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STUDENTS' ACADEMIC ACHIEVEMENTS: CLUSTERS BASED ON METACOGNITION, LITERACY AND NUMERACY SKILLS

SUCCESSO ACCADEMICO DEGLI STUDENTI: CLUSTER BASATI SU COMPETENZE METACOGNITIVE, LITERACY E NUMERACY

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Abstract

Which models and frameworks can guide research investigating the link between metacognition, literacy, numeracy, and academic success?
The study we present here is based on research involving 107 students enrolled in the Digital Education degree course at the University of Modena and Reggio Emilia.
We put in relation the results of three questionnaires on metacognition awareness (MAI), literacy, and numeracy to the students' university achievement and profiles.
Using cluster analysis, we identified groups of students with similar results in the three questionnaires. After, we verified if different values on academic performances characterized the clusters.
The Euclidean distance best fits our data, the method chosen to aggregate the groups is the Complete-linkage. A six-clusters solution was proposed.
Positive test results affect the quality and not the quantity of the exams passed. Students with higher exam grades belong to the groups in which numeracy test results are higher. The percentages of university credits acquired seemed higher when there was less uniformity in the students' entry test results.

Quali modelli e framework possono guidare la ricerca che indaga il legame tra metacognizione, literacy, numeracy e successo universitario?
Lo studio che qui presentiamo descrive una ricerca che ha coinvolto 107 studenti iscritti al corso di laurea in Educa-

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zione Digitale dell'Università di Modena e Reggio Emilia nella quale abbiamo messo in relazione i risultati ottenuti in tre questionari sulla consapevolezza della metacognizione (MAI), la *literacy* e la *numeracy* con i risultati universitari e i profili personali degli studenti.
Utilizzando la cluster analysis, abbiamo identificato gruppi di studenti con risultati simili nei tre questionari e, in seguito, abbiamo verificato se i cluster risultano contraddistinti da diverse prestazioni accademiche. Nella cluster analysis è stata utilizzata la distanza euclidea e il metodo del Complete-linkage.
Si propone una soluzione a sei cluster che ci permette di avanzare alcune osservazioni. In particolare, i risultati positivi nei 3 test influenzano la qualità e non la quantità degli esami superati; gli studenti con voti d'esame più alti appartengono ai gruppi in cui i risultati dei test di numeracy sono più alti; le percentuali di crediti universitari acquisiti sembrano più alte quando c'è meno uniformità nei risultati dei test d'ingresso degli studenti.

Keywords
Metacognition, Literacy, Numeracy, Academic Success, Cluster Analysis
Metacognizione, Literacy, Numeracy, Successo Accademico, Cluster Analysis

Introduction

The study we present is based on a research involving students enrolled in the Digital Education degree course at the University of Modena and Reggio Emilia.

The research aims to define the possible relationships existing between the levels of metacognition, literacy and numeracy skills, and academic success starting from the clustering of population in similar groups.

The research design planning began when, in the newly created degree course in Digital Education, we had to describe what prerequisites students should possess to complete the training effectively. Rather than thinking of specific knowledge in any discipline, we thought of basic skills as fundamental elements to build on specific professional skills in specific contexts, as in our case, those of the educational and digital sectors. Hence the decision to organise the Additional Training Obligations (OFA in Italian) at the beginning of the training, not as a traditional course (as is often the case in Italian universities) but as metacognitive, literacy, and numeracy skills tests. This choice would give us, as degree course managers, an overview of students' levels and provide students with a view of their level resulting from the tests they were asked to complete.

Grouping learners starting from the results corresponding to those three skills allows us to delineate students' entry profiles that not necessarily correspond only to the achievement of full or poor levels in all three skills concurrently but that return intermediate outcomes and variations. Can a latent association be established between the set of three competences (with their different levels) and academic success for groups of students? Thus moving from the particular case of degree course in Digital Education to a broader generalisation of the study and the results: the hypothesis, that would justify our choice for OFA and that we want to test through a quantitative research approach, is therefore that the set of the three skills (not the single one) represents a way to explain academic success for groups of students in the consideration that professional success is attributable, among many other things, to sums of knowledge and skills put together.

