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EDUCATION IN INDUSTRY 4.0

TEACH4EDU4

Accelerating the transition towards Edu 4.0 in HEIs

Catalogue of new forms of teaching, learning and assessment in Computer Science in Edu 4.0 and related teachers' skills and competences

Bart Rienties[1], Rebecca Ferguson[1], Christothea Herodotou[1], Francisco Iniesto[1], Julia Sargent[1] and Igor Balaban[2]

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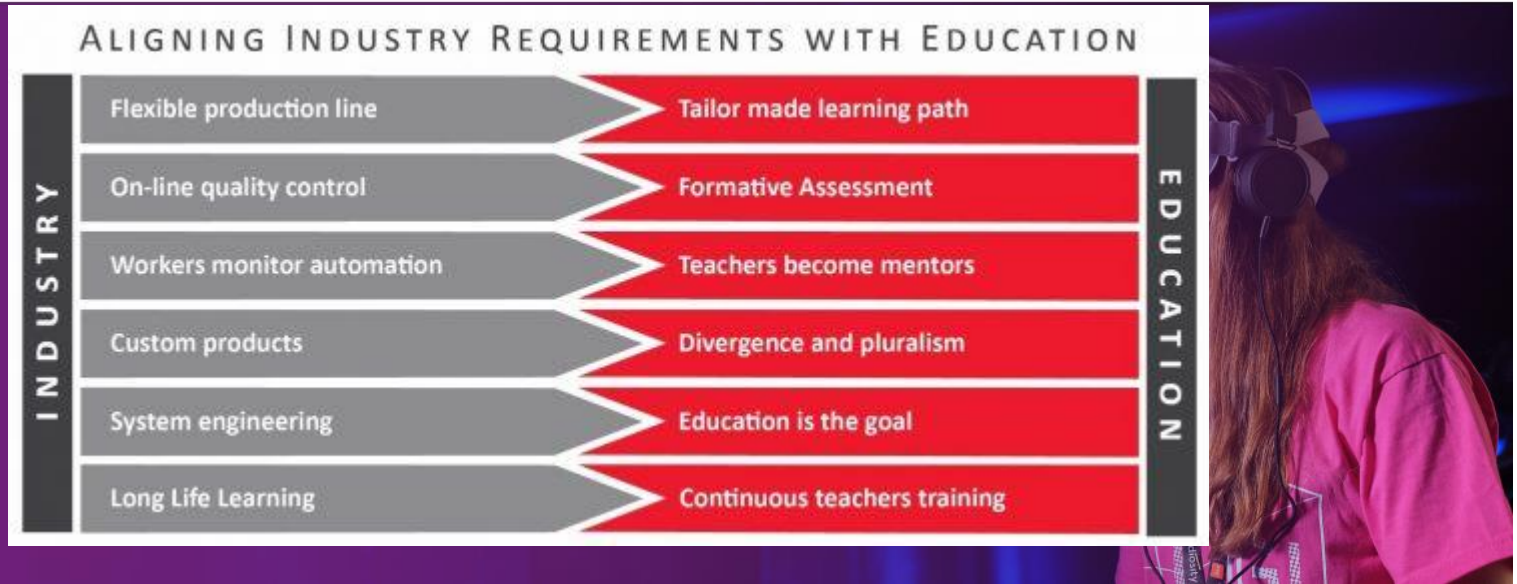
Jisc Education 4.0



Definitions about Education 4.0 vary but usually focus on innovation, novelty, use of technology, and connections with employment and industry (Hussin, 2018; Salmon, 2019). The number 4.0 makes a connection with the view that there have been four industrial revolutions with the current Industry 4.0 increasingly automated, making use of modern smart technologies and the Internet of Things (objects that can exchange information over the Internet).

What Education 4.0 means in practice is still being negotiated, so this catalogue uses two definitions.

The first is a well-cited version from Fisk (2017) and further updated by Hussin (2018), which included nine characteristics of **Education 4.0:**

1) Anytime / Anywhere;
2) Personalised;
3) Choice in how to Learn;
4) Project-based Learning;
5) Hands-on Learning;
6) Data Interpretation;
7) Assessed in New Ways;
8) Student Opinion Counts;
9) Develops Independence).

