A Competency Definition Based on the Knowledge, Skills, and Human Dispositions Constructs

Teresa Pereira[1(✉)], António Amaral[2], and Isabel Mendes[1]

[1] Centro ALGORITMI, Universidade do Minho, Guimarães, Portugal
tpereira@dsi.uminho.pt, mimp@ua.pt
[2] INESC TEC—Institute for Systems and Computer Engineering, Technology and Science, 4200-465 Porto, Portugal
antonio.m.amaral@inesctec.pt

Abstract. The competency-based learning approach arose from the Bologna signed declaration. However, a competency definition has never been easy and has been evolving and adapted over time, from indicators and learning goals to learning outcomes, which were formulated in terms of competencies. Meanwhile, the competency concept becomes discussed by pears, in particular, associating knowledge, skills, and human dispositions or attitudes into the competency definition. This information will be an essential update to the previous approaches and certainly contribute to achieving more accurate and reliable competencies information for employers and higher education institutions (HEI). This paper aims to reinforce the relevance of these concepts and suggest how each construct of "knowledge, skills and human dispositions" could be approached to formulate a competency. In addition, due to accelerated digital transformation, an example of a digital competency defined by the DigComp 2.0 framework, with proposed information regarding each of the three constructs, will be presented to consolidate this challenge. As future work, it is intended to analyze the eight different levels, and competency profiles defined by the European Qualification Framework (EQF) and assign a profile to each defined competency. In the end, it is expected altogether to contribute to achieving a competency roadmap definition.

Keywords: Competency · Knowledge · Skill · Human disposition or attitudes · Knowledge-based learning · Project-based learning · Competency-based learning · Computing curricula 2020 · Micro-credentials · *DigComp*

1 Introduction

More than 20 years ago, the Bologna Declaration was signed, which created a profound level of reforms to HEI, which besides other aspects, advocates a competency-based learning approach aiming to promote the overall development of students, both in specific and transversal competencies. The summarized vision guidelines rely on redesigning curricular programs and methods to promote learning to know, learning to do, learning to live

T. Pereira et al. (Eds.): IoECon 2022, LNICST 458, pp. 29–38, 2023.
https://doi.org/10.1007/978-3-031-25222-8_3

together, and learning to be, towards enabling students to adapt and successfully address the issues and changes emerging in a complex globalized world [1]. The European Union (EU) national bodies, education authorities, and quality assurance agencies have developed regulations and new program outcomes for accreditation of educational systems based on academic quality standards, such as Framework for Qualifications of the European Higher Education Area [2] as well as the European Qualification Framework for Life-long-learning [3] which are structured in terms of competencies and learning outcomes that graduates should obtain, of an accredited course, as the educational base for practicing their profession. HEI redesigned its curriculums for qualifications approval and accreditation reviews through the definition of several learning goals formulated and aligned with teaching and assessment methodologies. Two decades after this process began, the research community returned to this topic. It restarted the discussion of the competency-based learning concept expanding competency to the constructs of knowledge, skills, and human disposition or attitudes.

The relevance of the last construct, "human disposition or attitudes", is highlighted due to its impact on knowledge and skills performance. The universal acceptance of global diversity and cultural sensitivity, which are essential in all domains, turn the human dispositions or attitudes in conjunction with knowledge and skills the major challenge to comprise a competency definition. This is what employers have been "*crying to the moon*" for several years. This paper aims to highlight the importance of these concepts for the competencies design based on the competency model proposed by the ACM/IEEE Computing Curricula 2020 [13] and thus address the fundamentals of the Bologna restructuring. Furthermore, an approach is proposed to formulate a competency-based competency based on the three constructs: knowledge, skills, and human dispositions. To achieve this goal and due to the novelty of this theme, a literature review was carried out to increase the quality and promote long learning education through the micro-credentials project [4].

The paper is structured as follows: Sect. 2 will be presented an overview of the learning transition to competency-based learning; Sect. 3 presents a proposed example of knowledge, skills, and human dispositions to comprise a digital competency defined by the *DigComp2.0* framework; conclusions and future work are presented in Sect. 4.