After defining the three skills in the following paragraphs, we'll provide some details about the used methods (cluster analysis) and the results obtained.

1. Metacognition

Metacognition is the knowledge which each individual has regarding cognitive function (Flavell, 1979), how his and other people's minds function, and the different forms of control and regulation that can be implemented before, during, and after the execution of a task (Brown, 1987).

Knowledge about cognition refers to the beliefs about what factors or variables interact, in what ways they affect the course and outcomes of cognitive enterprises and includes three sub-processes (Jacobs & Paris, 1987): (1) declarative metacognitive knowledge represents knowledge about one's abilities and strategies; (2) procedural metacognitive knowledge refers to the knowledge regarding how to use most efficiently these strategies; (3) conditional metacognitive knowledge represents the knowledge regarding when and why to use specific strategies.

Regulation of cognition refers to three sub-processes related to the control of learning (Hacker, 1998): planning, monitoring, and evaluating. Planning involves selecting appropriate strategies and the allocation of personal resources, including goal setting, activating relevant background knowledge, and budgeting time. Monitoring refers to self-testing skills necessary to control learning, checking one's comprehension and performance. Evaluating designates the judgment about the products and efficiency of one's learning, e.g., by re-evaluating one's goals and conclusions. The interplay between metacognitive knowledge and metacognitive control significantly guides the decision regarding selecting a specific learning strategy, thus assisting learners in the control and execution of learning itself (Sperling, Howard, Staley & DuBois, 2004). The interest generated by metacognition is largely due to the fact that it is considered a powerful predictor of students' learning performance (Roebers, Krebs & Roderer, 2014): by encouraging the student to monitor and evaluate his thinking constantly, it is said to accelerate cognitive function.

The influence of metacognition on performance has been studied in both online and face-to-face university courses (Ohtani & Hisasaka, 2018). Romainville (1994) reported a relationship between academic performance and university students' metacognition. In particular, it was found that high achieving students seem to evoke metacognitive knowledge about cognitive processes and cognitive results more frequently; their metacognitive knowledge also seems more structured and hierarchically organised. Kramarski and Gutman (2006) and Azevedo and colleagues (2008) found that metacognition is closely related to students' achievements. Fiore and Vogel-Walcutt (2010) state that students with metacognitive skills can foresee problems that may arise during the learning experience and better allocate their cognitive resources for learning and determine the information they understand or need. In the same direction heading the results of Kállay (2012): her research shows that learning strategies and metacognitive awareness predict academic success in university students. Kim and colleagues (2015) reported a significant difference in emotion, motivation, and metacognitive self-regulation between students with low and high learning outcomes.

2. Literacy and numeracy: framework and research perspectives

Which models and frameworks can guide research investigating the link between metacognition, literacy and numeracy? What attention is paid to the relationship between cognitive and non-cognitive skills?

On the link between cognitive and non-cognitive skills, there are a number of studies and researches that have also investigated the relationship between metacognition, literacy and numeracy. The PIAAC[6] - "Programme for the International Assessment of Adult Competencies" is an example: a self-assessment tool "designed to provide a picture of an individual's literacy, numeracy and problem solving skills in technologically rich environments" (OECD, p.2, our translation). The aim of the PIAAC was the assessment of skills (adult population aged 16-

6 "The development and implementation of PIAAC was supervised by a Board (BPC) composed of the participating countries and the OECD. In 2010 the pilot survey was carried out (May-July 2010). Between the end of 2011 and 2012 the main survey was carried out" (ISFOL, 2014). In Italy the activities were curated by ISFOL (since 2016 ISFOL has become INAPP - Istituto Nazionale per l'Analisi delle Politiche Pubbliche: https://www.inapp.org/). For further details please refer to the website: https://www.oecd.org/skills/ESonline-assessment/