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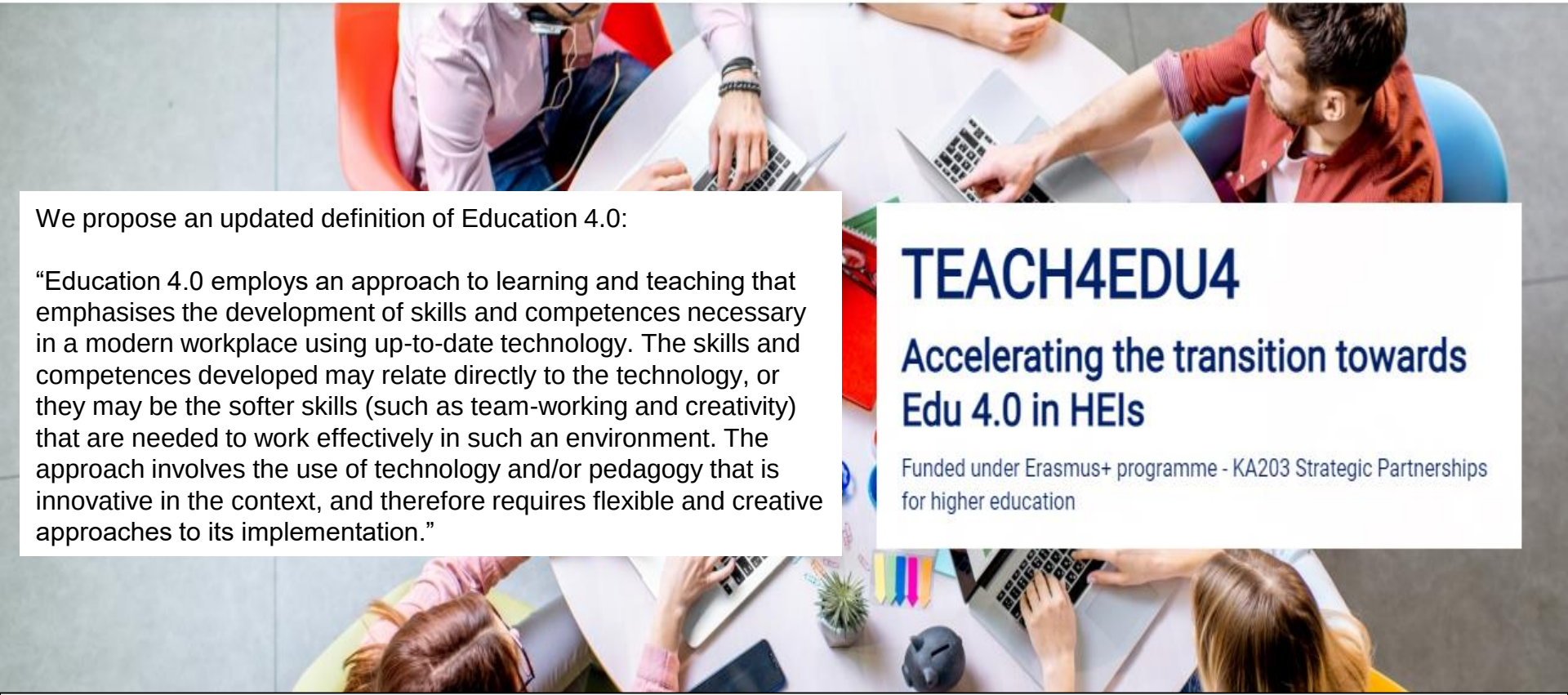

We propose an updated definition of Education 4.0:

“Education 4.0 employs an approach to learning and teaching that emphasises the development of skills and competences necessary in a modern workplace using up-to-date technology. The skills and competences developed may relate directly to the technology, or they may be the softer skills (such as team-working and creativity) that are needed to work effectively in such an environment. The approach involves the use of technology and/or pedagogy that is innovative in the context, and therefore requires flexible and creative approaches to its implementation.”