2 Overview on Education Paradigm in HEI (Higher Education Institutions)

The COVID-19 context accelerated the technological necessity, challenging new career opportunities and demanding far more from the HEI's capability to adjust or formulate curricula guidelines to quickly respond to those needs. The face-to-face courses and the large number of online educational courses offered worldwide by HEI have contributed to increasing the number of graduates and responding with knowledge workers highly required by the industry and raised by the emergence of Industry 4.0. The MICROBOL project (Micro-credentials linked to the Bologna key commitments) is related to the aims of the new Erasmus + Programme and the European Higher Education Area (EHEA) to promote continuous learning for all learners, regardless of age or experience. The EHEA intends to increase the recognized quality and quantity of micro-credentials offered by

different educational organizations and employers to promote and facilitate continuous learning and competencies acquisition [4]. The primary strategy is to introduce a new mindset, meaning that when a student graduates, he/she gets the degree and starts working but must continuously get micro-credentials to certify new competencies and change the idea that when a degree is achieved, no additional studies are considered necessary to develop their work, job or task.

This approach is strictly related to the individual characters and qualities of each employee. The individual behaviour, attitudes, values, motivation, and self-reflection expected in the workplace or academic activities are the most challenging and complex to teach but assumed by society and expected of every graduate. These individual qualities are the employer's first requirement, followed by technical knowledge. Employers seek employees with unique qualities to be effective in a job, role, function, task, or duty. Actually, the universal acceptance of global diversity and cultural sensitivity, which are essential in all fields, make human dispositions in conjunction with knowledge and skills the significant challenge for attaining a competency definition.

An overview of the learning transition to competency-based learning emphasizing an individual's intellectual, social, or moral tendencies in association with knowledge and skills introduced in the following sub-sections.

2.1 Learning Transition: From Passive to Active Approaches

Historically, the learning process and the knowledge management within HEI have been somehow static, with extremely low-tech inclusion and focused on passive approaches. Professors who were seen as stand-alone actors had been having a capital role in this learning ecosystem, especially by assuming the learning diffusion within the students' community.

In fact, the classical model of student learning fostered a knowledge transfer process in which it is mostly explicit and passively embedded. This factor restricts the learning potential and does not ensure the integral development of individuals' learning process, as it is often excessively theoretical and abstract. Therefore, given the significant variability of learning contexts and different existing combinations of restrictions, the passive approaches demonstrated a low level of effectiveness and, more importantly, showed that they were deeply misaligned with real-world companies' needs and expectations, and requirements.

Notwithstanding, the number of different stakeholders involved in the learning context was commonly scarce or deliberately omitted due to the assumption of not being relevant or needed. This contributed to increasing the gap between the real-world competencies' development and the knowledge gained within the HEI were getting broader, and huger.

A side effect emerged from this asymmetry, and the relationships and realities' perceptions between HEIs and businesses were fragile. An important consequence of this hiatus was the lack of competencies available in the market, which somehow limited the innovation potential and the value creation by the business teams. An excellent example of something that is helping to reduce this difficulty is the University-Industry Collaboration [5], wherein members of academia and industry professionals work collaboratively on a specific problem or challenge and are organized in research and innovation projects.

Therefore, towards potentiating the competency creation, the main scope of the pedagogical agenda of HEI could be the knowledge capture and gaining skills result of the learning achieved. The following topic will address the importance of having proper learning and knowledge creation ecosystem/environment with the involvement of all stakeholders that could positively affect knowledge creation.

2.2 Problem/Project-Based Learning

The transition between the knowledge-based learning paradigm and the appearance of new approaches that could enhance the knowledge and skills creation, especially by applying a context whether the learning environment guarantees active participation of the members involved and details a more specific condition in which they could have the contextual stimulus towards applying their knowledge and evolving their skills [6].

The problem-based learning emerged with enhanced visibility in the last quarter of the XX century by being applied in specific learning contexts for training health professionals [7]. The context-specific problems were extremely helpful in leading to an enduring understanding of the knowledge and skills students will need in a real-world scenario outside the classroom [8]. Despite its relevance, problem-based learning mainly focuses on scenario assessment within a single subject (limited scope) and a shorter time spent on obtaining a valid solution.

