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Educational Pyramids Aligned: Bloom’s Taxonomy, the DigCompEdu Framework and Instructional Designs

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Abstract—There are currently numerous learning theories and methodologies that teachers can use in their classes, depending on their educational goal and the specific subject matter taught. In addition, there are numerous technologies and tools that can help in the implementation of these learning theories and methodologies. This article builds on the Bloom’s taxonomy for the cognitive domain for learners and the DigCompEdu framework of digital competences for educators and defines a classification that organizes instructional design methods with the aim to help educators find the right method for orchestrating their classes. This classification uses the analogy of the pyramid, climbing levels as the student has a more active role in his own learning. The pyramid proposed to organize instructional design methods contains six levels, from the base of the pyramid (lowest level) to the top of the pyramid (highest level): knowledge transfer, interactive knowledge transfer, challenged knowledge, analytic learning, experiential learning, and active learning. This pyramid is intended to put some order into the many learning theories and methodologies that exist.

Keywords—Bloom’s taxonomy, DigCompEdu framework, educational technology tools, instructional design methods, pyramids.

I. INTRODUCTION

Prof. Cheops is a university professor who has been lecturing the classical way for a long time. The blackboard and the chalk are his tools, and his voice the means to convey information. But he is convinced that he must innovate his teaching methods, since today’s students are not paying much attention to what he says. However, he is overwhelmed by the wealth of literature for improving teaching. He looks at the many technologies and tools that exist and that can be used in and out of class: engagement apps, digital boards, video recording and edition tools, podcasts, presentation tools, etc. When and how should he use them? Then, there are a myriad of learning theories and educational methods and techniques [1]: problem-based learning, project-based learning, case-based learning, inquiry-based learning, collaborative learning, constructionism, connectivism, active learning, flipped classroom, and so many more. Which is the most appropriate for his subject, archeology? Should he combine several of these techniques?

One day a colleague, Prof. Khafre, points his attention to Bloom’s taxonomy for the cognitive domain, which is usually represented in the form of a pyramid (see Fig. 1) [2]. He tells him that his students should not only remember what he lectures (lowest level in Bloom’s taxonomy) but be able to create (highest level in Bloom’s taxonomy). So far, so good, but how does this relate to the educational tools and methods that exist?

Figure 1. Bloom’s taxonomy for the cognitive domain

Another colleague, Prof. Menkaure, comes another day and tells Prof. Cheops that the problem lies in his digital competences for teaching and that he should look at the Digital Competence Framework for Educators (DigCompEdu) [3], which has several levels of proficiency for each competency; these levels of proficiency can also be arranged in the form of a pyramid (see Fig. 2). Therefore, Prof. Cheops should learn how to use the technologies and tools that exist for education and move from being a newcomer (lowest level in this framework) to becoming a pioneer (top level in this framework). Furthermore, this climbing of the pyramid applies to 22 competencies from 6 areas that are present in the DigCompEdu framework, including professional competences of educators (area 1), pedagogical competences of educators (areas 2-5), and competences of students (area 6).

Keywords—Bloom’s taxonomy, DigCompEdu framework, educational technology tools, instructional design methods, pyramids.

I. INTRODUCTION

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This means a lot to learn, but the question remains: how can Prof. Cheops teach his class in a better way? He is confused. He would like to see another pyramid that is more educator-oriented and that helps him design and orchestrate his class for different purposes (see Fig. 3): from how to design a class so that the students remember (lowest level of the pyramid) to how to design a class for them to create (top level of the pyramid). Moreover, it is important to keep in mind that the design of a class may include methods that belong to various levels of the pyramid, and that lower levels of the pyramid are also contained in higher levels, so that a class designed to apply (third level from the base of the pyramid) also allows understanding and remembering, and that a class designed to create covers all the remaining levels.