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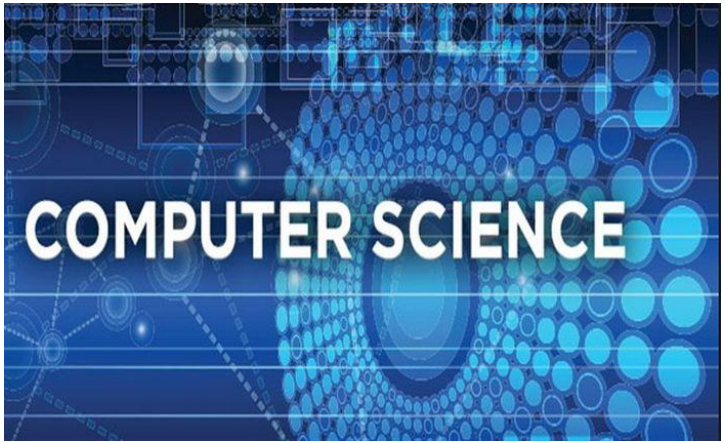
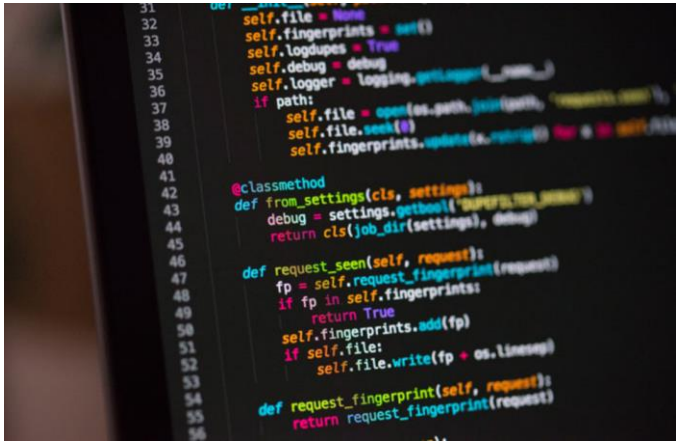
1. Collect and synthesize, in a form of catalogue: Education 4.0 compatible forms of teaching, learning and assessment
2. Collect and synthesize, in a form of catalogue: Teachers' skills and competences related to in Education 4.0





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Four research databases were searched: Science Direct, Wiley InterScience, Web of Science, and Scopus.

- Papers had to be published in English during the five-year period 2016–2020, thereby increasing the chance that a particular study used a contemporary and innovative pedagogical approach in CS.
- Keywords had to include Computer Science; undergraduate and/or postgraduate; as well as education, teaching and/or pedagogy.

- Search string: “computer science” AND education AND teaching AND pedagogy AND ("undergraduate" OR "postgraduate").

These search terms identified 231 unique publications across the four databases.

Publications identified using the search criteria were excluded if any of the following exclusion criteria applied:

1) The focus was on primary and/or secondary education;
2) The focus was on a subject other than Computer Science;
3) The focus was on learners (e.g., their gender or expectations) rather than teaching.

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3 Phase structure

1. Phase 0 Initial data export of key search terms and eye-balling of abstracts (done by RF): 150+ articles
2. Phase 1 Innovative teaching practice in Computer Science? 69
3. Phase 2 Which pedagogical approach and which Education 4.0 (if any)? 66

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Phase 1 First funnel: 09-19 February 2021

1. Phase 1 “Innovative” teaching practice in Computer Science
    a. Inclusion criteria 1: Is it an "innovative" application in a computer science course/module?
    b. Inclusion criteria 2: How does it use technology or pedagogy in an innovative way?
    c. Inclusion criteria 3: Is the innovation evaluated, if so how?
    d. Should we proceed reviewing this article in phase 2? → Leading to 69 studies

- One-hour online training and discussion of the online coding scheme
- 156 studies were read in depth by 18 members of Teach4EDU
- By including experts in CS and educational technology from six EU countries an inclusive multi-disciplinary team of coders analyzed data.
- Members coded 8.26 studies on average (range: 3-11)

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Phase 2: Coding relevant papers in more detail: 19 Feb - 12 March

RQ1: Which innovative pedagogic approaches are used to support the teaching of Computer Science (CS)?

RQ2: Which of these approaches align with Education 4.0?