Otherwise, in project-based learning, the project team members are deeply involved in the learning process and attain their goals through social interactions and by sharing their knowledge and understanding in a multidiscipline nature [7]. Thus, the context of learning is provided within real-world practices [9], with the expected level of uncertainty and complexity in which human dispositions or attitudes could have a major role in skills development.

The ability to introduce the right type and amount of technology into the learning environment will be essential to attaining 21st-century workforce competencies. The technology domain is vast and could be applied to support meaningful learning namely it could be a key player in the learning process. In this way, the project members can learn by using technology in its multiple possibilities, present or future, not just learning from it [10].

2.3 Competency-Based Learning

The competency definition has recently become of much interest to the research community and discussed the semantic meaning to formulate a competency. The concept of competency has overlapped with the skilled term. In practice, these two concepts are generally assumed with the same meaning and are very difficult to distinguish. The Cambridge dictionary defines competence as “the ability to do something well”. In contrast, a skill is defined as “the ability to do an activity or job well, especially because you have done it many times” [11]. The skills are proficiencies developed through training and experiences. They are associated with practice (hours or days of practice) to master a skill, whereas competency is a much broader concept than skills. Competencies involve skills, knowledge and human abilities that, combined with behaviours demonstrate the

ability to perform a task effectively and successfully. A summary comparison between competencies and skills is presented in Table 1.

Table 1. Competencies versus skills, adapted from [12].

Competencies	Skills
Competencies are a combination of skills, knowledge, and human abilities or dispositions that make an individual successful in a job	Skills are learned or acquired through training knowledge is needed towards completing a specific task
Indicate how a task is performed effectively and successfully	Indicate what talents or abilities an individual needs to complete a specific task

The Computing Curricula 2020 report published, on December 31 of 2020, by ACM and IEEE Computing Society, introduces the competency-based learning approach with three constructs – knowledge, skill, and human disposition- to be included in a competency definition [13]. Accordingly, to the authors of this report, a competency definition should comprise three things an individual must possess to be effective in a job, role, function, or duty within a given context or task, represented as follows:

Competency = Knowledge + Skills + Dispositions.

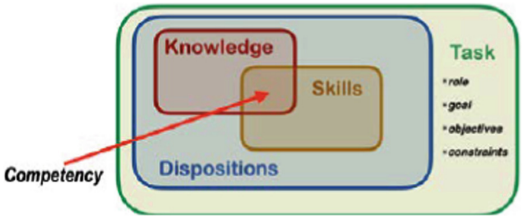

Fig. 1. Conceptual structure of the computing curricula 2020 competency model, source [13]

Knowledge. In a competency definition, the enumerated knowledge should answer the question "know-what", meaning "what is the subject matter a student must know to do a task or perform a role?". In practice, knowledge comprises proficiency in core concepts and content and the application of learning to new and unexpected situations. This construct refers to the list of topics teachers define in the syllabi according to the courses created by departments to offer in their academic program the accreditation agencies, which stipulate the accreditation criteria and employers identify in job descriptions [13].

Skills. A skill expresses a practical dimension of knowledge to define the "know-how" construct. This means identifying the capacities that should be exploited towards enabling students to know how to apply knowledge to accomplish a task actively. This construct is related to the ability to carry out tasks with determined results, requiring time

and practice to develop them. The acquisition of "know-what" trained or experienced by "know-how" combines knowledge and skills constructs [13].

Human Dispositions. Human dispositions are related to the question of "know-why". It is related to intellectual (e.g., School of thought such as Engineering, Social Science, Medical Sciences, et cetera), social (e.g., differences in how people have been brought up/raised, behavioural culture, and social dynamics), and moral or ethical tendencies. The human disposition will be influenced by how people have been raised, e.g., family values, the cultural and social dynamics an individual has been exposed to the ethical and moral standards associated with the character in task performance. The human temperament balances or influences the behaviour of applying "know-what" (knowledge) that becomes "know-how" (skill) [13].