65) for the collection of a "internationally comparable, qualitative-quantitative database on the distribution of foundation skills of the adult population, in order to provide knowledge on the dynamics and the stock of skills in the different countries, which are fundamental inputs for the definition and updating of educational and labour policies" (ISFOL, 2014, p. 15, our translation). Given the growth of the demand for cognitive and, at the same time, non-cognitive skills "in the face of a scarcity of existing databases on adult skills in the population of different countries, makes strategic the contribution deriving from PIAAC" (ISFOL, 2014, p. 15, our translation).

PIAAC focused therefore on the core competences of adults "defined by the OECD foundations skills - and in particular on reading (Literacy), logical-mathematical skills (Numeracy) and competences related to information and communication technologies (ICT)" (ISFOL, our translation). At the basis of the PIAAC Programme framework, we find literacy, numeracy and problem solving skills in technologically rich environments, which are fundamental for information processing (ISFOL, 2014) and vital skills for "accessing, understanding, analysing and using text-based information (in any paper or digital format) and, in the case of mathematical information, in any form of representation (images, graphs) [...]. They are considered key competences (or skills), as they are:

- necessary for full integration and participation in the labour market, education and training, and social and civic life;
- relevant for all adults;
- highly transferable, as they are relevant to different social fields and work situations;
- they are learnable and, therefore, subject to policy influence" (ISFOL, 2014, p.18, our translation).

Moreover, as the study found, both literacy and numeracy are the basis for the development of higher order cognitive skills (ISFOL, 2014).

The study also offers an interesting starting point for the definition of literacy and identifies six processes as critical components of literacy skills (Table 1).

Table 1. PIAAC - literacy definition and processes (ISFOL, 2014, p. 22).

Literacy Definition	Six critical processes
"Literacy, once viewed from the perspective of minimum competence, is defined here as a continuum of knowledge, skills and strategies that individuals acquire throughout their lives. It encompasses a set of skills and knowledge across more than one domain, including reading, writing and numeracy. Literacy is also seen as an evolving concept, recognising that it is necessary for individual growth, economic participation and citizenship" (ISFOL, 2014, p.21, our translation).	*Access*: Knowing and being able to collect and/or retrieve information.
	Management: Organising information into existing classification schemes.
	Integration: Integrating by summarising, comparing and contrasting information by using similar or different forms of representation.
	Assessment: Reflecting to make judgements about the quality, relevance, usefulness, or efficiency of information.
	Construction: Generating new information and knowledge by adapting, applying, designing, representing or creating information
	Communication: Transmitting information and knowledge to various individuals and/or groups.

Numeracy is defined as "the ability to access, use, interpret and communicate mathematical information and ideas in order to address and manage mathematical problems in different situations in adult life" (ISFOL, 2014, p.24, our translation). The study also focused on the use of competences in personal and not only professional contexts, on "aspects linked to the individual's life and professional orientations and lifestyles: behavioural orientations, subjective well-being and health, interests and career goals, frequency and context of use of competences"

(ISFOL). In the university context and in the development of students' competences these variables appear fundamental both for a reading and analysis of data linked to employability and for the strengthening of competences linked to specific professional figures.

What are the data emerging from the survey? In the Italian context:

- "adults (16-65 years old) are mostly placed at Level 2 in both the literacy (42.3%) and numeracy (39.0%), Level 3 or higher is reached by 29.8% of the population in literacy and 28.9% in numeracy, while the lowest performance levels (Level 1 or lower) are reached by 27.9% of the population in literacy and 31.9% in numeracy;
- in the numeracy domain, Italy is significantly below the OECD average of 269 points (Level 2 on the numeracy scale). The countries that together with Italy rank significantly below the OECD average are Spain, the United States, France, Ireland, Poland, the United Kingdom, the Republic of Korea, Cyprus and Canada.
- on average 33.7% of OECD-PIAAC countries reach level 2. The countries with the highest percentage of adults at Level 2 are Italy (42.3%) and Spain (39.4%), followed by Austria (37.9%), Ireland (37.7%) and the Czech Republic (37.7%).
- relationship between level of schooling and higher levels of competence, 49% of 16-24 year old who study reach Level 3, 23% of their peers are working at the same level, and only 18% are unemployed" (ISFOL, 2014, p. 69, our translation).

