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Taxonomies from a Cognitive to a Digital Revolution, Focusing on Transferable Skills

Abstract: The taxonomies that contributed to the cognitive revolution are an important starting point for the interpretation of knowledge. The aim of this article is to analyse Bloom's and related taxonomies in terms of transferable skills from a cognitive to a digital revolution. Benjamin Bloom published his taxonomy in 1956, in which he developed the classification of cognitive objectives, among others. In Bloom's taxonomy, transferable skills appear only indirectly in relation to the application of knowledge in new situations. However, de Block has already considered transferability of knowledge an aspect of learning objectives. In the SOLO taxonomy, transfer is accomplished at the relational and extended abstraction levels, when critical thinking and the generalization of the structure are in focus. Later, in Bloom's revised taxonomy, the meanings of each development level were expanded, emphasizing problem-solving skills in higher-order thinking. In today's unfolding digital revolution, collaboration is crucially important, which appears in the digital age learning matrix and also in the digital taxonomy. Consequently, transferable skills as general skills that must be also important among the higher educational objectives that can increase employees' chances to get non-matching jobs compared to their special degrees.

Key words: taxonomy, transferable skills, digital age, collaboration

Introduction

In addition to job-specific skills, transferable skills that can be applied more easily in other situations and context are also necessary for success in the labour market. Employers prefer employees who can cooperate with others, work within a team,

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have problem-solving skills and engage in critical thinking about their own work. These skills are becoming even more important in the digital age. The taxonomies that contributed to the cognitive revolution are of crucial importance in the interpretation of knowledge and in getting to know the background of transferable skills as well. In view of this, we ask the following questions: how does transferability appear in the taxonomies and what specific units of knowledge it can be related to? Consequently, the aim of this article is to analyse primarily Bloom's taxonomy and its revised forms in terms of transferable skills from a cognitive to a digital revolution.

Cognitive revolution and Bloom's taxonomy

In the first half of the 20th century, thinking about the learning process was determined by behaviourism. According to this theory, learning is nothing more than a change in behaviour as a result of the appropriate stimuli (Moore, 2011). In the theoretical framework of behaviourism, mental and internal psychic processes do not play a role in learning. However, a significant change began in the 1950s, when instead of stimulus-response automatism, focus was placed on learning about cognitive processes. As a result of this, many scientific fields, such as psychology, anthropology and linguistics were being redefined, which later become known as the cognitive revolution or the birth of cognitive science (Bruner, 1997; Miller, 2003). One of the most influential figures of the cognitive revolution and psychology was Jerome Brunner, who believed that learning basically serves the future through the transfer of thinking processes from one context to another (Bruner, 1968).

In 1956, revolutionary articles were published in several fields of science. The taxonomy of educational objectives was also published by Bloom in 1956, which gives a starting point in the interpretation of knowledge to be achieved related to curriculum reform originating in the United States. As it will be presented in Table 1 below, the cognitive domain was first developed by Bloom (Bloom, 1956). A few years later, the affective (Krathwohl, Bloom, & Masia, 1964) and psychomotor domains were also defined (Dave, 1969; Harrow, 1972)[3].

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[3] In addition to Dave's taxonomy, other psychomotor domains were also developed by Harrow and Simpson (1972).

Table 1. The development levels of educational objectives in three domains

Cognitive domain	Affective domain	Psychomotor domain
Knowledge	Receiving	Imitation
Comprehension	Responding	Manipulation
Application	Valuing	Precision
Analysis	Organization	Articulation
Synthesis	Characterization by value	Naturalization
Evaluation		

Sources: Own compilation based on Bloom, 1956; Krathwohl, 1956; Dave, 1969 and Báthory, 2000.