The EQF also introduces these concepts separately. While knowledge is described as theoretical and factual, skills are described as being cognitive and practical. A cognitive skill refers to logical, intuitive, and creative thinking, while practical involves manual agility combined with the help of methods, materials, tools, and instruments. In addition, to knowledge and skill, EQF associates responsibility and autonomy as required elements to enable the learner to apply knowledge [14]. Individual qualities, responsibility, and autonomy are highly relevant and are always needed for any job application. However, there are other equality relevant such as the capacity to adapt, collaboration meaning the ability and motivation to work with others, look beyond simple solutions, a strong commitment to goal-driven, achieve goals, self-motivated, determination, et cetera. Human dispositions are an intrinsic and relevant element in a competency definition. It expresses the institutional and programmatic values expected in the workplace.

The following section presents a practical example to supply evidence of knowledge, skills, and human disposition' proposal to address a competency definition. The competency described is "Protecting personal data and privacy", defined in the European Digital Competencies Framework (DigComp) [15]. The DigComp was selected because since 2013 it has been a European reference for the development and strategic planning of digital competence initiatives [16].

3 Knowledge, Skills, and Human Dispositions to Address the DigComp Competency "Privacy and Personal Data Protection" Defined

The European Commission's Digital Competence Framework 2.0 (DigComp 2.0) identified the key components of digital competence in the five following domains: 1) information and data literacy, 2) communication and collaboration, 3) digital content creation, 4) safety, and 5) problem solving [15]. Furthermore, within each domain, a set of competencies was defined. For each level of competency definition, the DigComp framework 2.0 introduces one single descriptor to describe knowledge, skill, and attitudes jointly. In the scope of the DigComp, the third construct is labelled as "attitudes", while in this paper, it is referred to as "human disposition", which follows the approach defined in the CC2020 report. This paper's major challenge and novelty are clearly on defining knowledge, skills, and human dispositions within one competency definition.

To evidence this challenge, the competency "4.2 Protecting personal data and privacy" was selected, and defined by the DigComp 2.0 framework, as the second digital competency of 4 competencies defined within competence area 4 "Safety".

The DigComp 2.0 framework summarises the "Safety" area as: "*To protect devices, content, personal data, and privacy in digital environments. To protect physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.*" [8]. To comprise this description, DigComp splits the "Safety" area into four competencies, namely: 1) protecting devices; 2) protecting personal data and privacy; 3) protecting health and well-being, and 4) protecting the environment.

Focusing on competency 2: "protecting personal data and privacy" DigComp2.0 defines this competency with the following descriptor: "*To protect personal data and privacy in digital environments. To understand how to use and share personally identifiable information while being able to protect oneself and others from damage. To understand that digital services use a "Privacy policy" to inform how personal data is used.*" [15].

Analysing this defined competency and identifying or extracting from this description the knowledge, skills, and human dispositions is extremely difficult, which may suggest or raise questions and different interpretations. In practice, this competency' description is the same approach followed since the establishment of the Bologna Process, the difference is in the names, e.g., learning outcomes, goals, indicators, et cetera. Although, it is important to highlight that the DigComp framework regards the definition of digital competencies, which has greater importance in the current digital context. In this paper, the authors intend to trigger the awareness of the fact a competency definition must or should embrace the intersection of knowledge, skills, and human dispositions.

In this context, and towards embracing this challenge, a proposal for the three constructs will be formulated to the defined competency of "protecting personal data and privacy".

Starting with knowledge description and addressing the question *Know-What*, the knowledge for "protecting personal data and privacy" competency is on:

- Knowing the information security properties (confidentiality, integrity, and availability) and others' properties like authentication, accountability, and no repudiation.
- Knowing the access mechanisms for authentication (passwords, biometrics, et cetera) and their requirements;
- Knowing and applying information security policies and requirements;
- Knowing the standards and good practices of safety and regulations.

Accordingly, to the knowledge previously described, the enumerated skills were defined to respond to the question "*Know-how*", which are as follows proposed:

- Apply the adequate security policies to protect the information security properties, confidentiality, integrity, and availability, as well as to protect personal and sensitive information;
- Apply security policies that ensure data privacy to comply with regulations, for example, the General Data Protection Regulation (GDPR);
- Apply security good practices and standard guidelines.

