International Journal of Educational Technology and Learning
ISSN: 2523-0581
Vol. 18, No. 2, pp. 54-68, 2025
DOI: 10.55217/101.v18i2.927

From competence 1.0 to competence 4.0: An open, unifying and global education framework

Kostis C. Koutsopoulos[1]
Yannis Kotsanis[2]

[1]*Technical University of Athens, Athens, Greece.*
Email: koutsop@survey.ntua.gr
[2]*Research and Innovation Department, Doukas School, Athens, Greece.*
Email: kotsanis@doukas.gr

Abstract

This paper, in dealing with the Competence of Learning (CoL), has the *purpose* of substantiating that: first, the main elements of CoL—knowledge, skills, and psychosocial factors—are based on literacies, which nowadays rely on technology in the form of digital literacy; second, there have been paradigm shifts based on changes in all the major factors related to CoL; and third, these shifts have *resulted* in the development of four major CoL paradigms, forming a continuum from Competence 1.0 to 4.0. In addition, based on two proposed *mechanisms* of CoL development—the operation of triggers, fluctuations, and feedbacks, and the integration of revised taxonomies of learning objectives and outcomes—combined with the constant evolution of all the factors influencing CoL, an open, unifying, global, innovative, and comprehensive CoL framework has *resulted* in the form of a 3D model. The three axes of this framework are: the *Domain/Content axis*, which expresses individuals' needs and enhancement in targeted subject areas and diverse academic contexts; the *Competence axis*, which expresses the ability to do something by learning or developing, based on knowledge, skills, and psychosocial factors; and the *Integrated Scaffolding axis*, which focuses on supporting learners and enabling them to progress to enhanced levels within their Zone of Proximal Development. The *practical implication* of this framework is that it can be utilized by/for anyone, at anytime, anywhere, for anything, satisfying the 5W1H questions of learning.

Keywords:
Competence framework
Competence of learning
Digital literacy
Paradigm shift
Scaffolding
Artificial Intelligence.

Publisher:
Scientific Publishing Institute

Received: *25 February 2025*
Revised: *16 April 2025*
Accepted: *29 April 2025*
Published: *22 May 2025*

(Corresponding Author)

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.

1. Introduction

"What does competence mean? This question is still asked in the educational community, and there is not a universally accepted answer (Vitello, Greatorex, & Shaw, 2021). It is evident how fragmented the debates around this notion are among educational stakeholders and the literature (Ashworth & Saxton, 1990; OECD, 2017; Rychen & Salganik, 2001; UNESCO, 2018; Valtin, 2016).

The question then is: why do we need another competence description when there are many others in the literature? The following sections show that this need is well justified. For example, the Cambridge English Dictionary includes a multitude of definitions of competence, which can be summarized in the simplistic "the ability to do something (in the case of education, learning) well." In support of this paper's goal, a perfunctory answer could have been that all the definitions found cannot satisfactorily support today's learning conditions. However, the basic argument is that some fundamental factors bring changes to how Competence of Learning (CoL) is considered and achieved that are the result of the shifts in the perceptions and beliefs of society, which have an impact and are impacted by technology that, in turn, affects competence and CoL.

This position is identical to the OECD competence framework, which has stated, "contemporary societies are increasingly based on information and knowledge, and the ubiquity of technologies."

This paper examines competence from an integrated and comprehensive perspective by addressing the following: first, CoL and its main elements (knowledge, skills, and psychosocial factors) are based on or require the appropriate literacies, which nowadays rely on the ubiquitous use of technology, in the form of digital literacy; second, there have been four major CoL paradigm shifts (from competence 1.0 to 4.0) resulting from changes in all the factors affecting competences (i.e., society, digital literacy, teaching, etc.); third, there is a unified changing mechanism of CoL characterized by triggers, fluctuations, and feedback; fourth, any CoL represents a concept that incorporates Revised Taxonomies principles of learning objectives and outcomes (e.g., Revised Bloom's Taxonomy, Anderson and Krathwohl (2001) Revised SOLO taxonomy, De Florio (2023) but in combination with the constant evolution of society and the latest digital tools, etc.; and fifth, a global, open, innovative, and comprehensive CoL framework is presented as a 3D model, whose three axes are Domain/Context, Integrated Scaffolding, and Competence.

In summary, the major components of this paper are the concepts of literacy, the bedrock upon which competence is based, in order to formulate the competence of learning.

2. Clarification of Major Competence Factors

2.1. Literacy

Silvia Montoya UNESCO (2018) has defined literacy as "the ability to identify, understand, interpret, create, communicate, and compute, using printed and written materials associated with varying contexts." Additionally, "literacy involves a continuum of learning that enables individuals to achieve their goals, develop their knowledge and potential, and participate fully in their community and wider society," which is practically identical to those used by academics, NGOs, think tanks, and advocacy groups since the 1990s (Belshaw, 2012, Brandt, 2001, European Commission, 2016, 2022, Knoth et al., 2024, OECD, 2018, UNESCO, 2023). However, what is important is that since the 1990s, there has been a shift in understanding literacy from a "discrete skill" to a "social practice."

That is, from the traditional "ability to read and write" to a broader view that includes social, cultural, and other aspects. A systematic example is the study of Stolpe and Hallström (2024) that aims to critically analyze five AI literacy frameworks related to "three traditions of technological knowledge: technical skills, technological scientific knowledge, and socio-ethical technical understanding."

As a result, nowadays literacy in education: first, is not only a determining factor in all learning subjects, but is about learners being able to interpret, react, articulate, and express their thoughts; second, it cannot be assumed to be just an academic activity and thus the sole responsibility of the school, which partly is, but a 'Life Skill' that is a component of education that practically represents it; and third, has evolved into multiliteracies, so that it is no longer used to mean having knowledge or skills in a specific field (computers, statistics, ecology, health, music, etc.), which is explained by the fact that literacies are domain-general and context-specific, substantiating their difference (e.g., musical literacy vs. health literacy), all of which nowadays rely on the development of digital technology.

Finally, the difference between literacy, which encompasses various forms of communication and critical engagement, and competence, defined as a combination of knowledge, skills, and psychosocial factors or attitudes/values, is supported by the literature (e.g. Kotsanis, 2018; Ng, Leung, Chu, & Qiao, 2021; Temitayo Sanusi & Chiu, 2024) but needs clarification, as they are two distinct concepts characterized as follows:

- Literacy focuses on knowing, depends on context, can mediate technologies, and mainly is a *condition,* not a threshold.
- Competence is concerned with the quality of being suitable to carry out a desirable task. In addition, competence is about applying knowledge in order to resolve a desirable societal need. Competency also indicates that a learner has the experience and the capability to use various applications in order to perform different tasks as well as to be able to learn how to utilize new applications.

These two different concepts, however, have many common elements, which can be expressed in a Boolean manner as the intersection between them that includes common contributions such as:

- Provide basic skills required to enhance independent living and achieve daily tasks.
- They are useful across various contexts, not just specific tasks, situations, etc.
- Offer structured development help with well-defined expectations.

- Depend on technological development.

As a result, literacy has two components: the intersection with competencies, which today is expressed by digital literacy that plays a determining role in CoL, and the literacies that are important and/or necessary in other educational functions.

2.2. Competence

The concept of competence has been part of the educational landscape since education became part of society's activities. Presently, attention to competence in education has exploded because it represents the focus of educational stakeholders' debates on learning and curricula (i.e., (European Commission, 2022; UNESCO, 2024a, 2024b); etc.).

The reason is simple but has a tremendous impact because competence(s) are not only a goal of education but mainly a determining factor for the economy and the well-being of all citizens. Students who are the future workers, if they become competent in school (in one or more learning areas), will contribute constructively to their future workplace and improve their living conditions.