The Italian National Agency for Active Employment Policies (ANPAL) started in 2017 an experimentation also on the OECD PIAAC tool (Online Training & Skills in Provincial Centres for Adult Education - CPIA) offering a reading in a different context, with the indirect (non-cognitive) assessment module called acted competences "which allows to obtain information on the use of literacy, numeracy and ICT skills in work and daily life" (ANPAL, 2020, p. 26).

A recent study (Turda et al., 2020) highlighted how poor literacy skills limit adults' opportunities both in work contexts and in accessing resources related to health, social and political participation and linked this aspect to the need and possibility of comparing data from different studies such as the Level One Study (LEO), the Programme for the International Assessment of Adult Competencies (PIAAC), and the National Educational Panel Study (NEPS): "most occupations require the ability to engage with written materials, literacy proficiency also has a direct effect on labour market outcomes. For example, information such as work instructions are difficult to obtain without a functional level of literacy" (p. 13).

In accordance with Reder and colleagues (2020), what emerges from these studies is also supported by the Practice Engagement Theory (PET) that "posits that individuals' literacy proficiencies develop as a by-product of their engagement in everyday reading and writing practices and, reciprocally, that literacy proficiencies affect levels of engagement in reading and writing practices. This suggests that literacy training which increases engagement in meaningful practices might generate proficiency growth" (p. 267).

3. Method

The study is placed "at the crossroads of educational research and cognitive neuroscience" (De Smedt et al., 2010, p. 97) and investigates the relationship between academic success and the development of metacognition, literacy and numeracy skills in university students.

107 students enrolled in the first-course year of Degree Course in Digital Education at the University of Modena and Reggio Emilia during a. y. 2019/20 compiled three questionnaires related to the three skills during Additional Training Obligations. We chose to propose these activities because we desired to reflect with them on their metacognitive awareness and their text comprehension and numeracy skills. Students could compile metacognition inventory only once but could take more time questionnaires on literacy and numeracy.

We put in relation the results of the three questionnaires to the students' university achievement and profiles collecting data through, respectively, the consultation of the university archives and a brief survey.

Using cluster analysis, we identified groups of students with similar results in the three questionnaires on metacognition, literacy and numeracy. After, we verified if different values on academic performances characterized the clusters.

Cluster analysis (Hair et al., 2014; Bartholomew et al., 2008) comprises a set of methods that allow the analysis objects to be collected in groups (clusters) in which the observations have similar characteristics among them and each group results dissimilar from the other groups. The researcher aims to obtain a high homogeneity among the objects in each cluster (minimal distance among objects) and high heterogeneity among clusters (maximal distance among clusters). Assuming a natural group structure within a population allows us to test hypotheses on their characteristics and generate new ones on the functioning of (educational) systems.

We used R-Studio as a computational environment and, in particular, the library Psych.

3.1 Data collection

Data related to metacognition, literacy and numeracy were gathered from questionnaires put on the Moodle platform used for the delivery of the courses; data about academic success and exams were obtained from university archives and databases.

All questionnaires were administered in Italian. Authors produced literacy and numeracy tests.

In details, the questionnaire related to literacy was an exercise on text comprehension made of ten close-ended questions.

To detect numeracy level, we used a test structured as the Professional Skills Tests used in the UK for Qualified Teacher Status, QTS. It is composed of two parts: the first consists of 12 closed questions on *mental* abilities; the second of 16 closed questions on *written* abilities.