As seen above, Bloom's taxonomy was organised by hierarchical levels, containing six cognitive categories of intellectual development. These learning objectives have a content and an operational aspect. The content aspect includes information, facts, concepts, connections, theories, etc. The operational side indicates development levels, which are identified with cognitive abilities (Báthory, 2000). The first level refers to recalling and recognizing facts, information, concepts and rules. Comprehension is the next level of thinking, where knowledge is interpreted, recoded and transformed. The third level is the application of acquired knowledge in new situations. Application also includes the transfer of knowledge acquired at school into the world of work, but it is not necessarily an application in a new context. The next three levels are commonly referred to as "higher-order thinking" or "more complex levels of application", but Bloom did not originally use these terms (Adams, 2015). At the level of analysis, focus is on the essential elements and the structure, which includes arguments and explanations as well. Synthesis refers to the creation of a new product after planning and realization. The highest level is evaluation, i.e., forming opinions and judgments through critical thinking.

In Bloom's taxonomy, learning objectives are developed hierarchically according to complexity. However, subsequent studies related to development levels have pointed out that the existence of the hierarchy is becoming uncertain and unprovable in the case of the last three levels (Báthory, 2000). Nevertheless, Bloom's cognitive taxonomy has been used by many to create new typologies related to knowledge.

In terms of our topic, it is interesting to note that transferability in Bloom's taxonomy is emphasized only within the category of application, however, it had

great impact on those scientists in education, who also classify knowledge transfer as one of the learning objectives in order to better take into account the requirements of the labour market (Zerényi, 2019).

De Block's taxonomy

De Block, a Belgian professor, also published his own taxonomy in 1975, in which he revised the development level of knowledge and redefined learning/teaching objectives in three directions. As seen in Figure 1 below, in terms of learning/teaching objectives, he distinguished three directions, such as method, content and transfer (de Landsheere, 1979).
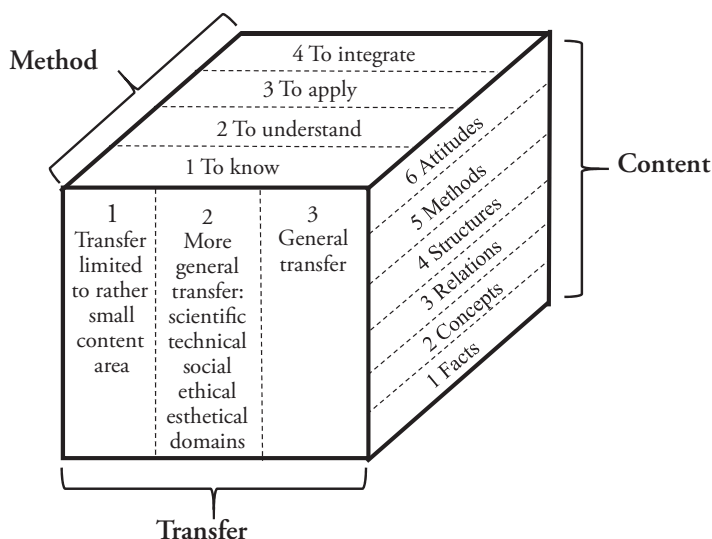

Figure 1. de Block's taxonomy in cube form, based on de Block, 1979 and de Landsheere, 1979 with own modification

De Block expanded the first three levels (knowledge, understanding and application) of cognitive domain of Bloom's taxonomy with a new level called integration (de Block, 1979)[4], which is the final objective in this model.

In the hierarchically structured taxonomy based on those didactic ideas, in which the role of transfer also appears from specific skills to broadly applicable,

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[4] Nyéki (1993) notes that in de Block's taxonomy, in addition to the cognitive, affective and psychomotor areas, the volitional area also appears.

transferable skills, in other words—from special learning to general learning. The transfer of content elements includes among others critical thinking, structuring, abstraction and deduction (de Block, 1979). From the point of view of curriculum development, Bruner already drew attention to the importance of transfer. According to him, emphasis should be placed on the teaching and recognition of structure in the learning/teaching process (Bruner, 1968). Structure includes general principles (ideas) related to a specific subject matter, which affects the efficiency of knowledge transfer. The structure in de Block's taxonomy also appeared especially among the content elements.