Lastly, the human dispositions identified as relevant may influence and contribute to the successful achievement and integration of previously defined knowledge and skills. Following the previous approaches, the human dispositions were defined to address or respond to the question "know-why":

- Adjustable – the capability to adjust in response to change;
- Collaborative – the capability to work with others;
- Strong commitment;
- Communicative;
- Ethical.

The human dispositions definition is a major challenge. It is undoubtedly the relevance and the impact of human dispositions on knowledge and skills acquisition. Dispositions are an intrinsic component of competency; it represents an opportunity to express institutional and programmatic values expected in the workplace. The association of the human dispositions' description to a competency reveals a clear commitment to self-reflection and examination that distinguishes a competency from a learning outcome.

Figure 2 illustrates the described competency definition, highlighting the intersection of the three constructs and the dispositions component embracing the knowledge and skills constructs.

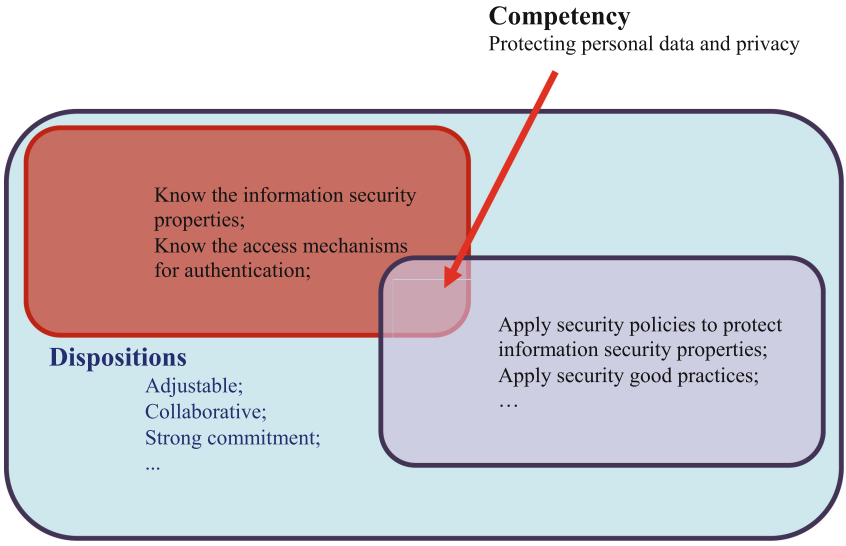

Fig. 2. Competency definition, adapted from [13].

4 Conclusions and Future Work

The rapid evolvement of technological applications with the decreased financial costs of technological gadgets promotes speed and accessibility to information and new

Internet-enabled services, accelerated by the digital transformation challenge of the learning process. Despite being pointed out in the past through the Bologna Declaration, competency-based learning is still not consensual and broadly understood by multiple stakeholders involved in competency development. Bloom's Taxonomy identifies characteristics aligned with "know-how" and "know-why", where each level (i.e.: remember, understand, apply, analyze, evaluate, and create) articulates an attitude toward engaging knowledge [17]. This reveals that still is a lot to be done to identify the potential paths that promote the adequate development of competencies, both for the sphere of the individual or the group.

Simultaneously, the digital transformation process will ensure that it is possible to develop new teaching and learning approaches that could be more personalized and aligned toward enhancing the individual's knowledge [18] whether these could be by using digital twins, supported by virtual and augmented reality that can accelerate the process of converting information into knowledge. Throughout time the technology will allow the usage and analysis of the longitudinal data from the interaction with digital equipment and with an intelligence layer to help identify the appropriate context for developing and enhancing knowledge into skills. Furthermore, identifying the attitudes and behavioural characteristics that, at the individual level, will allow better efficiency and performance and, in this way, support the transition from skills to competencies.

In future work, it would be relevant to study in detail the multi-layers of the digital transformation competencies, the right way to measure them and propose a roadmap for its adoption. A technological environment should be created to support an individual and group diagnosis to potentiate the individual performance.