RQ3: What skills and competences do CS educators require in order to align their CS teaching with Education 4.0

- 17 members of Teach4EDU participated in a follow-up one-hour online training and discussion of the online coding scheme of 20 variables.
- Coders were randomly allocated a new set of studies
- For RQ2, we adopted the nine key EDU 4.0 characteristics [11] and our Education 4.0 definition.
- For RQ3, coders indicated whether (or not) any specific skills required by teachers to support the teaching of CS to students were mentioned.
- Members coded on average 4.25 studies (range: 2-10)
- A random sample of 15 studies was double coded and indicated reliable coding (average Cohen Kappa EDU 4.0 = 0.84).
- Afterwards, the first coders from Phase 1 checked the codes from the second coders in Phase 2, discussed any differences, and agreed on the final coding (average Cohen Kappa EDU 4.0 = 0.93). If a study did not indicate any EDU 4.0 characteristic, we removed it from further analysis
- We ended up with a total of 66 studies.

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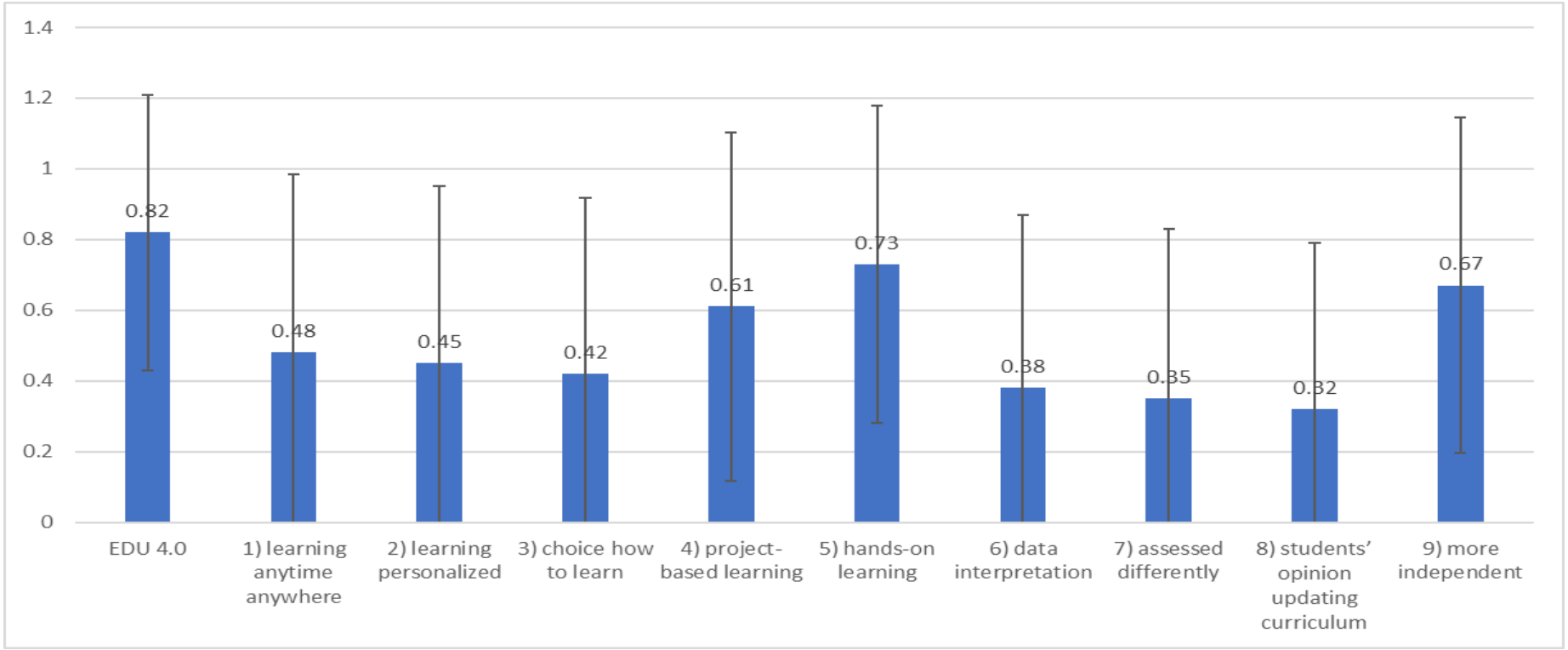
Results



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Pattern structure of Factor analysis EDU 4.0 Characteristics

	1	2
2) learning will be personalized to individual students	.769	
1) learning can take place anytime anywhere	.644	
6) students will be exposed to data interpretation in which they are required to apply their theoretical knowledge to numbers and use their reasoning skills to make inferences based on logic and trends from given sets of data	.618	
9) students will become more independent in their own learning	.617	
3) students have a choice in determining how they want to learn	.589	
8) students' opinion will be considered in designing and updating the curriculum		
4) students will be exposed to more project-based learning		.883
5) students will be exposed to more hands-on learning through field experience (e.g., internships, mentoring projects, collaborative projects)		.836
7) students will be assessed differently and the conventional platforms to assess students may become irrelevant or insufficient		.455
Extraction Method: Principal Component Analysis.		
Rotation Method: Oblimin with Kaiser Normalization.		