SOLO taxonomy

The formerly presented taxonomies were not designed especially for higher education, which is why Biggs and Collis developed the SOLO taxonomy ("Structure of The Observed Learning Outcome") in 1982 (Biggs & Collis, 1982). The SOLO taxonomy contains five development levels in the cognitive domain which show the structure of knowledge elements. These levels are structured hierarchically similar to Bloom's and de Block's taxonomies. The essence of this hierarchy is presented in the following figure.
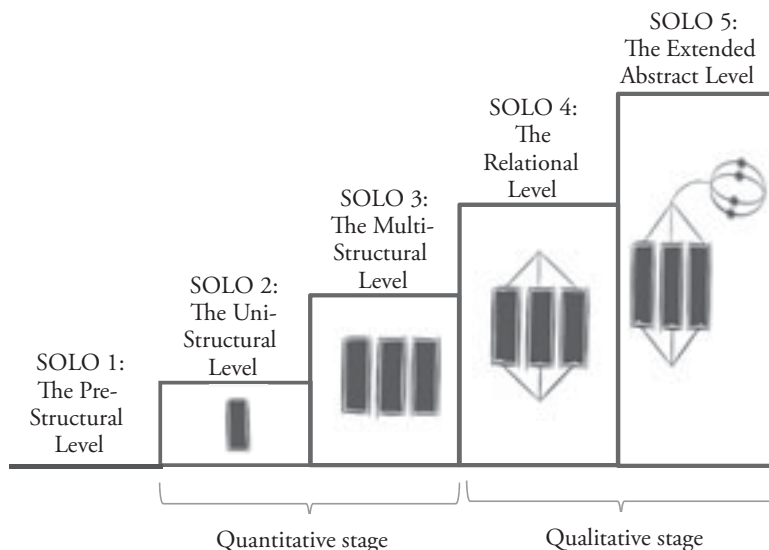

Figure 2. Levels of the SOLO taxonomy, based on Brabrand and Dahl, 2009 with own modification

At the pre-structural level, the student has some kind of information, but they are unorganized, unstructured, so they are insufficient to answer a specific question or solve a problem. At the uni-structural level, the student is able to deal with one single aspect and can use terminology and perform simple algorithms. At the third level, the student can deal with more aspects, using which she/he is able to apply methods, structure and execute procedures, but she/he does not yet see the connections between individual aspects. At the relational level, the student may understand how several aspects form a whole, thus she/he may have the competence to analyse and compare things. At the extended abstract level, the student is able to generalize the structure, and may have the competence to criticize as well as transfer ideas to new areas.

The levels of SOLO taxonomy can be divided into quantitative and qualitative stages based on the structure of knowledge. In the quantitative stage, at second and third level the emphasis is on knowing the facts. On the contrary, in the qualitative stage, at fourth and fifth level connected knowledge elements, creative ideas and transferability are prioritized (Brabrand & Dahl, 2009). In addition, the levels related to the quantitative stage can be characterized by surface knowledge and the qualitative stage by deep knowledge.

Although the levels of SOLO taxonomy similar to Bloom's taxonomy are structured hierarchically, the former is based on the processes of student understanding, so they are valid at all levels. However, complexity and difficulty are closely related in Bloom's taxonomy[5].

Anderson's (Bloom's revised) taxonomy

In the period following the appearance of Bloom's taxonomy, with the expansion of research results related to mental processes, the question arose whether the original taxonomy was still valid. Bloom's former student Lorin Anderson and former colleague David Krathwohl concluded that the original taxonomy needs to be revised, and in 2001 they published Bloom's revised taxonomy (Anderson & Krathwohl, 2001). Figure 3 below presents a comparison of Bloom's and Anderson's taxonomy.