Metacognitive awareness was assessed by the Metacognitive Awareness Inventory (MAI), developed by Schraw and Dennison (1994). Although the Italian translated version of the inventory has not undergone a full validation process, the coefficient of internal consistency (Cronbach's alpha) measured for all students in Digital Education is 0.85. The MAI has 52 items that are classified by type of cognitive knowledge and regulation. *Knowledge of cognition* is made up of: Declarative knowledge (DK) (knowledge about one's skills, intellectual resources, and abilities as a learner), Procedural knowledge (PK) (knowledge about how to implement learning procedures, e.g., strategies), and Conditional knowledge (CK) (knowledge about when and why to use learning procedures).

Regulation of cognition refers to: Planning (P) (goal setting and allocating resources before learning), Information management strategies (IMS) (skills and strategy sequences used to process information more efficiently, e.g., organizing, elaborating, summarizing, selective focusing), Monitoring (M) (assessment of one's learning efficacy or strategy use), Debugging strategies (DS) (strategies used to correct comprehension and performance errors), and Evaluation (E) (analysis of performance and strategy effectiveness after a learning episode).

3.2 Variables

Table 2 shows all the variables in the dataset. The variables used for the cluster analysis are those related to the full results of questionnaires on metacognition, literacy, and numeracy. In particular:

- MAI1 and MAI2 that synthesize the scores in the two parts of Metacognition Awareness Inventory: *Knowledge of Cognition* and *Regulation of Cognition*;
- LITERACY that is the final score in literacy test;
- NUM_PART1 and NUM_PART2 that synthesize the scores in the two parts of the numeracy test: *Mental Section* and *Written Section*.

The variables considered for the following analysis are AVE_EXAMS and P_CREDITS as indicators of academic success and those in the group of Students' Profile.

Table 2. Variables List

STUDENTS' PROFILE		**METACOGNITION AWARENESS INVENTORY**	
GENDER	Student's gender	MAI1_DECLARATIVEK	Percentage of questions indicated as true by the student in the questions in the Declarative Knowledge section
AGE	Student's age	MAI1_PROCEDURALK	Percentage of questions indicated as true by the student in the questions in the Procedural Knowledge section
HS_TYPE	Type of high school attended	MAI1_CONDITIONALK	Percentage of questions indicated as true by the student in the questions in the Conditional Knowledge section
HS_GRADE	High school grade	MAI2_PLANNING	Percentage of questions indicated as true by the student in the questions in the Planning section
PRE_DEGREE	Previous degree before enrolling in Digital Education course	MAI2_INFO	Percentage of questions indicated as true by the student in the questions in the Information management strategies section
WORKING	Working status	MAI2_MONITORING	Percentage of questions indicated as true by the student in the questions in the Monitoring section
EXAMS		MAI2_DEBUGGING	Percentage of questions indicated as true by the student in the questions in the Debugging strategies section
P_EXAMS	Percentage of passed exams	MAI2_EVALUATION	Percentage of questions indicated as true by the student in the questions in the Evaluation section
P_CREDITS	Percentage of university credits acquired	MAI1	Percentage of questions indicated as true by the student in the questions in the section Knowledge of Cognition
AVE_EXAMS	Weighted average of exam grades	MAI2	Percentage of questions indicated as true by the student in the questions in the section Regulation of Cognition
FAIL_VALUE	Percentage of failures on attempts to take exams	MAI_OVERALL	Percentage of questions indicated as true by the student in the questions in the Metacognition Awareness Inventory
P_SEM_EXAMS	Percentage of exams passed in the semester of course delivery		
EXAMn (*For each exam*)	Passed exam	**NUMERACY**	
EXAMn_GRADE (*For each exam*)	Exam Grade	NUMERACY	Numeracy test score in thirtieths
LITERACY		NUM_PART1	Mental Section score in thirtieths
LITERACY	Literacy test score in thirtieths	NUM_PART2	Written Section score in thirtieths
LIT_FAIL_VALUE	Percentage of failure on literacy test attempts	NUM_FAIL_VALUE	Percentage of failure on numeracy test attempts