Prof. Cheops sees pyramids everywhere (Fig. 4) but no clear way to improve his teaching. In this paper, we want to help him and align Bloom’s taxonomy with the DigCompEdu framework and many of the instructional design methods that currently exist in a way that helps Prof. Cheops and other educators find the right methods to design their classes. Moreover, the implementation of these methods can be supported by technologies and tools that facilitate the orchestration and that will also be discussed in this article. All in all, this article proposes a classification for organizing instructional design methods into six levels following the analogy of the pyramid, from levels in which the learner plays a more passive role (lowest levels of the pyramid, teacher-centered education) to levels in which the learner plays a more active role (highest levels of the pyramid, student-centered education). This six-level pyramid is composed, from bottom to top, by the following levels: knowledge transfer, interactive knowledge transfer, challenged knowledge, analytical learning, experiential learning, and active learning.

II. A PYRAMID FOR SUPPORTING EDUCATORS DESIGN THEIR CLASSES

Let’s define an additional pyramid that helps educators identify the best instructional design methods. This pyramid also consists of 6 levels, from the lowest level for knowledge transfer to the top one for active learning:

1. **Knowledge transfer**
2. **Interactive knowledge transfer**
3. **Challenged knowledge**
4. **Analytical learning**
5. **Experiential learning**
6. **Active learning**

We will draw this pyramid upside-down (see Fig. 5) to reflect the fact that the lowest level is simpler and that the higher levels include the lower ones. We also use a color code to represent the level of activity of the student in class: from blue (like cold ice) where the student is more passive in a lecture to red (like fire) where the student is more active.

A class designed for the student to remember according to the Bloom’s taxonomy (Fig. 1, lowest level) is a class based on just knowledge transfer (Fig. 5, lowest level). If we want the student to understand as well (Fig. 1, second level from the bottom), we will need to add some interaction, climbing the pyramid to the interactive knowledge transfer (Fig. 5, second level from the bottom). And so on, until we reach the highest level of purely active learning (Fig. 5, top level), which corresponds to students creating according to the Bloom’s taxonomy (Fig. 1, top level).

Interestingly, the teacher plays a different role at each level of the pyramid. Figure 6 complements the instructional design pyramid in Figure 5 by adding the teacher’s role on the left side, considering the levels defined in the DigCompEdu framework, from A1 to C2 (see Figure 2). It is important to note that there are three clearly differentiated roles that correspond to levels A, B, and C of the DigCompEdu framework: lecturer (A), facilitator (B), and coach (C). In addition, each of these roles has a regular level and an advanced level (1 and 2, for example in B1 and B2). The major leap is done when the teacher moves between letters (e.g., going from A to B or from B to C), with a smaller leap when the teacher moves between numbers (from 1 to 2 of the same letter). Therefore, a teacher who designs a class based on knowledge transfer is a lecturer, while a teacher who designs a class for active learning is an advanced coach.
For each of these 6 levels there might be different examples of instructional designs that may serve the purpose. Figure 7 shows several examples. These examples are not perfect, since the same design might be used in different ways to serve different purposes but can give a rough idea.

A traditional live lecture is a design that can be used for remembering (level A1 of Bloom’s taxonomy). To advance to level A2, we add interaction by including live discussion or quizzes and polls in the lecture to help the student understand (level A2 of Bloom’s taxonomy).

Level B1 would include more structured discussions, such as a debate, as well as additional activities in which learners may take a somewhat more active role to apply the concepts explained by the teacher, such as problem solving or participating in a contest. Level B2 would involve a more analytic learning through, e.g., collaborative learning, structured groupwork, case-based learning, or peer teaching, among others.

Level C1 would mean designing activities for the learners to experience a certain subject, including, e.g., peer assessment, problem-based learning, lab work, field trips, or inquiry-based learning. For the highest level C2, there is a variety of active learning models, such as Design Thinking, Project-based Learning, Capstone projects, work in a Makerspace, Service Learning, or doing an internship at a company.

The examples of instructional designs illustrate the evolution of the teacher and the competences required. In a traditional live lecture (A1), learning is teacher-centered, with the student playing a passive role listening to the teacher. It is precisely the teacher who is active throughout the lecture. The educator learned the facts and then explains them in class to the learners. However, the effort and difficulty of preparing a rich active learning experience is much higher than preparing a lecture, because the educator must take care of the orchestration of the activities and supporting technologies and tools besides mastering the contents, thus needing technological, pedagogical, and content knowledge (TPACK) [4] (see Figure 8). All in all, the teacher’s knowledge, competences, and workload increase as one moves up the instructional design pyramid.