Moreover, the present century is a period of intense transformation. In order to meet societal needs, it is essential for individuals to possess the competence to face new challenges. However, what is most important in achieving that goal is not just the change itself, but the rapid pace at which these changes are occurring. Therefore, these changes require society as a whole, and education in particular, to adapt and educate students to become more knowledgeable, possess the necessary skills, attain the right attitudes, values and motivations, and be able to contribute to sustainable development (Dunning, 2000; Kozma, 2008; Pigozzi, 2006) and, most importantly in this paper, to achieve the necessary digital literacy.

Of course, as UNESCO (2023) stated in a very comprehensive report, "the adoption of digital technology has resulted in many changes in education and learning," but at the same time "digital technology has changed, but not transformed education," supporting our suggestion of the importance of competences, which, as they progress, will accomplish the first and ratify the second.

In addition, the P21 Framework (P21, 2009) suggests, among other competence issues, that "students in the 21st century live in a technology- and media-suffused environment" exhibiting three major characteristics: first, access to an enormous wealth of information; second, rapid shifts in technology tools; and third, an unprecedented number of ways to collaborate and make individual contributions. In other words, reaffirming this paper's position that students should have digital literacy.

That is, students, the future active workers, in order to be effective in the 21st century, must be able to exhibit a range of functional and critical thinking skills related to information, media, and mainly technology that create a large set of necessary competencies.

2.3. Competence of Learning

In outlining CoL in a new way, certainly the key fundamental features of literacy and competence discussed earlier are helpful. In addition, the results of various articles and reports available in the literature (e.g., Cambridge Report: (DeSeCo, 2019; UNESCO, 2022; Vitello et al., 2021) etc.) were taken into consideration. As a result, a decalogy of CoL principles is presented as necessary to efficiently and effectively outline the CoL concept. More specifically, competence learning:

- It is and should be treated as a holistic concept.
- Is always linked to a specific broad area of study or domain.
- Is unconditionally dependent on one or more contexts in each broad area of study.
- Its performance is consistent across various contexts related to the same domain or study area.
- It can support predictions and comparisons of future performances for different contexts, but within the same study area.
- Is connected to a specified level of learners' ability.
- Is connected to a specified level of learning.
- Involves applying contextually appropriate factors, which substantiate its usefulness.
- Involves understanding, organizing, managing, and evaluating information and ethical/legal issues related to the access and primarily the use of digital technologies
- Involves literacy (mainly digital), which determines how the CoL is applied.

These principles represent the building blocks in formulating a generalized competence learning concept, which consists of the following:

- The broad area of study (most researchers use the term domain), which is the learning area that competence learning is operating in and is part of and directly related to.
- Within each domain, there are one or more contexts (referring to the situations, tasks, and settings) with which competence learning is associated, meaning that different contexts can and should be performed in the specific area of study, but mainly represent the surrounding circumstances in which they have developed) (Lave & Wenger, 1991; Wake, 2014).

- Each context contains the basic components of competence learning, such as knowledge or body of information, skills or applying knowledge, and psychosocial elements or those elements beyond knowledge (beliefs, attitudes, values, motivations, etc.), upon which digital literacy or technology advancements are put into practice or competence learning is based upon.

Based on the generalized competence learning concept presented previously, and in order to substantiate the newly proposed unifying CoL framework, the examination of three important CoL aspects is required, because they practically represent the base upon which it is built: the SoL principal dimensions' paradigm shifts); the mechanisms that lead to the development of a specific level of competence learning; and the educational (learning) environment on which they operate.

3. Competence of Learning Principal Dimensions' Paradigm Shifts

The importance of the constant changes in all the principal factors affecting the cost of living (CoL) has been practically ignored as a unifying force in determining it. Therefore, there is a need for the most important aspects to be examined, representing a major contribution of this paper.

3.1. Societal and Technological Shifts

The state of the principal elements of CoL, at any given moment, is the result of the interaction of two important conditions: the interrelated paradigm shifts in society and technology. A fundamental principle in the epistemology of CoL is that the way we achieve it is determined by the societal conditions that prevail at any given time, which are affected by and affect the advancements of technology that, in turn, determine how we achieve CoL.

These paradigm shifts, a term introduced by epistemologist Kuhn (1962), which he did not consider unusual events in education, demarcate the framework within which competence learning is achieved. The major shifts in these fundamental CoL concepts are examined next:

- Society: The way CoL is achieved has evolved considerably. More specifically, society for many years, until very recently, had ignored education, focusing on enhancing living conditions. That is, competence learning in schools was not a concern in education. Later on, society accepted that education should cover needed competences that require basic human dexterities to support regional and economic development and, in general, improve citizens' living conditions. As a result, education and consequently CoL took their place at the center of societal concerns and activities. Nowadays, society's response to education has further shifted into a holistic approach, which accepts that teaching and learning should be in dialectical harmony with all the factors of education. As a result, CoL has to be treated as a holistic concept, which represents the fulfillment of society's needs and thus has to serve all of them, with the constraint that those learners have to choose from the broad area of study and the context(s) they like or fit(s) them.
- Technology: Technology has also experienced the following educational paradigm changes affecting teaching and learning in general (Dhar, 2024; Koutsopoulos & Kotsanis, 2023) and CoL in particular: first, the appearance and use of Personal Computers, which have enhanced learners' ability to integrate and apply the contextually appropriate combinations of the needed CoL determining elements; second, the Internet and Cloud Computing, which provide CoL capabilities to learners to communicate, create, disseminate, store, and manage information that enables them to choose the context to develop their chosen competence(s); third, Mobile and Ubiquitous Learning (Tablets, Smartphones, Mobile apps for learning), which, by becoming successful CoL tools, have helped learners to consistently develop their competence(s) anytime with any device in any area of study and context; and fourth, Artificial Intelligence and Adaptive Learning, the latest form of technology tools, which not only has transformed the way we live and work, but from the perspective of this paper has altered all the previous approaches in developing and achieving CoL.

Given the paradigm shifts in society and technology, CoL cannot be addressed in the traditional way. That is, in considering CoL, we cannot only rely on what learners, in order to develop competencies, have been taught, or on how they have been taught, but mainly consider CoL as an approach to achieve them as an evolving concept determined by societal needs and the necessary technological tools, which nowadays are basically the determining factors.

Moreover, CoL is not only a structured system that defines literacy or competencies, but rather an ontological framework in which CoL represents the integrated dimensions of holistic educational processes.

3.2. Digital Literacy: Paradigm Shifts

Given that literacy to support learning is the result of the interrelated shifts of society and technology that in turn affect CoL, its importance is not only paramount, but precedes the shifts of the other major CoL elements (knowledge, skills, and psychosocial) that will be examined in the next sections.

A report by UNESCO (2018) has a section titled "literacy: an evolving concept."

Indeed, the concept of literacy has gone through several minor or major changes from being predominantly the skills of reading, writing, and arithmetic (the so-called three R's) to being considered an exponential advantage in technology. That is, nowadays we are in the era of digital literacy, which is based on technology at an increasing rate from pre-school to universities.

As a result, CoL literacy, in the form of digital literacy, can be considered the ability to utilize, understand, manage, and analyze technology in a safe, responsible, and mainly effective and efficient way. In other words, CoL incorporates the use of technology to receive, evaluate, formulate, and integrate information utilizing different digital platforms. However, this aspect of literacy involves: first, "a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential to participate fully in their community and wider society." UNESCO (2018) and second, it enhances the CoL process through problem-solving, critical thinking, and carrying out tasks or developing competencies.

In summary, digital literacy: first, is practically a prerequisite for any learner nowadays, and the context elements of CoL must be considered as impacted by it; and second, is a proficient way of using different technology tools as they continue to evolve (personal computers, the internet, mobile devices, and lately artificial intelligence) (Terra, 2024) in order to keep up with the shifts in technology paradigms.