Acknowledgement. This work has been supported by FCT – *Fundação para a Ciência e Tecnologia* within the R&D Units Project Scope: UIDB/00319/2020.

References

1. Delors, J.: Learning: the treasure within; report to UNESCO of International Commission on Education for the Twenty-first Century (highlights). UNESCO Publishing (1996). https://unesdoc.unesco.org/ark:/48223/pf0000109590. Accessed 20 Oct 2021
2. Bologna Working Group on Qualifications Frameworks, *A Framework for Qualifications of the European Higher Education Area* (Copenhagen: Ministry of Science, Technology and Innovation, 2005). http://ecahe.eu/w/images/7/76/A_Framework_for_Qualifications_for_the_European_Higher_Education_Area.pdf
3. E Commission The European Qualifications Framework for Lifelong Learning (EQF) Publications Office of the European Union Luxembourg (2008)
4. MICROBOL Recommendations On Micro-Credentials. https://microcredentials.eu/. Accessed 07 Dec 2020
5. Fernandes, G., Amaral, A., Peixoto, J., Pinto, E.B., Araújo, M., Machado, R.J.: Key initiatives to successfully manage collaborative university-industry R&D: IC-HMI case study. Procedia Comput. Sci. **164**, 414–423 (2019). https://doi.org/10.1016/j.procs.2019.12.201
6. Hallinger, P.: Mapping continuity and change in the intellectual structure of the knowledge base on problem-based learning, 1974–2019: A systematic review. Br. Educ. Res. J. **46**(6), 1423–1444 (2020). https://doi.org/10.1002/berj.3656

7. Kokotsaki, D., Menzies, V., Wiggins, A.: Project-based learning: a review of the literature. Improving Schools **19**(3), 267–277 (2016). https://doi.org/10.1177/1365480216659733
8. Hung, W.: All PBL starts here: the problem. Interdisc. J. Prob. Based Learn. 10(2), 2 (2016). https://doi.org/10.7771/1541-5015.1604
9. Al-Balushi, S.M., Al-Aamri, S.S.: The effect of environmental science projects on students' environmental knowledge and science attitudes. Int. Res. Geog. Environ. Educ. **23**(3), 213–227 (2014)
10. Rahmawati, A., Suryani, N., Akhyar, M., Sukarmin.: Technology-integrated project-based learning for pre-service teacher education: a systematic literature review. Open Eng. **10**(1), 620–629 (2020). https://doi.org/10.1515/eng-2020-0069
11. Cambridge Dictionary. https://dictionary.cambridge.org/dictionary/english/. Accessed 20 Dec 2021
12. Hasa. PEDIAA. What is the difference between competencies and skills (2021). https://pediaa.com/what-is-the-difference-between-competencies-and-skills/. Accessed 27 Dec 2021
13. Clear, A., Parrish, A., Impagliazzo, J., Wang, P.: Computing Curricula 2020: Paradigms for Global Computing Education, 1st edn. Association for Computing Machinery, New York (2020)
14. Europass European Union – Description on the eight EQF levels. https://europa.eu/europass/en/description-eight-eqf-levels. Accessed 12 Aug 2021
15. EU Science HUB. The European Commission's science and knowledge service. The Digital Competence Framework 2.0 (2019). https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework. Accessed 18 Mar 2021
16. Carretero, S., Vuorikari, R., Punie, Y.: DigComp 2.1: The digital competence framework for citizens with eight proficiency levels and examples of use. JCR Science Hub, JCR106281. (2017). ISSN 1831–9424. https://doi.org/10.2760/38842. Luxembourg: Publication Office of the European Union
17. © European Union, 2017
18. Waguespack, L., Topi, H., Frezza, S.: Adopting competency mindful of professionalism in baccalaureate computing curricula. In: Proceedings of the EDSIG Conference. Cleveland Ohio (2019). ISSN 2473, pp. 3857 v5 n4955
19. Santos, H., Pereira, T., Mendes, I.: Challenges and reflections in designing cyber security curriculum. IEEE World Eng. Educ. Conf. (EDUNINE) **2017**, 47–51 (2017). https://doi.org/10.1109/EDUNINE.2017.7918179