A. Knowledge Transfer (A1)

Level A1, knowledge transfer, corresponds to the unidirectional transfer of knowledge from the teacher to the students. It therefore involves the traditional lecture or conference, which is typically designed to make the student remember what has been explained. The competencies needed by the teacher in level A1 refer to the ability to speak to an audience in a convincing way. Some related recommendations by Carmine Gallo on how to make good TED Talks [5] include: to share your own passion, to tell stories, to use humor, to teach something new, to build a multisensory experience, or to practice a lot, among others.

Nevertheless, the ability to deliver a good lecture is not new at all and is related to ancient theories on rhetoric, oratory, and dialectic [6]. Rhetoric provides heuristics for understanding, discovering, and developing compelling arguments and includes data and statistics to reinforce the objectivity of the arguments (logos), the ability to convey emotion to the audience with words and body language (pathos), and the authority of the lecturer and the credibility he/she inspires (ethos), in addition to the opportunity created by the specific moment in which the lecture occurs (kairos). The five canons of rhetoric for a convincing lecture include [6]:

1. finding the material (inventio)
2. selecting and ordering the material (dispositio)
3. choosing the appropriate words and forming sentences (elocutio)
4. memorizing and being remembered (memoria)
5. conveying with voice, body, and soul (actio)
Oratory is the art of speaking with grace, applying rhetoric to a specific speech. Finally, dialectic is the art of argumentation. The rhetoric, oratory, and dialectic of a speaker must be able to persuade and enchant the audience [7].

The rhetoric, oratory, and dialectic of a lecturer must serve the purpose not only to convince but also to teach through didactics [8], following a certain educational style to present the information to the learners.

Knowledge transfer in level A1 can be achieved directly in the classroom in onsite education. Nevertheless, it is also possible to use simple videoconferencing systems (without any extra features needed in upper levels of the pyramid) for the online transfer of knowledge, like Skype (skype.com), BlueJeans (bluejeans.com), or mmHmm (mmHmm.app). Additional tools for the creation and edition of videos and animations can also be used to transfer knowledge through “canned lectures”, such as Camtasia (techsmith.com), Kaltura Capture (kaltura.org), or Screencastify (screencastify.com), for video creation and edition, and PowToon (powtoon.com), Animoto (animoto.com), or Moovly (moovly.com) for the creation of animations.

In the case of knowledge transfer, students must make an important effort outside the class for self-study to remember the information provided by the teacher. Ebbinghaus defined the forgetting curve [9], which depends on the student’s retentiveness, the stability of the memory, and the time elapsed. It is therefore necessary for the student to increase the retention of the information [10], using, for example, textbooks, videos recorded by the teacher (or third parties), or flashcards, among others (see Figure 9). One possible strategy to increase retention is spaced repetition [11], whereby information that has not been retained in the students’ memory is reviewed more frequently than information that has been retained. There are multiple algorithms to implement spaced repetition, such as Leitner system [12], as well as applications that use spaced repetition to help remember information, such as Duolingo (duolingo.com), Memrise (memrise.com), anki flashcards (apps.ankiweb.net), or Cerego (cerego.com), among others.

In-class writing activity in which students have to respond to a specific speech. Finally, dialectic is the art of argumentation. The rhetoric, oratory, and dialectic of a lecturer must serve the purpose not only to convince but also to teach through didactics [8], following a certain educational style to present the information to the learners.

B. Interactive Knowledge Transfer (A2)

Level A2, interactive knowledge transfer, builds on the knowledge transfer level but includes some simple activities to be done by the students intertwined with the professor’s lecture; these activities are aimed at helping students understand the information provided by stimulating recall and the assimilation of knowledge. Classes designed to understand can be implemented in several ways. For example, a discussion can take place between the teacher and a student (or several students) on a piece of information delivered during the lecture, either because the teacher initiates the discussion, or the student initiates it [13]. Another alternative is the introduction of short exercises and/or polls during the lecture [14] so that the teacher could verify if the concept explained has been understood by the learners and, if not, explain it over again in a different manner. Finally, the method known as the 1-minute paper [15] can also be used as a short in-class writing activity in which students have to respond to an instructor-posed question.