3.3. Knowledge: Paradigm Shifts

At the onset, it should be mentioned that knowledge plays a central role in building learners' CoL as well as helping them think critically and creatively in order to solve problems with increasing independence. That is, knowledge supports learners in becoming confident and creative individuals, independent lifelong learners, and informed members of the workforce and the community. This is clearly stated in the Merriam-Webster Dictionary, which defines knowledge as involving understanding, comprehending, mastering, acquiring, and applying information to achieve a task. In addition, knowledge is directly connected to learning because both represent the two sides of the same coin. This is also clear in the same dictionary, which considers learning as the process of studying curriculum subjects, and we may add in developing CoL that it is centered on the delivery of knowledge. Finally, knowledge is closely related to memory, which is the storage of information in the brain, and thus how learners access and retrieve the stored knowledge when they need it also determines CoL.

However, a closer examination of these knowledge characteristics shows that a key consideration is missing. A worker's success doesn't result only from what he has learned by retrieving and utilizing knowledge, but mainly from the efficiency and effectiveness of his work (e.g., the quality of the products, customer satisfaction, or even the safety of his workplace). That is, a learner needs to have the "right" knowledge or that CoL is not the means of acquiring and constructing knowledge, but has to be efficient and effective in satisfying societal needs.

Given the evolution of society and societal needs, the 'right' knowledge has, by necessity, gone through corresponding changes. More specifically, the acquisition of knowledge to develop CoL shows the following evolution:

- Factual knowledge: For many years, students simply learned academic subjects and social issues, both inside and outside the classroom. As a result, their CoL was mainly focused on curriculum subjects, partly on behaviors outside the classroom (e.g., learning which behaviors are likely to be rewarded and which are likely to be punished) and limited social skills (e.g., interacting with other children). Digital literacy was absent.
- Explicit knowledge: In the last few years and even up to the present time, teaching has been utilized to provide knowledge by delivering instructions that are well-sequenced and explicit. Thus, CoL represents students' ability to develop critical and creative thinking skills by drawing on explicit and well-designed knowledge they have acquired. Digital literacy is simply participating in the process.
- Contextual knowledge: Recently, a new approach to CoL has been put into use, although it has been known for many years. The contextual knowledge represents an efficient combination of all the CoL determining elements, based on the principle that Tutwiler (2019) defined as "the framing of ideas and mental models" in constructing context(s) and broad study area (domain)-specific information. In this process, digital literacy plays a pivotal role.

3.4. Skills: Paradigm Shifts

Knowledge is the initiator and the means for students to perform tasks requiring skills (Willingham, 2021). That is, skills are distinct from knowledge and more specifically represent the *application* of acquired knowledge (Anderson & Krathwohl, 2001). These considerations inevitably lead to the acceptance that CoL based on skills has also undergone changes, presented briefly next.

- Traditional Skills: Traditional taught skills allowed societies to run for centuries and thus exemplify the way people have been living. As a result, skills were constrained into developing dexterities necessary to face life in order to survive, where limited knowledge and some psycho-social factors (usually unfounded and misleading) were involved.

- Critical or Creative Skills: The traditional skills have been replaced because societal values and technological advancements have provided the convenience to replace the traditional time-consuming skills (time, a precious human commodity, was given back to them) and forced them to acquire skills that matter to present-day living issues such as raising a family, entertaining ourselves, and addressing complicated health problems, etc. That is, these skills are the outcome of CoL focusing on content knowledge, which enhances learners' ability to develop critical and creative thinking skills. As a result, it is based on the broad study area-specific or domain-specific knowledge they have acquired and the help of digital literacy.
- Holistic Skills: Teaching programs focusing on the present critical or creative thinking skills are not effective or efficient for two reasons: first, such an approach focusing on developing such a dexterity coincides with what learners already naturally possess; second, such an approach develops domain-specific skills that are not transferable to other contexts or learning areas. Therefore, a different holistic approach where knowledge, psycho-social factors, and digital literacy are fully participating to meet today's needed skills.

3.5. Psychosocial Elements: Paradigm Shifts

According to the Oxford (2012) psychosocial elements are "pertaining to the influence of social factors on an individual's mind or behavior" and include the following two groups:

- The psychological elements such as core beliefs, relationships, emotions, attributes, anxieties, self-perceptions, and so on, which impact our actions and reactions;
- The social elements such as school or occupational stress, social support or isolation, social situations, emotions, and attributes, etc. (Vizzotto, de Oliveira, Elkis, Cordeiro, & Buchain, 2013).

According to the BESSI framework (Napolitano, Sewell, Yoon, Soto, & Roberts, 2021) the hundred taxonomies for Social, Emotional, and Behavioral (SEB) skills are categorized into five domains of SEB skills: Social Engagement, Cooperation, Self-Management, Emotional Resilience, and Innovation Skills.

From a CoL point of view, they can be defined as the mediation of the effects of these elements on individuals' CoL within specific contexts of the domain in which learners work. Given that society has been evolving, all of the CoL elements have also been changing, resulting in a paradigm shift in the role of the psychosocial factors on CoL.

4. Competence of Learning Mechanisms

It is suggested that there are two important mechanisms for students to achieve and for teachers to teach CoL, because their understanding helps them improve this important task.

4.1. The Formation of Competence 1.0 to 4.0

The mechanism of students' learning to be competent is based on the appropriate use of three concepts: the broad study area or domain (a term used by most researchers), context, and context dimensions. More specifically, students learn to be competent (or to develop competence) in a specified broad study area and/or activity of the curriculum.

The study area may refer to an academic or curriculum subject (e.g., mathematics) or an area such as problem-solving and/or collaboration and how broad they are (e.g., mathematics vs. calculus). But mainly, CoL cannot be observed outside the broad study area or domain (Hager & Gonczi, 1996).

Moreover, CoL is operating in particular times and places, and under particular social and technological conditions. Therefore, the fundamental role of the broad study area and the context is that they emphasize the role of all the competence-determining elements, which in turn require their contextual combination. This substantiates that CoL is not merely an attribute of the individual, but the interaction between all the determining elements. As a result, competent students are the ones who: first, can integrate and apply the contextually appropriate combinations of the CoL determining elements; and second, can compare and choose the context that will permit them to change their CoL level from "what he knows" to "what he can do".

But most importantly, all elements participating in the development of CoL, as they were changing, have created a continuum from Competence 1.0 through Competence 4.0. It should be noted, however, that this continuum, although in general follows the well-known shifts of education (Education 1.0 to 4.0), at the same time differs significantly from it. More specifically, the education continuum is based only on technological improvements and changing teaching approaches, while the competence continuum is the result of the set of shifts described earlier, and is briefly examined next, representing one of the two fundamental contributions of this paper.

Competence 1.0 - Seat Time System: This term describes the present educational system, which is characterized by: first, the prevailing assumption that the longer students are exposed to specific curriculum areas (domains) and contexts, the more they will develop their competencies or the time spent in school (ExcelinEd.org, 2019) is the determining factor; and second, it involves the traditional tools in use since the inception of formal learning. This paradigm is characterized by the following:

- Society/Teaching: Competence was focused on basic skills and knowledge acquisition; it emphasized memorization and simply measured factual knowledge, thus often being defined in narrow, subject-specific terms.
- Technology: The basic technological tools and programming languages were the first programming languages, and the centralized systems were focused on mainframe computers.
- Digital literacy: Practically non-existent
- Education 1.0: It follows education 1.0 in that competencies were focused on the teacher-centered passive learning, while they were simply skills to be acquired.

Competence 2.0 - PC/Internet: In this period, students demonstrated creative thinking approaches, developed innovative products, and the CoL fully utilized the three-element approach (construct knowledge, use the basic technology tools, and face some psychosocial issues). This paradigm is characterized by the following:

- Society/Teaching: The conditions of this period provided a broader set of skills, including problem-solving and critical thinking, and at the same time increased the emphasis on applying knowledge in different contexts, while assessments could include some application-based tasks.
- Technology: The basic tools were the internet and personal computers both in and outside the classroom. In addition, desktop platform software and client-server architecture were utilized by students.
- Digital literacy: At this time, digital technology in the form of digital literacy is slowly emerging as a supporting instrument in CoL, becoming a key component in competence development.
- Comparison with Education 2.0: As in Education 2.0, competence reflects the integration of technology and more interactive learning. However, in contrast, competencies begin to encompass higher-order development approaches.