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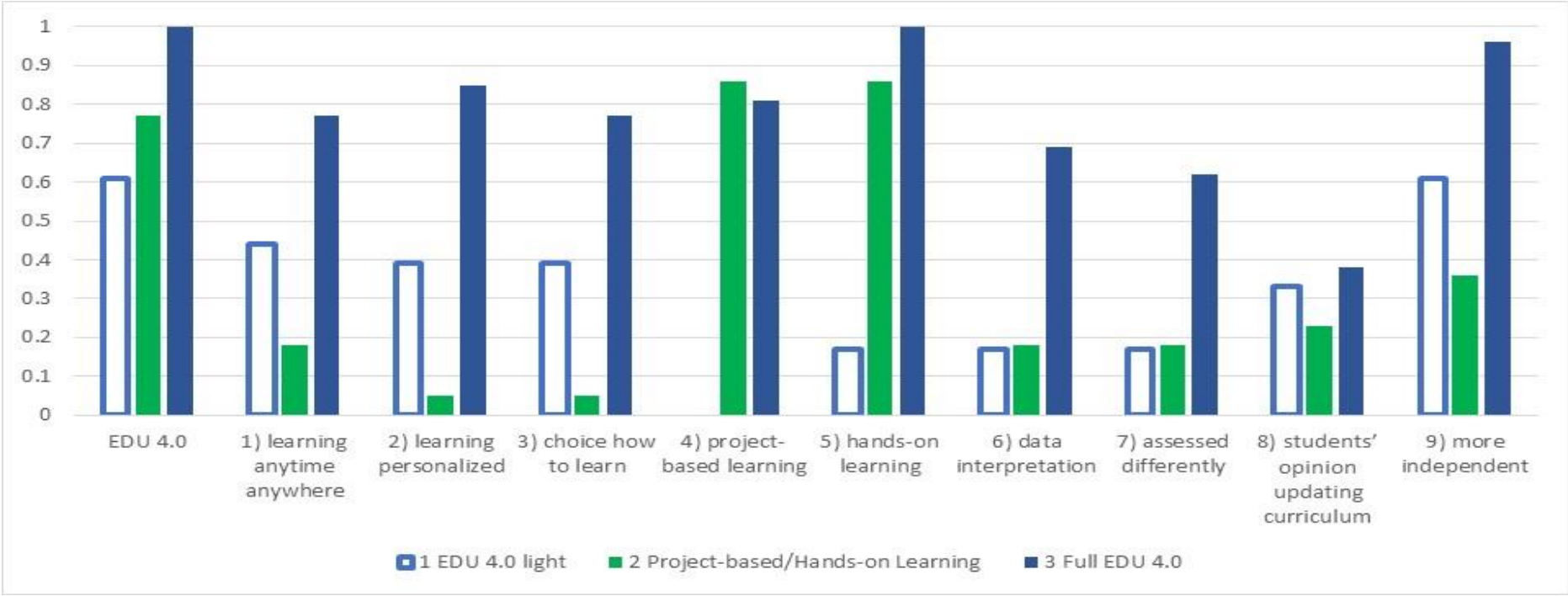
3 clusters: 1) Edu 4.0 Light; 2) Project-based/Hands-on; 3) Full Edu 4.0