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[5] Pintér (2015) notes that there is no close relationship between the question asked and the difficulty level of the answer, since a question formulated at a lower level can be answered at a higher level and vice versa.
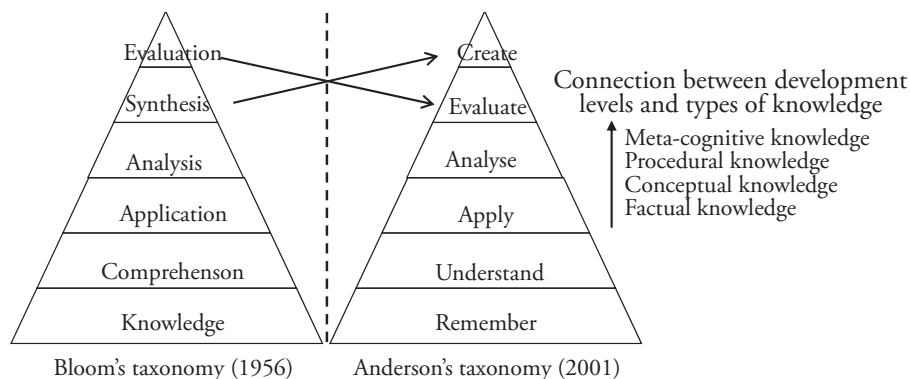
Figure 3. Anderson's (Bloom's revised) taxonomy based on Anderson and Krathwohl, 2001 with own modification

Anderson partly changed the terminology and structure of Bloom's original taxonomy. The original terminology of Bloom's categories has been modified from nouns to verbs, thereby emphasizing that it is a cognitive process as opposed to a behavioural one (see behaviourism critique of cognitive psychology). In the revised taxonomy, the last two levels have been essentially reversed, so that evaluation has been placed behind synthesis under the name of "Create". Therefore, the creation-oriented approach overrides the evaluation-oriented approach. Besides, Anderson also made structural changes in the taxonomy, who distinguished between the types of knowledge which are closely related to all levels of the cognitive process.

Bloom was critical of his own taxonomy, so he was aware that there is a difference between the first level designated as knowledge and the intellectual abilities and skills, therefore he identified several types of knowledge, including factual, conceptual and procedural knowledge (Wilson, 2001). In fact, Anderson merely added meta-cognitive knowledge to the original taxonomy. In the revised Bloom's taxonomy, factual knowledge refers to the terminology related to the field of science, which has to be acquired by the student in order to be able to solve the specific problems. Conceptual knowledge means knowledge of theories, models or structures relevant to the field of science. Procedural knowledge is a knowledge expressed in individual activities, which can be used for successful problem-solving by applying various algorithms, techniques and methods (Pickard, 2007). In the case of metacognitive knowledge that refers to knowledge about one's own cognition, there are two types of relationships. One is self-regulated learning and the other is transferability (Bransford et al., 1999; Amer, 2006).

In Bloom's original taxonomy, transferability has already appeared in relation to application. However, Apple and Krumsieg (2001) further expanded the meaning of cognitive development levels in terms of transferable skills. At the level of "Application" or "Apply", the student can transfer the acquired knowledge not only to new situations, but also to a new context. In addition, at the increasingly higher levels of learning, transferable skills play a role during analysis and synthesis, as the widest possible use of problem-solving (Bobrowski, 2003).

Digital revolution and taxonomy

As a result of the rapid development of information technology, we have entered the age of the fourth industrial revolution. A wide variety of digital solutions, such as artificial intelligence, Internet programs and apps etc., 3D-printing, virtual reality make the interaction between people and machines extremely multipurpose compared to earlier times (Sharma, 2019). The spread of smart tools predicts the digital revolution in education, which provides students with the digital skills needed to thrive effectively in a changing world. Nowadays, access to information technology tools should not be a problem for students and teachers, however, their effective use in education has only been realized to a limited extent. The millennial generation approaches learning and information acquisition in a completely different way than previous generations, since this new generation has already grown up in a digital world, where the use of smart tools has become the part of everyday life (Wedlock & Growe, 2017). The millennial generation is just entering higher education, that is why it is crucially important for universities to offer personalized learning opportunities to students through the effective use of various digital tools.

Recognizing the role of digitalization in the teaching-learning process, Andrew Churches (2008) combined the levels of the revised Bloom's taxonomy to digital activities, which can be seen in Table 2 in details.