Competence 3.0 - Cloud Computing/Mobility: In this period, students can develop competencies leading to critical thinking, planning and conducting research, managing projects, solving problems, and making informed decisions using responsive and interactive tools. That is, "the implementation and use of interactive technology tools introduce new habits and roles in didactic practice" (Chronaki, 2000) advancing competence abilities.

- Society/Teaching: Students focus on new tasks such as collaboration, communication, creativity, and critical thinking. As a result, competencies are becoming interdisciplinary and to some extent holistic by emphasizing self-directed learning, personal development, and assessments that are project-based and portfolio-based approaches.
- Technology: Technology is ever-present and a determining factor, leading the CoL to be based on cloud computing, mobile computing, etc.
- Digital literacy: Digital technology is becoming a supportive instrument in CoL, demonstrating the important role of digital literacy in CoL.
- Comparison with Education 3.0: Given that competencies are seen as dynamic and evolving, this aligns with personalized learning and student-centered approaches. Competence 3.0, in general terms, follows Education 3.0.

Competence 4.0 - Artificial Intelligence: Competences' utilization participates in the AI era, and students can gather, evaluate, and use information in order to develop them by applying this groundbreaking technology. As a result, CoL is based on apps that are more context-aware, adaptive, and intuitive, which anticipate the requirements and actions of students.

- Society/Teaching: Competence use: 21st-century skills; new and advanced knowledge; and facing many psychosocial issues. As a result, competencies are more holistic and interdisciplinary and emphasize self-directed learning and personal development. In this way, assessment includes project-based and portfolio-based approaches that improve student experiences and firmly establish the necessity for digital learning in CoL.
- Technology: Competencies exhibit a continuing effort for full integration of digital technologies, primarily AI.
- Digital literacy: Competencies that emphasize data literacy and primarily digital literacy can focus on analyzing and interpreting data and information when dealing with complex problem-solving and innovation.
- Comparison with Education 4.0: Both paradigms reflect AI-driven and personalized learning (WEF, 2024). However, competencies based on a specialized changing mechanism (i.e., fluctuations and feedback) are constantly refined and updated.

In sum, the proposed competence continuum clearly shows that the development of competencies is an ongoing process, influenced by a set of individuals', societal, and other changes. But most importantly, it is essential to recognize that competencies are not the outcome of just any single factor (i.e., skills or technology). The integrated mechanism showing the full development of CoL is shown in Figure 1.

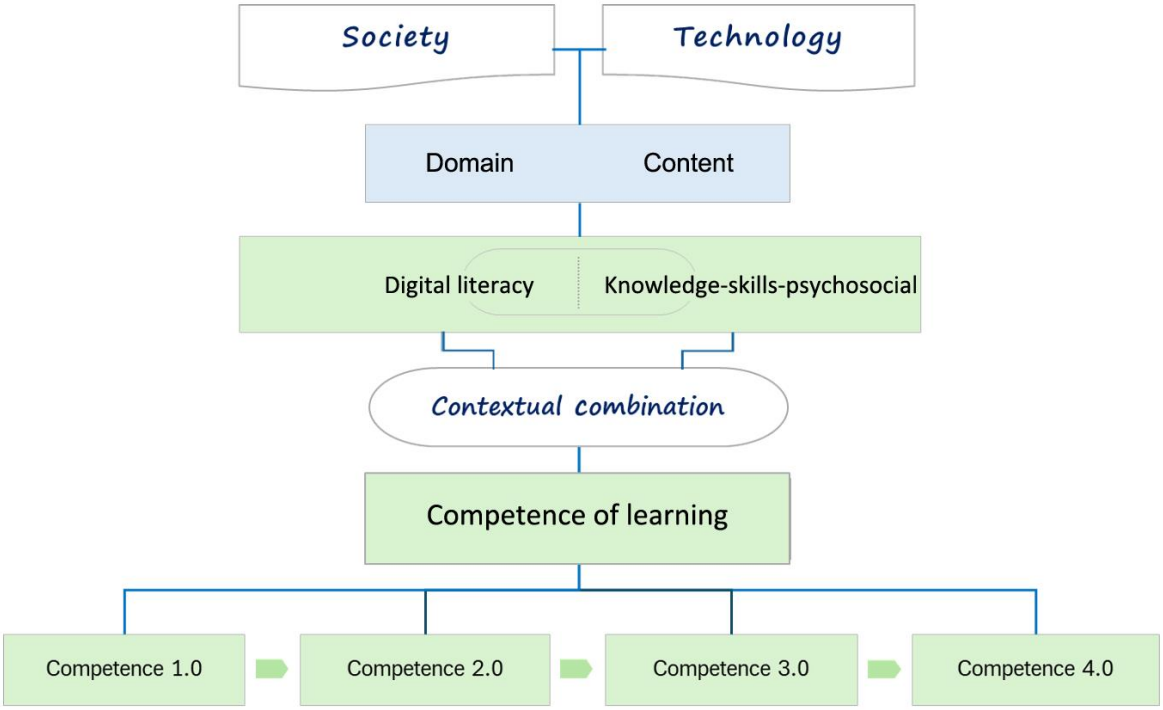

Figure 1. Integrated CoL mechanism.

4.2. CoL Shift Mechanism

In order to understand the previous CoL mechanism, whose principal characteristic is the paradigm shifting of all its components it is suggested that there is a CoL changing mechanism (adopted from Koutsopoulos and Kotsanis (2023)) that is based on: first, multiple changes of CoL considerations due to changes in educational triggers (e.g., educational tools and approaches), which include major technology shifts in the form of digital literacy; second, a non-linearity or disproportionality between cause (paradigm CoL shift) and effect (e.g., the impact of CoL tools and approaches), especially the digital tools; third, fluctuations that express the appearance of competing effects that any CoL change initiates (e.g., the resistance of stakeholders in accepting the changes in CoL associated with digital tools); fourth, feedback that is related to system-internal drivers, which bring changes in the CoL development by creating new CoL stabilizers (e.g., the increasing number of teachers' digital literacy); and fifth, the use of CoL tools and approaches, which appear in shorter time intervals and with greater influence than previous ones, and are becoming easier and less time-consuming (Figure 2).

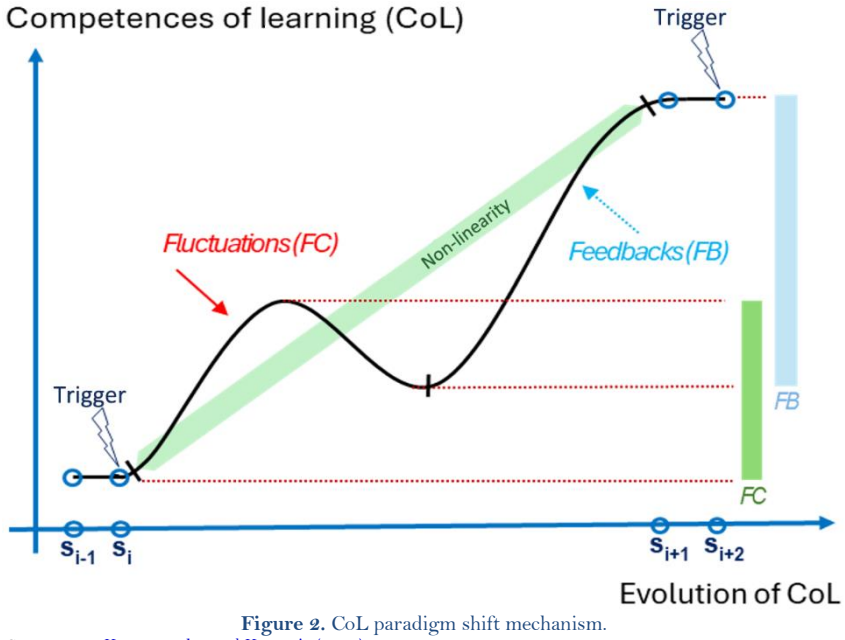

Figure 2. CoL paradigm shift mechanism.
Source: Koutsopoulos and Kotsanis (2023).