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For example Edu 4.0 Light

Authors	E1	E2	E3	E4	E5	E6	E7	E8	E9	Country
Aplola, Lokkila and Laakso [31]	Y		Y		Y				Y	Finland
Burrows and Borowczak [32]	Y	Y		Y				Y	Y	USA
Degener, Haak, Gold-Veerkamp and Abke [33]	Y								Y	Germany
Dickson, Dragon and Lee [34]		Y	Y		Y					USA
Dondio and Shaheen [35]								Y	Y	Ireland
Fisher, Rader and Camp [36]	Y	Y						Y		USA
Frevert, Rorrer, Davis, Latulipe, Maher, Cukic, Mays and Rogelberg [37]								Y	Y	USA
Giacaman and De Ruvo [38]			Y							New Zealand
Hosseini, Hartt and Mostafapour [39]							Y		Y	USA, Wales, Canada
Parejo, Trova, Segura, del-Río-Ortega, Gámez-Díaz and Márquez-Chamorro [40]	Y						Y			Spain
Park and Kim [41]	Y	Y					Y		Y	Korea
Pilkington [42]	Y					Y			Y	South Africa
Scatalon, Garcia and Barbosa [8]		Y								Brazil
Schäfer [30]	Y								Y	Germany
Shi, Min and Zhang [43]			Y							China
Silva, Steinmacher and Conte [44]			Y					Y	Y	Brazil
Tyler and Abdrakhmanova [45]		Y	Y			Y		Y		Kazakhstan

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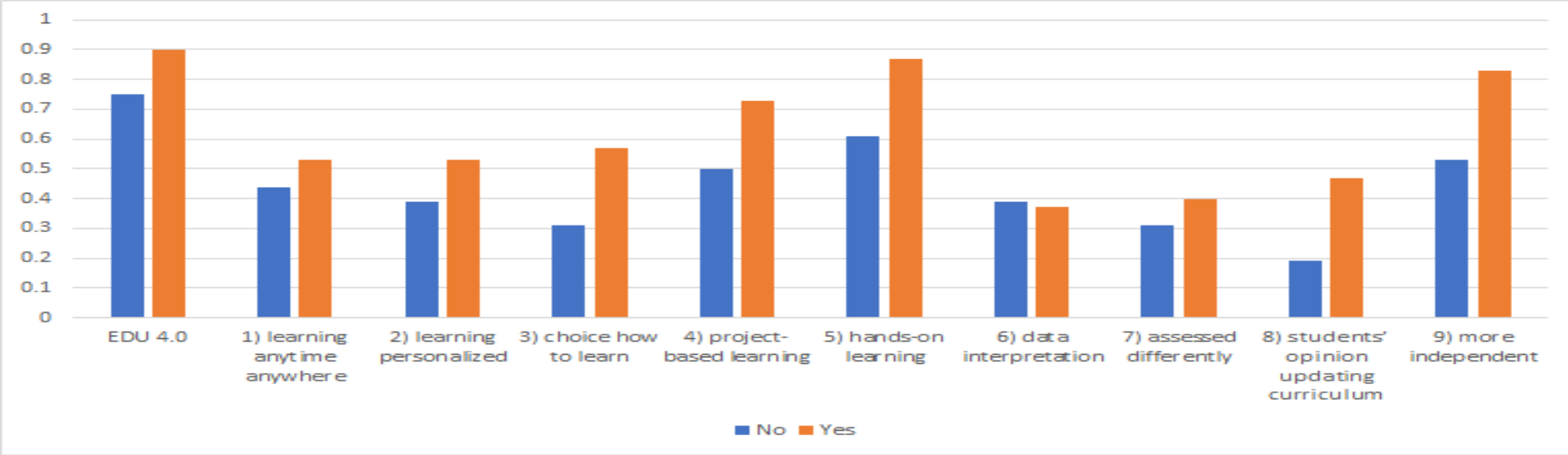
RQ3 Skills of teachers



- A reference to skills and competences was often presented as an implication of the proposed study rather than being examined as the starting point of a given article.
- Some skills referred were rather generic, such as the creation of student-centered environments. Others were more concrete (e.g., specific mobile games in teaching).
- A recurring theme was the teacher as facilitator, moderator or learning consultant as opposed to a teacher controlling or being the center of the learning process

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Conclusion

1. No study explicitly mentioned Education 4.0 (so term not well embedded yet)
2. No difference in terms of design based upon nationality/culture (i.e., CS seems similar in terms of design across the globe)
3. CS teachers seem to design three broad learning designs (light, project-based, full)
4. Teaching skills and competences more likely to be included when using fuller Education 4.0 approaches (perhaps due to complexity)
5. Need to understand whether these different designs lead to different learning outcomes, and whether Education 4.0 as a construct is useful (or not).

Full report should become available soon at https://teach4edu4-project.eu/

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