Table 2. Churches' digital taxonomy based on Churches, 2008, Watanabe and Crockett, 2015 and Wedlock and Growe, 2017 with own modification

	Level	Activities with digital tools
Higher-Order Thinking skills	Creating	Animating, blogging, collaborating, composing, designing, filming, making, podcasting, producing, programming, publishing, solving, wiki building
	Evaluating	Assessing, checking, critiquing experimenting, hypothesising, posting, predicting, rating, reflecting, reframing, reviewing, testing, validating
	Analysing	Appraising, attributing, breaking down, contrasting, correlating, deducing, differentiating, integrating, mind mapping, organising, questioning, structuring, surveying
	Applying	Calculating, charting, collecting, computing, constructing, demonstrating, displaying, examining, explaining, interviewing, editing, operating, presenting
	Understanding	Advance search, annotating, categorising, classifying, commenting, contrasting, demonstrating, extending, identifying, interpreting, predicting, summarising, tagging
Lower-Order Thinking skills	Remembering	Googling, highlighting, identifying, listing, matching, networking, quoting, recording, retrieving, searching, selecting, tabulating, visualising

Among the digital activities related to the development levels of the expanded digital taxonomy (Table 2), Churches considered collaboration to be of great importance, which can take different forms, and indicated it as one of the most important skills of the 21st century[6]. Collaboration is not necessarily part of the learning process, but it often enhances it and facilitates higher-order thinking. In addition, collaboration as part of communication spectrum includes many other digital activities such as Skyping, chatting and blogging.

Starkey (2011) argues that digitalization has basically three effects on learning. The first aspect of learning is that students collaborate with each other using digital technologies. Furthermore, they create knowledge together, which can be the basis for flexible and creative knowledge. The second one is the construction of knowledge as a result of interactions and reflections between students through a kind of constant networking. In the digital age the third aspect is the importance of critical thinking, because the students must evaluate the validity of a large amount of widely accessible information in a critical point of view as well. Considering the structure of Bloom's and SOLO taxonomy, Starkey developed the six-item Digital Age Learning Matrix.

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[6] A special aspect of Churches' taxonomy is collaboration, for which some digital activities are listed as part of the communication spectrum such as: moderating, negotiating, debating, connecting, net meeting, Skyping, video conferencing, reviewing, questioning, replying, posting and blogging, networking, contributing chatting, e-mailing, Twittering/Microblogging, instant messaging, texting.

Reading items from bottom to top, the first aspect of the learning matrix is when students work within one context (doing together). The second aspect of learning is when students comparing their activities connect with other people. The third aspect is when students must demonstrate their own conceptual knowledge. The fourth aspect includes evaluation that essentially corresponds to the level of procedural knowledge. The fifth aspect is when students create an original product using their own ideas and experiences. The final aspect of learning is when students share their new knowledge trough authentic contexts gaining feedback. It has to be noted that the aspects of learning are not necessarily and always sequential (Starkey, 2011). In the next Table we will summarize how these levels of the learning matrix are connected to digital activities.

Table 3. 'Bloom's extended digital taxonomy' based on Starkey, 2011 and Grantham, 2015[7]

	Level	Frequent activities with digital tools
Higher-Order Thinking	Sharing	Contributing to open social networks, publishing, broadcasting, networking
	Creating	Animating, blogging, collaborating, composing, designing, filming, making, podcasting, producing, programming, publishing, solving, wiki building
	Evaluating	Assessing, checking, critiquing, experimenting, hypothesising, posting, predicting, rating, reflecting, reframing, reviewing, testing, validating
	Conceptualizing	Appraising, attributing, breaking down, contrasting, correlating, deducing, differentiating, integrating, mind mapping, organising, questioning, structuring, surveying
	Connecting	Advance searching, annotating, categorising, classifying, commenting, contrasting, demonstrating, extending, identifying, interpretating, predicting, summarising, tagging
Lower-Order Thinking	Doing	Googling, highlighting, identifying, listing, matching, networking, quoting, recording, retrieving, searching, selecting, tabulating, visualising