5. Educational Operating Environment and Competence Learning

The educational operating environment for the development of CoL should enable learners to reflect on their own future activities by considering the social, cultural, economic, technological, etc., future impacts on their lives. As a result, CoL is an integral part of quality education. That is, all educational institutions ranging from preschool to universities should be responsible for fostering the development of societally needed competencies. In essence, the development of these competencies is a fundamental contribution of CoL to achieve a sustainable society by equipping learners to engage as informed and competent citizens in promoting an economic, technological, cultural, etc. viable society. Therefore, CoL operates in an environment characterized by action-oriented and transformative pedagogy, having as major elements: self-directed learning, participation, collaboration, problem orientation, and inter- and intra-disciplinarity.

But in order to understand this multi-dimensional operating environment of CoL, the mechanism that creates it should be presented. It is suggested that CoL, based on the fundamental factors in shaping competencies, has to accomplish at least the following three major goals:

- A mechanism for receiving data that is provided by individual disciplines and which enhances learners' competence.
- Searching for information by creating literacies out of related disciplines (i.e., for students to be familiar with phenomena and processes in chemistry, it is necessary to also be familiar with certain principles of physics).
- Formulate knowledge by instituting knowledge, which has to include in addition to knowledge all the other competence elements (skills, physio-social factors as determined by digital literacy).

A similar approach has been proposed by various (e.g., (OECD, 2017, 2024; UNESCO, 2024a, 2024b)). All these goals and the tasks they can accomplish create a large set of competencies, clearly showing that the operating environment of CoL has many categories, and each of them is multi-tasked.

It is universally accepted that the Revised Bloom's Taxonomy is the foundation of modern education (Anderson & Krathwohl, 2001). As Ruhl (2024) has written, "learning objectives we (as education stakeholders) are exposed to daily are a product of Bloom's Taxonomy." As a result, there is no doubt that both this paper's proposed integrated approach for competence learning and other similar frameworks (e.g., OECD, UNESCO) are based on Bloom's Taxonomy, which is a framework for categorizing educational goals including CoL. This not only substantiates our suggested mechanism but also reveals the need to establish a new comprehensive and integrated approach for competence development.

Indeed, Bloom's Taxonomy, since its inception in the '50s, has established some universally accepted principles that lead us in this direction. The most important of these are:

- Students' achievements, inside and outside the school environment, are affected by factors such as societal conditions and technological tools that directly determine how children learn and teachers teach competencies. As a result, the Revised Bloom's Taxonomy indeed helps them to understand the process of learning, but mainly provides them with clear and applicable guidance on how to create effective and efficient learning objectives, which, however, cannot be accomplished without considering societal needs and the use of technological tools.
- categorizes learning objectives, which certainly include CoL, into three components: cognitive (knowledge-based), affective (emotion-based), and psychomotor (action-based), each one divided into a set of levels representing different knowledge, skills, and social attributes, which are now determined by digital literacies. That is, this categorization of Bloom's taxonomy clearly substantiates the need to include digital literacy as a CoL objective, because all three categories not only affect Bloom's taxonomy learning goals, but also depend on societal needs.
- The constant changes of all the principal factors affecting the cost of living (CoL) are also fundamental in completing the CoL creation mechanism, because these changes not only lead to the development of a specific level of competence in learning, but are part of the intersection between Bloom's goals and societal needs.

In summary, the Revised Taxonomies of Learning objectives and outcomes are the main contributors to CoL, including an integrated mechanism for considering the societal needs; the latest state of the constantly changing elements affecting CoL; and learners' ability to manipulate the new learning tools (digital literacy), which are necessary in CoL.

6. An Open, Global, Integrated, Comprehensive Framework

6.1. The CoL Framework

In the literature, three interrelated questions are abundant that relate to the future of preparing students for CoL. More specifically, can students learn competencies: first, for jobs that do not exist? Second, for resolving issues and societal needs that cannot be determined? And third, for the use of technologies that are unknown and, of course, unavailable? In other words, how can students be equipped to understand and appreciate different perspectives and take meaningful actions toward resolving social issues and enhancing individual and collective well-being? To face these questions, it is suggested that CoL is not only about teaching students something; it

is more important to develop a reliable compass, a navigation instrument, or a framework to enable them to develop their competencies in an environment that is complex, constantly changing, and uncertain (Koutouki & Vassiliou, 2024; OECD, 2018; UNESCO, 2018, 2024a, 2024b).

The framework proposed is a three-dimensional CoL visualization, which answers the basic concerns of competence learning and has the following axes: the Domain/Content axis that expresses individuals' needs and enhancement in targeted subject areas and diverse academic contexts; the Competence axis that expresses the ability to do something by learning or developing, integrating knowledge, skills, and psychosocial factors; the Integrated Scaffolding axis that is focused on supporting learners, enabling them to progress to enhanced levels within their Zone of Proximal Development. More specifically:

AXIS 1. Domain/Content: Competences are associated with specific domains related to certain contents, in that a learner becomes competent by being able to perform in different contexts within a specific domain (e.g., map of domains and subdomains for AI education, UNESCO (2022)). More specifically:

- The domain expresses the broad area of study, the set of ideas or activities that a competence focuses on. For example, it can refer to a set of skills or an academic discipline.
- Context refers to the tasks, conditions, and the educational environment in which the competencies are utilized. In essence, it determines the conditions for competencies to be applied.

Given that society requires citizens to take meaningful actions toward resolving social issues and enhancing individual and collective well-being, both of these concepts express the means to achieve their needs, which range from simple to complex. The elements of this axis (curriculum, syllabus, field, subjects, topics, sectors, aspects, etc.) answer the educational question of WHAT. From another perspective, it is usually the axis related to data that is 'timeless' (not linked to a specific time), 'spaceless' (not associated with space or place), and 'impersonal' (not connected to individuals, groups, or communities). Moreover, the elements may encompass purposes, goals, objectives, and expected results, but they are intangible data.

AXIS 2. Competence: A learner's competence expresses his ability to do something by learning or developing a dexterity well, both inside and outside the classroom. It is determined by the combination of three elements: knowledge, skills, and psycho-social factors, empowered by digital literacies. For example, a student can develop competence in creating knowledge as well as in handling digital tools. Examples of the three selected elements are:

- *Knowledge*: the 6 standard cognitive competences (Anderson & Krathwohl, 2001; Knoth et al., 2024) from the Revised Bloom's Taxonomy and DigComp (remembering, understanding, applying, analysing, evaluating, creating),
- *Skills*: The 6 standard competences (communicating, collaborating, critical thinking, problem solving, data processing, safety and security) from DigComp 2.2, P21 and OECD (European Commission, 2022; OECD, 2018; P21, 2009).
- *Psychosocial competences:* the 5 core SEL competencies (Gimbert, Miller, Herman, Breedlove, & Molina, 2023) of the Collaborative for Academic, Social, and Emotional Learning's framework (self-awareness, self-management, social awareness, relationship skills, responsible decision-making), and the 3 Digital Emotions and Future-Readiness Skills (emotional regulation, adaptability, resilience) of the DQ Framework (DQ Institute, 2023).

All the elements of this axis are answering the educational question of HOW.