4. Results and Discussion

76% of the analysed population were women; 62% worked, and 15% already had a university degree; 50% were under 25 years old. Going over the inter-group correlations, we found a weak linear correlation between the scores on the literacy test and the weighted average of exam grades (0.18), percentage of credits acquired (0.17) and exams taken in the semester of reference (0.11); higher ρ values (0.20-0.34) between the numeracy test scores and the variables of academic success; ρ values close to 0 between the MAI scores and the same variables. A complete preliminary analysis of the population is published in De Santis et al. (in press).

There are three key elements in carrying out a cluster analysis: similarity measure (distance) between the elements constituting the group, procedure through which we construct the clusters, and interpretation of differences among the constituted groups.

We calculated the distance in several ways, the Euclidean distance best fits our data; the method chosen to aggregate the groups is the Complete-linkage. We studied the solutions with three, four, five, six clusters. The six-clusters solution (Figure 1) is the one that gives the possibility to identify different situations given by the multiple combinations of results in the questionnaires and make reflections on students' achievement.

We describe the clusters considering before all the five variables used to identify them (Figure 2, Table 2) and after the variables relating to the profile and academic achievements of the students (Figure 3, Table 3).

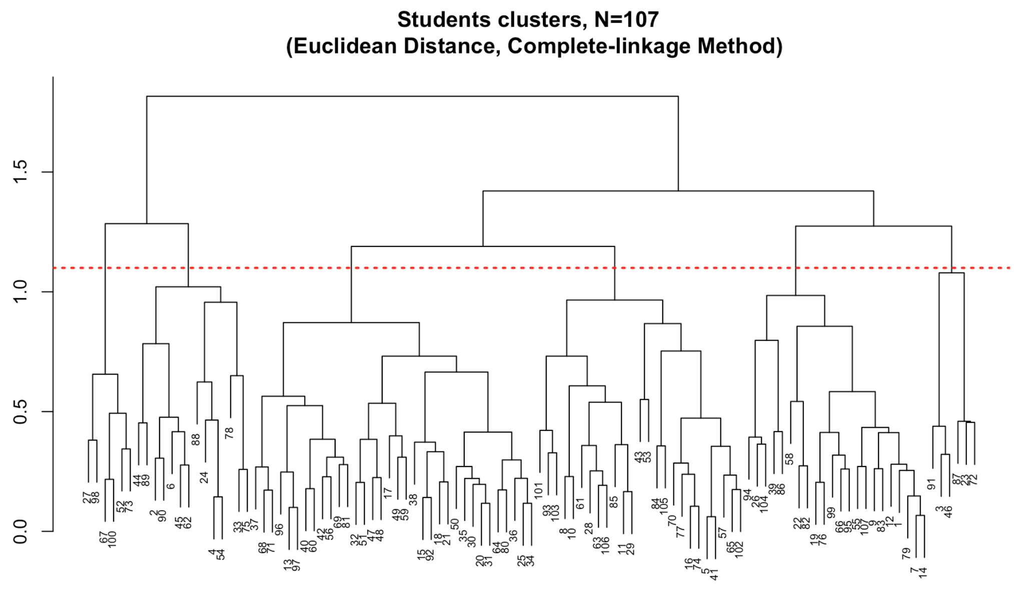

Fig. 1. Dendrogram of clustering, cut for the six-cluster solution (red line).

Fig. 2. Boxplots of variables related to the results in three questionnaires for the six clusters.