There are numerous applications that the teacher can use both in the classroom and online to implement exercises and polls. This is the case of Kahoot! (kahoot.com), Mentimeter (mentimeter.com), Wooclap (wooclap.com), Quizizz (quizizz.com), Quizalize (quizalize.com), Socrative (socrative.com), Pickers (pickers.com), or Poll Everywhere (polleverywhere.com), among many others. Moreover, most of the videoconferencing tools used for synchronous online classes have recently included features to launch polls, such as Google Meet (meet.google.com), Zoom (zoom.us), Microsoft Teams (microsoft.com/microsoft-teams), or Blackboard Collaborate (blackboard.com), among others. Furthermore, when implementing a 1-minute paper, in addition to a text output generated with any regular text editor, students can be asked to make a short video with applications such as Flipgrid (flipgrid.com).

In the case of interactive knowledge transfer, students must also make an important effort outside the class for self-study to understand the information provided by the teacher. For example, exercises could be added to the teacher-recorded or third-party videos that were used in level A1 for the self-study of students. There are numerous tools that allow quizzes to be added to videos (these are known as in-video quizzes [16]) by remixing own and third-party content. Some of these tools are Edpuzzle (edpuzzle.com), Mediabreaker (mediabreaker.org), Kaltura (kaltura.org), Nearpod (nearpod.com), Panopto (panopto.com), or Yuja (yuja.com), among others. In most cases, the teacher can get the answer given by each student to each in-video quiz to have a better overview on whether the students have understood the information provided. Other elements for self-study outside the class include doing formative assessments [17] or creating concept maps [18] (see Figure 10) with tools such as MindMeister (mindmeister.com), or Coggle (coggle.it), among others.

Figure 9. Examples of self-study elements for level A1: textbook, video class, flashcards, and spaced repetition.

Figure 10. Examples of self-study elements for level A2: in-video quizzes, formative assessment, and concept maps.
C. Challenged Knowledge (B1)

Level B1, challenged knowledge, involves an important change in the role of the teacher, who must shift from lecturer to facilitator. The class becomes less teacher-centered and more student-centered. Knowledge is questioned and applied in level B1. Classes designed to apply can be implemented in several ways. For example, the teacher can foster the debate among learners. This can be done, for instance, through Socratic dialog [19], in which a character (e.g., the teacher) asks a question to another character (e.g., one student). This question is intended to show ignorance of the teacher and at the same time is intended to promote reflection and critical thinking on the respondent.

There are several formats to implement the Socratic dialog including: interactive (high student-teacher talk ratio with interactive exchanges), question-answer (teacher asking questions and students answering them or vice versa), conversational (instructional dialog in the form of a conversation), and without authority (dialog among peers). The construction of knowledge from dialog has been extensively studied in the conversation theory by Gordon Pask [20] according to which learning occurs through conversations that make knowledge explicit. Regarding the debate among learners, it is also important to consider the ability to convince the other. This issue has also been extensively studied, for example, in the book “eristic dialectic” by Arthur Schopenhauer [21], which contains 38 stratagems to win an argument, many of which are also used in numerous contexts outside the classroom nowadays, such as politics and media. Other ways in which the teacher can design the class to apply the knowledge include the use of contests or competitions [22] as elements of intrinsic motivation of students, and problem solving as a way of applying the theoretical concepts to practical problems [23].

There are numerous applications that the teacher can use in a class designed to apply knowledge. Kialo-edu (kialo-edu.com) is a tool that can be used to promote rational debate and helps students develop critical thinking skills. The teacher can pose an idea in Kialo-edu and the students must raise pros and cons on it (and where each positive and negative argument provided can be discussed again recursively). In relation to competition, there are tools that can be used to generate contests and competition environments in a simple way, as it is the case with Flippity (flippity.net), which does not need any programming skills. Flippity includes templates to create quiz shows, scavenger hunts, board games, and matching games, among others. Finally, there are many tools that can be used to generate contests and competition environments in a simple way, as it is the case with Flippity (flippity.net), which does not need any programming skills. Flippity includes templates to create quiz shows, scavenger hunts, board games, and matching games, among others. Flippity.net does not require any programming skills.