AXIS 3. Integrated Scaffolding: A major component of this axis is the notion of scaffolding (Sun, Chou, Yang, & Yang, 2024), which emphasizes the importance of providing structured support to learners in facing new concepts and allowing them to achieve a higher or appropriate level of understanding and competence within the Zone of Proximal Development (ZPD). However, in this axis, a series of other elements should be included as having the same role, creating an integrated scaffolding axis. Examples of such elements are:

- Cognitive development (scaffolding mental processes involved in learning)
- Age differences (varying capacities for learning within the nature of appropriate domains)
- Time for learning activities (allocating appropriate time for tasks)
- Learning environment and space (highlighting the role of physical and social surroundings)
- Cultural differences (shaping learning processes in diverse cultural backgrounds)
- Social interaction – stresses the importance of collaboration and communication in extending a learner's Zone of Proximal Development (ZPD) through guided assistance

The elements of this axis are answering the rest of the principal 5W1H educational questions of WHY, WHO, WHEN, and WHERE.

These axes and the major elements associated with them are shown in Figure 3.

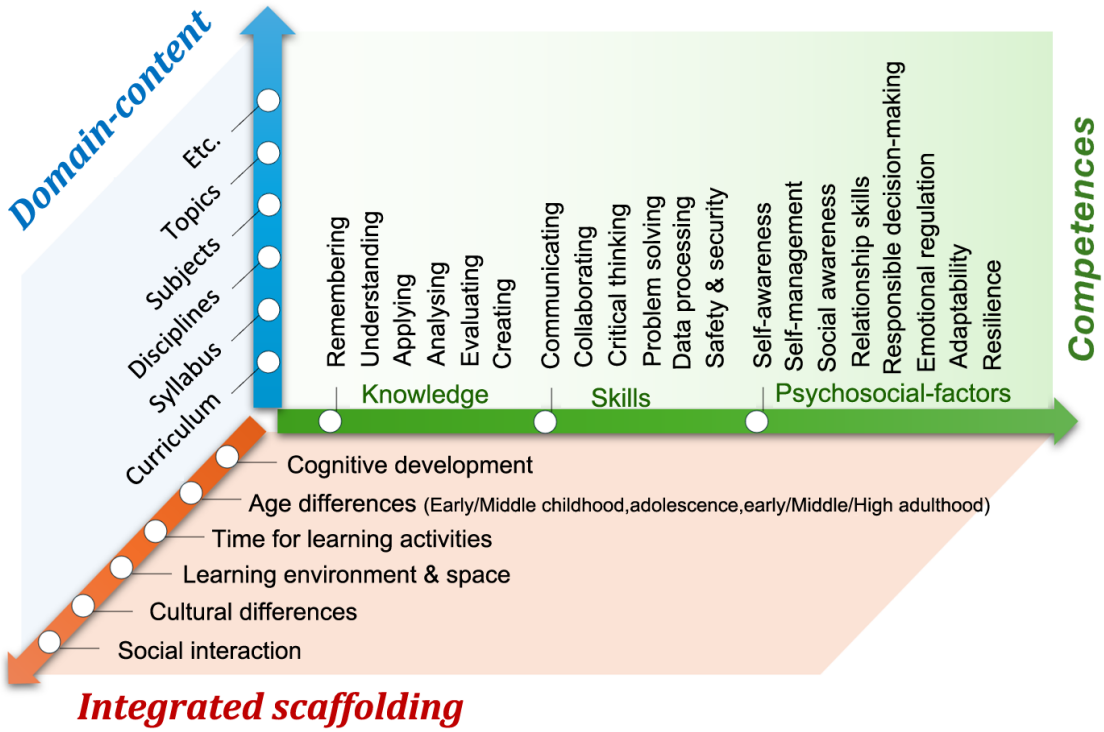

Figure 3. The 3-dimensional framework for competence of learning.

The proposed framework has three dimensions, each of which includes a number of basic elements that, in turn, have specific characteristics and should be treated as such. More specifically, all the points whose coordinates in the three axes are optimal or ideal create a sphere. For example, the optimal position in the 3D visualization of a learner with a specific cultural background has the competencies that his culture can accept and can utilize only to resolve societal problems pertinent to his culture, representing an ideal situation. On the other hand, in real life, absolute coordination between elements and their characteristics of Domains/Contexts, Integrated Scaffolding, and Competence does not exist; rather, there is a disharmony between them, which removes learners' coordinates away from the sphere, creating an amoeba figure to represent the proposed framework (Figure 4).

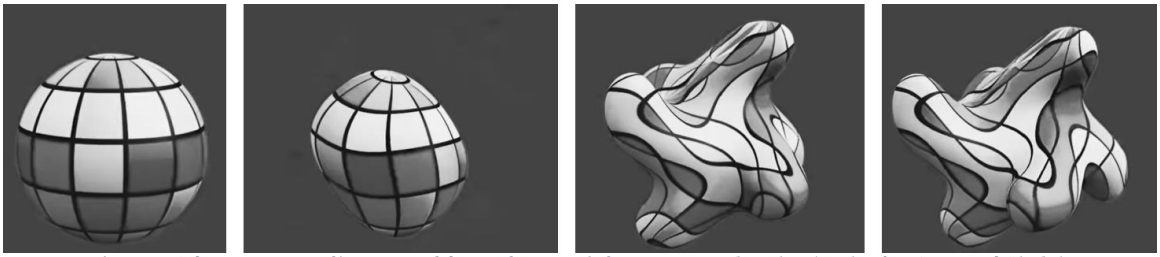

Figure 4. Scheme-concept of instances of the 3D framework for competence learning (Design by 'OpenMathCircle').

This framework has been implicitly or explicitly accepted for many years, as demonstrated by Andreas Schleicher, who wrote: *"Our imagination, awareness, knowledge, skills (expressing Competence), and, most importantly, our common values, intellectual and moral maturity, and sense of responsibility (expressing Integrated Scaffolding) are what will guide us in making the world a better place (expressing Domain/Context)."* However, as far as we know, no such 3D Framework has been formally proposed or implemented (presentation of the OECD Learning Compass 2030) OECD (2018)).

Indeed, the literature has provided several competence frameworks, usually emphasizing two of the three proposed dimensions. For example, many focus on competence achievements combined with various characteristics of content, which are related to similar aspects of learning and align with the proposed axes of domain/content (curriculum, subjects, disciplines, etc.). The key difference and major contribution of the proposed framework is the third axis of *Integrated Scaffolding*, which considers socio-cultural differences as well as the time-space learning interrelationship of diverse social groups with different Zones of Proximal Development (Chaiklin, 2003).

It should be evident that the proposed framework, based on a 3D visualization, differs significantly from previous competence frameworks in three key ways. First, it introduces an additional dimension. Second, this

addition, by addressing all learning questions, allows the framework to be used at any time, in any place, by anyone, for anything, and for any societal issue, answering the four main questions: WHY, WHO, WHERE, and WHEN. Third, every dimension has many elements, and each of them has many characteristics, resulting in an extremely large number of combinations providing the ability to express any competence development situation.

6.2. Visualisation

Based on the review of the literature (European Commission, 2016; OECD, 2017, 2018; P21, 2009; UNESCO, 2018, 2022) and our experience, the CoL framework helps us construct specific competence development pictures focusing on their elements (recognizing and indicating that CoL has many expressions and visualizations), namely: learning subjects and curricula in the dimension of Domain/Context axis; cognitive development based on age differentiation in the Integrated Scaffolding axis; and knowledge, skills, psycho-social factors, empowered by digital literacies in the Competence axis.

To clarify the proposed unifying, open and global CoL framework, Figure 5 provides a simplified 3D visualisation of a recent UNESCO's "AI Competency Framework for Students and Teachers" (UNESCO, 2024a, 2024b). The figure illustrates the "high-level" relationships between the three dimensions of the CoL, recognizing its varied forms.