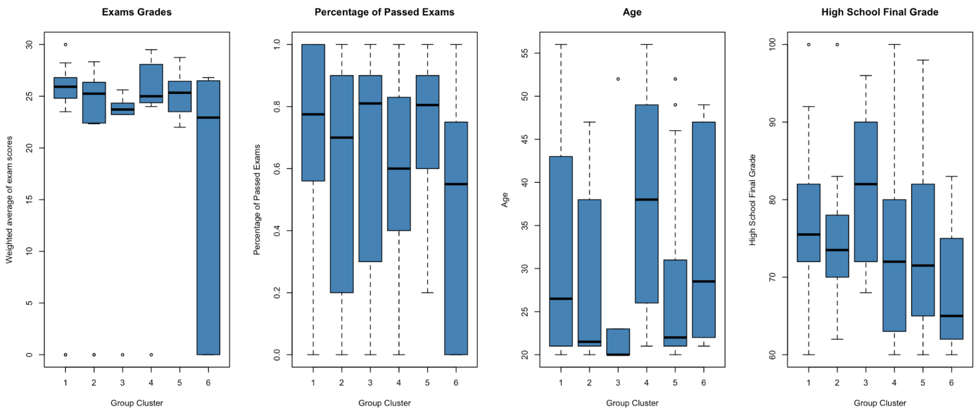

Fig. 3. Boxplots of variables related to Academic achievement and Students' Profile for the six clusters.

Table 2. Centroids of six-clusters solution.

CLUSTER	**1**	**2**	**3**	**4**	**5**	**6**
AGE	31.8	29.6	25.8	36.9	27.1	32.7
HS_GRADE (max = 100)	78.0	74.9	81.7	74.5	74.1	68.3
AVE_EXAMS (max = 30)	23.8	21.7	20.1	25.0	25.2	16.5
P_CREDITS (max = 100)	0.7	0.6	0.6	0.6	0.7	0.5
MAI1 (max = 100)	60.4	57.1	80.4	81.4	74.2	94.1
MAI2 (max = 100)	75.8	71.2	66.7	93.2	78.6	92.4
LITERACY (max = 30)	27.9	19.0	28.8	25.0	20.8	18.5
NUM_PART1 (max = 30)	24.8	18.8	16.7	23.1	25.4	20.0
NUM_PART2 (max = 0)	21.9	16.4	18.2	21.8	21.6	15.5

Table 3. Distribution of clusters by gender, previous degree and working status.

	N.	**Male**	**Female**	**Previous Degree***	**Working Status***
TOT	107	24.3%	75.7%	14.9%	61.7%
Cluster 1	22	36.4%	63.6%	15.0%	55.0%
Cluster 2	14	28.6%	71.4%	0.0%	66.7%
Cluster 3	6	16.7%	83.3%	25.0%	25.0%
Cluster 4	25	24.0%	76.0%	20.0%	72.0%
Cluster 5	34	17.6%	82.4%	12.5%	65.6%
Cluster 6	6	16.7%	83.3%	25.0%	25.0%

*There are 13 NA among the observations.

The first cluster consisted of students who scored on average lower than the whole population on the MAI and higher on the literacy and numeracy tests. They were young/adult students, among whom there was a higher percentage of men than in the other clusters. Part of them was working when data was collected. Nevertheless, workers' percentage in this cluster is slightly lower than in the population. These students had good exam grades average and a high percentage of passed exams. It can be assumed that they underestimated their metacognitive skills or that their declared level was sufficient for attending university successfully.

Students who performed poorly in all preliminary tests (MAI, literacy, and numeracy) belonged to the second cluster. These were younger students who, on average, did not excel, neither in terms of examination grades nor the percentage of exams passed.

In contrast, students in cluster 4 had high scores in the preliminary tests. They are the ones who, on average, took fewer exams but had better results. Adult learners belonged to this group, where we found a higher number of working people.

