1–2, pp. 1–8.
3. Cooper A., et al. (2014). *About Face: The Essentials of Interaction Design.* Wiley; 4th Edition, 720 p.
4. Cowan, N. (2001). *The magical number 4 in short-term memory: a reconsideration of mental storage capacity.* Behavioral and brain sciences, v. 24, iss. 1, pp. 87–114.
5. Kalyuga, S. (2009). *Student perceptions and cognitive load: what can they tell us about e-learning web 2.0 course design.* E-Learning, v. 6, iss. 2, pp. 150–163.
6. Костюк, Д.А., Латий, О.О., Маркина, А.А. (2016). *Подход к биометрической оценке эргономики графического интерфейса пользователя.* Вестник БрГТУ: физика, математика, информатика, No. 5, с. 46–49.