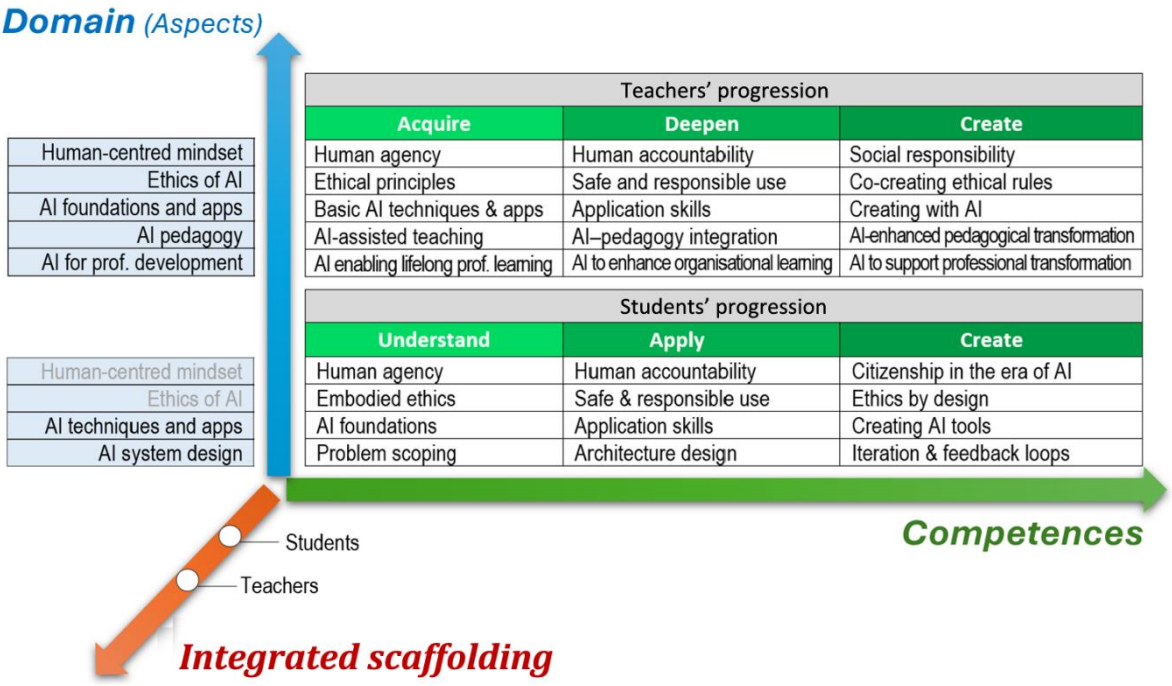

Figure 5. Visualisation of the CoL for the AI competency framework for students and teachers.
Source: UNESCO (2024a) and UNESCO (2024b).

6.3. Example

Given that every dimension has many elements and each of them has many characteristics, resulting in an extremely large number of combinations, an example is provided that is easy to understand and follow. It focuses on the characteristics of one of the basic elements for each of the three dimensions of the proposed framework (Scaffolding, Domain/Context, and Competence, in that order) as follows:

- Information and Data Literacy: For each of the several age intervals (e.g., primary school) and for any of the many specific learning subjects (e.g., language), learners exhibit a well-defined competence related to their ability to fulfill their information and data needs in terms of: first, locating and retrieving data and information; second, evaluating their content and their sources; and third, storing, managing, and organizing them.
- Cultural Differentiation/Curriculum/Communication and Collaboration: for each of the several cultural differentiations (e.g., Native Americans) and for any of the many specific curricula (e.g., Greek Schools), learners exhibit a well-defined competence in learning related to their ability, through digital technologies, to: first, interact, communicate, and collaborate; second, participate in society by enlarging citizenship; and third, integrate new information and content to create new and relevant knowledge.
- Social Differentiation/Disciplines/Digital Content Creation: For every one of the several social differentiations (e.g., low income) and for any of the many specific disciplines (e.g., Mathematics), learners exhibit a well-defined competence related to their ability, utilizing digital technologies, to: first, create

digital content to express a learner's digital learning dexterities; second, integrate information and content into an existing set of knowledge; and third, develop a set of instructions addressed to a computing system to solve problems or to perform tasks.

- Scaffolding/Topics/Safety: For each of the several learning scaffolding approaches (e.g., emphasis on learners' independence to consolidate a particular skill) and for any of the many topics of interest to learners (e.g., teaching dexterity), learners exhibit a well-defined competence related to their ability to: first, understand digital risks and threats in order to create a safe environment, protect any device, and primarily the digital content; second, comprehend and apply impact-free digital tools; and third, avoid or minimize any risks and threats, both physical and psychological, to the digital environment they operate in.
- Problem Solving: For every integrated learning approach to space-time (e.g., space and time as the integrated dimensions of the learning processes) and for any of the many syllabi differentiated between schools, regions, and countries (e.g., the Greek schools) exhibit a well-defined competence related to their ability to solve problems by: first, addressing technical problems using digital literacy to solve them; second, assessing needs and identifying, evaluating, selecting, and using digital literacy in order to solve them; third, using digital literacy to understand and resolve conceptual problems and problem situations related to the space-time issue; and fourth**,** understanding the digital competence needs requiring improvement or updating.

In summary, it should be clear that: first, the examples provided represent a few points in a 3-D sphere of competence learning (ideal condition); and second, the ISTE standards can provide the characteristics of the third axis of the proposed framework for competence learning.

7. Conclusions

This paper presents a fundamental change in the way CoL should be considered and applied. More specifically, it suggests that CoL and its main elements (knowledge, skills, and psychosocial factors) are based on or require the appropriate literacies, which nowadays rely on the technology, in the form of digital literacy. That is, CoL should be considered as being determined by the study area or domain and its context(s), but is based on digital literacy(ies). The development of such a CoL approach is the result of the constant evolution of all competence aspects (the state of its principal dimensions; the mechanisms that lead to the development of a competence; and the educational framework it operates on).

The paper also presents an open and unified interpretation of competence to support its learning, which can be applied to a diverse range of educational domains and contexts, at any time, in any place, by anyone, for anything, and for any societal issue of learning. This approach to CoL is critical for ensuring that the learning processes aimed at developing CoL meet the needs of not only the individual students and learners but also of society as a whole, as well as of the labor market, locally, nationally, and internationally, in a diminishing order (Baartman & De Bruijn, 2011). Moreover, it is strongly suggested that the changed way competences are considered and applied forces the education system to take advantage of the evolving technological improvements because they enhance the capability of that system to support learners in developing competence learning. In addition, it is suggested that because all elements participating in the development of CoL have been changing, CoL has gone through four major paradigm shifts, and now we are in the Competence 4.0 or the era of Education 4.0 and AI.

Moreover, the paper suggests an integrated mechanism for educational competencies representing a fundamental and determining process in dealing with CoL, which includes Revised Taxonomies, its basic component, but in combination with the latest state of the constantly changing elements affecting competence learning, through digital literacy, which is necessary.

Finally, a CoL framework is presented, expressed as a three-dimensional competence Learning Ecosystem having three axes (Domain/Context, Integrated Scaffolding, and Competence). In that Ecosystem, the ideal coordinates of all points form a sphere, while in real life, an amoeba figure is formed. But most importantly, the proposed framework considerably enriches all previous 2D competence frameworks.

References

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A review of Bloom's taxonomy of educational objectives*. New York: Addison Wesley Longman.

Ashworth, P. D., & Saxton, J. (1990). On 'competence'. *Journal of Further and Higher Education, 14*(2), 3-25.

Baartman, L. K., & De Bruijn, E. (2011). Integrating knowledge, skills and attitudes: Conceptualising learning processes towards vocational competence. *Educational Research Review, 6*(2), 125-134.

Belshaw, D. (2012). *On the important differences between literacies, skills and competencies. Open Thinkering*. Retrieved from https://dougbelshaw.com/blog/2012/07/12

Brandt, D. (2001). *Literacy in American lives*. Cambridge: Cambridge University Press.

Chaiklin, S. (2003). The zone of proximal development in Vygotsky's analysis of learning and instruction. In Kozulin, A., Gindis, B., Ageyev, V. S., Miller, S. M. (Eds.), Vygotsky's Educational Theory in Cultural Context. In (pp. 39-64). Cambridge: Cambridge University Press.