The largest group was cluster 5, in which students had more difficulties in literacy and less in numeracy, with MAI levels in the average of the population. This group collected more young people, women, and workers than average. They passed a good percentage of exams with good grades. In this case the scores on the self-assessment in the MAI test are very good but not excellent, which could be justified by a not quite full achievement of awareness on one's metacognitive abilities by students. The low score on the literacy test is not compliant with what we would expect considering exams scores. Looking at the boxplot (Figure 2), the median value divides students into two equal parts: students who scored below 20 and those who scored above 20. More investigation on the result and especially on the group below 20 is necessary.

Two tiny clusters can be distinguished. The six students of third cluster had high scores in the first part of the MAI that concerns the knowledge about cognition and in text comprehension (literacy) but showed poor competences in numeracy and the regulation of cognition (second part of MAI). They are the youngest students' group with higher high school grades; five of them were women. They passed many exams but with less encouraging results, probably because they had more difficulty organising their study, and although they could well understand the concepts, they did not have sufficient levels of numeracy (logic-mathematical processes) to leap.

The other small group consisted of the students in cluster 6, where six students self-assessed their metacognitive skills as high but in practice have low literacy and numeracy. This group, which consists mainly of women, had poor study results.

We can assume that members of this group overestimated their metacognitive skills or took the survey superficially or without fully understanding the demands (remember that MAI is a self-assessment test). The low pass rates and exam grades show that these students cannot cope and need more help in studying or organising their studies to succeed.

We add some observations about the findings:

- we can compare results in clusters 2 and 4 that are those in which the students had all low and all high marks in the three preliminary tests. We can see a difference between the weighted averages of the exam marks of 3.3 (Table 2). We find no difference between the averages of the percentages of the exams taken. Positive test results affect the quality and not the quantity of the exams passed.
- students with higher exam grades belong to the groups in which numeracy test results are higher.
- the percentages of university credits acquired seemed to be higher when there was less uniformity in the students' entry tests results.
- the two less numerous clusters represented two interesting situations that were more difficult to analyse because of the low numeracy of the groups. In cluster 3, only numeracy and regulation of cognition were low; in cluster 6, the metacognition test had high levels, and numeracy and literacy tests had shallow marks. In both cases, students' performance was more unsatisfactory, especially in cluster 6, where we also find students who do not complete any exams. We cannot add other details because of few observations, but the combination of results could be relevant to consider for future works.

Conclusions and future works

"Adults with higher proficiency in literacy, numeracy and problem solving in technology-rich environments tend to have better outcomes in the labour market than their less-proficient peers. They have greater chances of being employed and, if employed, of earning higher wages" (OECD, 2016, p. 17).

As highlighted in the PIAAC project (2014) in numerous studies on key competences "competence is conceived in functional terms", seen as "the ability to generate adequate performance: to mobilise resources (tools, knowledge, techniques) in a social context (involving interaction with others, understanding, expectations) to achieve objectives appropriate to the contexts" (p. 19, our translation). It is necessary to consider metacognitive, literacy and numeracy competences in the course design not as fixed elements or acquired once and then valid for a lifetime (ISFOL, 2014); the choices of training and professional paths can over time influence the skills levels.

Furthermore, as surveys and researches have shown (Bowles et al., 2001; Heckman et al., 2006; Adhitya et al., 2019) there is a need to make room for studies that foster the relationship between cognitive and non-cognitive skills.

In this complex framework the role of motivation and engagement appears strategic in future research, in fact, the engagement construct "represents a clear recognition of factors related to motivation (pleasure and interest in reading) and metacognitive aspects in learning processes. Similarly, engaging in mathematical practices is associated with proficient counting behaviour" (ISFOL, 214, p. 23, our translation).

At the same time, the academic success that in this research has been put in relationship with metacognition, literacy and numeracy, could be linked to the teaching methodologies used in the courses that, in particular, in our case involved the use of technologies because the degree course in Digital Education is delivered in blended mode.

More investigations providing the validation of the questionnaires and a larger sample, not only in the field of digital education, and integrating variables such as motivation and teaching strategies, will provide further insights into the complex framework of knowledge and basic skills for academic and professional success.

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