Problem solving, collaboration and critical thinking are extremely important in the digital age, and can be interpreted as transferable skills (van Laar et al., 2017; UNICEF, 2019). Consequently, in the taxonomy-added digital activities, the applicability of context-independent knowledge as widely as possible comes to the fore. In the digital revolution of education, higher education

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[7] Referring to Bloom, Grantham (2015) considers the level of applying between connecting and conceptualizing as the seventh aspect, which includes the following digital activities: calculating, charting, collecting, computing, constructing, demonstrating, displaying, examining, explaining, interviewing, editing, operating, presenting.

institutions have a key role in the effective integration of digital technologies into learning, which enables students to acquire transferable skills and digital skills as well.

Conclusions

The pandemic created a new situation both in the labour market and education through online communication using digital technologies. In higher education, even before the pandemic, efforts were made to integrate digital tools as much as possible into the teaching-learning process, which was significantly accelerated by the pandemic restrictions. At the same time, the routine use of information technology requires not only job-specific skills, but also general skills, so-called transferable skills. The latter skills can be used in many fields, situations and professions. It is about the fact that during the pandemic, there was not only the possibility of transferable skills, but also its necessity. In other words, in addition to communication skills, there was a demand for transferable skills that made the wide spread of digital skills indispensable. The importance of transferable skills also remained in the post-epidemic labour market from the point of view of improving employability. Apart from this, we would like to highlight another aspect of the described process, which could be of particular importance in higher education. It is known that incongruent employment in the labour market has particularly increased during the pandemic, in particular, the matching between degree and job requirements were separated in many cases from each other. This situation raises the earlier idea of curriculum theory that in higher education, besides special training, there would be a greater need for general training as well. This must be emphasized because the recognition of the importance of general training cannot be considered widespread in the practice of higher education institutions. If we look back at the taxonomies, there are plenty of elements that serve to facilitate transferable skills in addition to job-specific skills. The prominence of transferable skills was initiated by the cognitive revolution, but its importance really prevailed in the digital revolution. In our opinion, this perspective of curriculum theory should be enforced more emphatically in higher education in order to better adapt to the needs of the labour market.

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Taksonomije u razdoblju od kognitivne do digitalne revolucije, s fokusom na prenosive veštine

Apstrakt: Taksonomije koje su doprinele kognitivnoj revoluciji predstavljaju važnu početnu tačku u tumačenju znanja. Cilj ovog rada je da se analiziraju Blumove i srodne taksonomije u pogledu prenosivih veština u razdoblju od kognitivne, pa do digitalne revolucije. Bendžamin Blum je predstavio svoju taksonomiju 1956. godine, a u nju je, između ostalog, uvrstio klasifikaciju kognitivnih ciljeva. U Blumovoj taksonomiji prenosive veštine se javljaju isključivo posredno, u vezi sa primenom znanja u novim situacijama. Međutim, De Blok je već smatrao da je prenosivost znanja jedan od aspekata ciljeva učenja. U taksonomiji SOLO prenos se ostvaruje na relacionom nivou i nivou proširene apstrakcije, u kojima su kritičko razmišljanje i generalizacija strukture u glavnom fokusu. Nešto kasnije, u revidiranoj Blumovoj taksonomiji, značenja svakog nivoa razvoja bila su dopunjena, s naglaskom na veštinama rešavanja problema u mišljenju višeg reda. U današnjoj digitalnoj revoluciji, koja se neprestano razvija, saradnja je od ključnog značaja, te je uvršćena u matricu učenja u digitalnom dobu i u digitalnu taksonomiju. Samim tim, prenosive veštine kao opšte veštine moraju biti važne i među višim obrazovnim ciljevima i mogu poboljšati prilike zaposlenih da se oprobaju u novim sferama rada, koje nisu nužno povezane s njihovim dotadašnjim obrazovanjem.

Ključne reči: taksonomija, veštine koje se mogu prenositi, digitalno doba, saradnja

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