Chronaki, A. (2000). *Computers in classrooms: Learners and teachers in new roles. In B. Moon, M. Ben-Peretz, and S. Brown (eds.) Routledge International Companion to Education.* London: Routledge.
De Florio, I. (2023). In from assessment to feedback: Applications in the second/foreign language classroom. In (pp. iii–iii). Cambridge: Cambridge University Press.
DeSeCo. (2019). *Definition and selection of competencies: Theoretical and conceptual foundations. OECD Report.* Paris: OECD Publishing.
Dhar, V. (2024). The paradigm shifts in artificial intelligence. *Communications of the ACM, 67*(11), 50-59. https://doi.org/10.1145/3664804
DQ Institute. (2023). *DQ framework: Global standards for digital literacy, skills, and digital readiness.* Singapore: DQ Institute.
Dunning, J. H. (2000). *Regions, globalization, and the knowledge economy: Issues stated. In J. H. Dunning (Ed.), Regions, Globalization, and the Knowledge-Based Economy.* Oxford: Oxford University Press.
European Commission. (2016). *European declaration of the right to literacy.* Brussels: European Literacy Policy Network.
European Commission. (2022). *DigComp 2.2: The digital competence framework for citizens.* Luxembourg: Publications Office of the European Union.
ExcelinEd.org. (2019). *Debunking the myth of seat-time, a national analysis of seat-time requirements for credit, ExcelinEd.org.* Retrieved from https://excelined.org/wp-content/uploads/2019/11/ExcelinEd.Innovation.NextGenerationLearning.SeatTimeReport.pdf
Gimbert, B. G., Miller, D., Herman, E., Breedlove, M., & Molina, C. E. (2023). Social emotional learning in schools: The importance of educator competence. *Journal of Research on Leadership Education, 18*(1), 3-39. https://encyclopedia.pub/entry/56461
Hager, P., & Gonczi, A. (1996). What is competence? *Medical Teacher, 18*(1), 15-18.
Knoth, N., Decker, M., Laupichler, M. C., Pinski, M., Buchholtz, N., Bata, K., & Schultz, B. (2024). Developing a holistic AI literacy assessment matrix–Bridging generic, domain-specific, and ethical competencies. *Computers and Education Open, 6*, 100177.
Kotsanis, Y. (2018). Models of competences for the real and digital world. Handbook of Research on Educational Design and Cloud Computing in Modern Classroom Settings, edited by K.C. Koutsopoulos, et al. In (pp. 52-80): IGI Global. https://doi.org/10.4018/978-1-5225-3053-4.ch004.
Koutouki, S., & Vassiliou, A. (2024). *STEAM competence framework for educators. Encyclopedia MDPI.* Retrieved from https://encyclopedia.pub/entry/56461
Koutsopoulos, K. C., & Kotsanis, Y. (2023). Space without time and time without space in education. *Journal of Education, Society and Behavioural Science, 36*(12), 34-47. https://doi.org/10.9734/jesbs/2023/v36i121286
Kozma, R. B. (2008). Comparative analyses of policies for DIGITAL in education. In J. Voogt, G. Knezek (Eds.), International Handbook of Information Technology in Primary and Secondary Education. In (pp. 1083–1096). Berlin: Springer Science.
Kuhn, T. S. (1962). *The structure of scientific revolutions.* Chicago: University of Chicago Press.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.
Napolitano, C. M., Sewell, M. N., Yoon, H. J., Soto, C. J., & Roberts, B. W. (2021). Social, emotional, and behavioral skills: An integrative model of the skills associated with success during adolescence and across the life span. *Frontiers in Education, 6*, 679561. https://doi.org/10.3389/feduc.2021.679561
Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence, 2*, 100041. https://doi.org/10.1016/j.caeai.2021.100041
OECD. (2017). *Global competency for an inclusive world.* Paris: Organization for Economic Cooperation and Development.
OECD. (2018). *The future we want. The future of education and skills education 2030.* Paris: OECD.
OECD. (2024). *Survey of adult skills (PIAAC).* Retrieved from https://www.oecd.org/en/about/programmes/piaac
Oxford. (2012). *Oxford English dictionary.* Oxford: Oxford University Press.
P21. (2009). *P21 framework definitions. Partnership for 21st century skills. Scientific Research Publisher.* Retrieved from http://slacca.pbworks.com/f/Framework+for+21st+Century+Learning+Overview.pdf
Pigozzi, M. J. (2006). A UNESCO view of global citizenship education. *Educational Review, 58*(1), 1-4.
Ruhl, C. (2024). *Bloom's Taxonomy of learning. SimplePsycology.* Retrieved from https://www.simplypsychology.org/. [Accessed 06 October 2024]
Rychen, D. S., & Salganik, L. H. (2001). *Defining and selecting key competencies.* Göttingen: Hogrefe and Huber Publishers.
Stolpe, K., & Hallström, J. (2024). Artificial intelligence literacy for technology education. *Computers and Education Open, 6*, 100159. https://doi.org/10.1016/j.caeo.2024.100159
Sun, D., Chou, K. L., Yang, L., & Yang, Y. (2024). A systematic review of technology-supported scaffoldings in empirical studies from 2017-2022. *Educational Technology & Society, 27*(3), 185-203. https://doi.org/10.30191/ETS.202407_27(3).RP11
Temitayo Sanusi, I., & Chiu, T. K. F. (2024). *AI literacy for all (Special issue), ScienceDirect.* Retrieved from https://www.sciencedirect.com/special-issue/10Q8L40P9HV
Terra. (2024). Digital literacy in the age of technology shifts: Adapting to the evolving paradigm. *Journal of Digital Education, 15*(2), 45-60.
Tutwiler, M. S. (2019). Exploring The relationship between attentional capture and prior knowledge in a science-based multi-user virtual environment: an individual growth model analysis. *Journal of Science Education and Technology, 28*, 299-309.
UNESCO. (2018). *ICT competency framework for teachers. United Nations Educational, Paris 07 SP, France.* Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000265721
UNESCO. (2022). *K-12 AI curricula: A mapping of government-endorsed AI curricula. United Nations Educational, Paris 07 SP, France.* Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000380602
UNESCO. (2023). *Global education monitoring report 2023: Technology in education - A tool on whose terms?* Paris: UNESCO.
UNESCO. (2024a). *AI competency framework for students. United Nations Educational, Paris 07 SP, France.* Retrieved from https://doi.org/10.54675/JKJB9835

UNESCO. (2024b). *AI competency framework for teachers. United Nations Educational, Paris 07 SP, France.* Retrieved from https://doi.org/10.54675/ZJTE2084

Valtin, R. (2016). *European declaration of the right to literacy (Full version). ELINET, European Literacy Policy Network.* Retrieved from https://discovery.ucl.ac.uk/id/eprint/10026205, https://doi.org/10.25656/01:23731

Vitello, S., Greatorex, J., & Shaw, S. (2021). *What is competence? A shared interpretation of competence to support teaching, learning and assessment. Cambridge Report. Cambridge University Press Assessment. Research Division, CB2 8EA UK.* Retrieved from https://www.cambridgeassessment.org.uk/Images/645254-what-is-competence-a-shared-interpretation-of-competence-to-support-teaching-learning-and-assessment.pdf

Vizzotto, A. D. B., de Oliveira, A. M., Elkis, H., Cordeiro, Q., & Buchain, P. C. (2013). *Psychosocial characteristics. In: Gellman, M.D., Turner, J.R. (eds) Encyclopedia of Behavioral Medicine.* New York: Springer.

Wake, G. (2014). Making sense of and with mathematics: The interface between academic mathematics and mathematics in practice. *Educational Studies in Mathematics, 86*(2), 271-290.

WEF. (2024). *Shaping the_future of_learning: The role of AI in education 4.0.* Geneva: World Economic Forum.

Willingham, D. T. (2021). *The role of knowledge in learning: How cognitive science informs education.* San Francisco, CA: Jossey-Bass.