D. Analytic Learning (B2)

Level B2, analytic learning, builds on the challenged learning level and requires the teacher to become an advanced facilitator, with additional competences compared to level B1, and possibly with an increased use of technology, especially in online and hybrid education. Classes designed to analyze can be implemented in several ways. For example, the teacher can use peer instruction in such a way that the students themselves explain a certain concept to other students (peers) [25]. Peer instruction is also known as reciprocal teaching, where a dialogue between teachers and students happens, with students taking turns to assume the role of teacher and the role of student [26]. One of the best ways to learn something (and to know if the concept learned has been correctly grasped) is to explain it to others (learning by teaching) [27]. Other possible designs for classes aimed to analyze include case-based learning, where students must make decisions about real cases that have occurred in the past (e.g., in subjects related to Law, Business, and Management) [28], or collaborative learning where students work in groups to create artifacts or products as a result of their learning [29]. There are several patterns that can be used when working in groups. These are known as CLFPs (Collaborative Learning Flow Patterns). CLFPs contain several phases in which the number of groups and their members can be modified, and in which the outputs of one phase serve as input to the following one [30]. Some well-known CLFPs include pyramid, think-pair-share, or jigsaw [31].

There are numerous tools that promote peer teaching, case-based learning, and collaborative learning. For example, Perusall (perusall.com) is a platform co-created by Eric Mazur, who popularized peer instruction [25], and that is aimed to enhance active reading of texts (uploaded by teachers or through agreements with editorial), including discussions and instruction among peers. Another meaningful example is Engageli (engageli.com), which builds on the idea of virtual tables to create groups of students in online and hybrid learning environments. Each table has a shared document anchored so that all the students in the table can see and collaboratively edit this document. In addition, Engageli supports the implementation of peer instruction in a way that the teacher can launch a question in a built-in poll, see students’ answers (without them having to see the answers), and determine if there are a significant number of students who have not answered correctly, starting a peer teaching per table which ends with the teacher launching the poll again to check if the results improve. Other tools and platforms that rely on the ideas behind peer teaching, typically connecting
student tutors with other students, include Wyzant (wyzant.com), which was recently bought by another related platform calledIXL (ixl.com), Tutor Universe (tbs.com/tutoruniverseinc), or Chegg (chegg.com/study). For case-based learning there is Case Center (thecasecentre.org), a not-for-profit organization that is dedicated to promoting the case method. Finally, collaborative learning and structured groupwork can be fostered in online and hybrid environments through the breakout groups available in most videoconferencing tools, such as Zoom, Google Meet, or Blackboard Collaborate, but also through other tools that provide virtual spaces for people to talk and discuss in groups, such as Wonder (wonder.me), Remo (remo.co), Gatherly (gatherly.io), Gather.town (gather.town), or Circle (letscircle.co).

E. Experiential Learning (C1)

Level C1, experiential learning, brings with it the transition of the teacher from facilitator to coach. Classes at this level are designed to evaluate and become very student-centered with the teacher providing support to the students when needed. Level C1 is grounded by the most relevant student-centered pedagogical theories, including:

1. Piaget’s constructivism, according to which learners construct new knowledge from what they already know [32];

2. Papert’s constructionism, according to which learners create mental models and meaningful products as part of their learning process [32];

3. Siemens and Downes’ connectivism, according to which learners in the digital age connect information sets across networks as part of their learning [33];

4. Kolb’s experiential learning, according to which learning happens through experience (through learners’ reflection of what they have done) [34].

These theories also lay the foundation for some active learning techniques, such as inquiry-based learning [35] or discovery learning [36]. The former starts with the teacher posing questions or problems and facilitating materials and methods (when needed), and with the learners doing research to get to a solution to the question or problem posed by the teacher and developing new related questions and methods. The latter can be understood as a specific inquiry-based learning technique where learners rely on their own experience and explore and manipulate objects to get to the solution to the question or problem posed by the teacher. Hypotheses can be defined along the way and the student must accept or reject them based on the data collected. Other methods and techniques that can be included in C1 include peer assessment [37], where students submit an assignment and assess several of those from their peers, and where some calibration [38] may be added if the results are to be used as part of the student’s summative assessment; problem-based learning [39], where students must solve open-ended problems, typically in groups, and based on some general instructions (e.g., in health sciences courses); laboratory work, where students must use some kind of equipment to perform experiments on their own, generate data, and draw conclusions based on these data (e.g., in science and engineering courses) [40]; or field trips where students visit a certain location for observation or sample collection for subsequent analysis (e.g., in life sciences courses) [41].

There are several tools that can be used to support the activities in this level. For example, inquiry-based learning and discovery learning can be supported by the Golabz initiative (golabz.eu), which contains a large collection of inquiry learning spaces created in Graasp (grasp.eu) by teachers following an inquiry cycle. This cycle typically consists of five phases: orientation, conceptualization, investigation, conclusion, and discussion; labs and apps are normally included to support the investigation phase so that learners conduct scientific experiments guided through the inquiry-based learning process. Regarding other methods and techniques, peer assessment can be supported by tools such as Peergrade (peergrade.io) or directly through some learning platforms (e.g., Moodle contains a peer assessment activity called workshop). Laboratory work can be supported by some virtual laboratories for online or hybrid education, such as Labster (labster.com). Virtual field trips are also possible through interactive field casts where cameras are placed in certain locations of interest to collect data that is then processed by students (enhancingfieldwork.org.uk).

F. Active Learning (C2)

The highest level is C2, active learning, where the teacher goes one step further and becomes an advanced coach [42]. At this level, activities are designed for students to create products or projects of a large scale and that are typically developed through large periods of time (e.g., several weeks or months). This level may include, for example, Design Thinking [43] as a way to create innovative products or services, usually in a creative way, using lateral thinking, making rapid models and prototypes to be tested, evaluated, iterated, and refined [44]. Project-based learning can also be included in this level as a form of active learning in which students work on a project that solves a complex real-world problem or challenge [45]. This is also the case with capstone projects, which serve to close students’ academic experience in most university degrees combining the knowledge and skills acquired throughout the degree, carrying out a complex project for about a year [46]. Some projects (including capstone projects) can be carried out in a MakerSpace, especially those related to the areas of STEM (Science, Technology, Engineering, and Mathematics); MakerSpaces are open laboratories where students can make prototypes or products (either individually or in teams) under the supervision of a teacher [47]. Also worth mentioning at this level is service learning, which combines the academic curriculum with community service, and that has a learning purpose through dealing with real-world situations [48], or internships in companies related to the student’s academic field [49].

There are some tools that can support the activities in this level. For example, project-based learning is supported by several initiatives, such as AlgoExpert (algoexpert.io), JetBrains Academy (jetbrains.com - hyperskill.org/onboarding), or Codecademy (codecademy.com/projects) in the field of computer science and programming, or by PBLWorks (my.pblworks.org) in general. Design Thinking is supported by IBM (ibm.com/design/thinking). Projects to be done in a MakerSpace can be found at Markespaces.com or in Instructables (instructables.com), the latter mainly in the field of electronics.
III. CONCLUSION

Bloom’s taxonomy of the cognitive domain refers to the competences of learners from the basic remembering to the advanced creation. We relate this taxonomy to the six proficiency levels of digital competences for teachers defined in the DigCompEdu framework. This relationship is established by using the analogy of the pyramid. An additional pyramid serves to organize different instructional designs that the teacher can use in the classroom, with and without technology. The teacher moves from designing a class for remembering through lecturing (teacher-centered education and passive learning) to designing for creation, getting the student to work on real projects (student-centered education and active learning). The teacher also shifts from a lecturer to facilitator, becoming finally a coach for the learner as the teacher reaches the highest levels in the pyramid. It should not be forgotten, however, that the classification proposed in this article builds on well-established educational theories and methods as well as on technological tools and applications that can support each instructional design. The balance lies in finding the flow channel [50] that allows students to face challenges adapted to the knowledge and skills they have and to increase those challenges as students acquire new knowledge and develop new skills.

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