

Digitalizing value co-creation: how artificial intelligence redefines human-computer interactions in service ecosystems?

ABSTRACT

This paper adopts a broad definition of the technology-enhanced teaching and learning process (TEL), thus including not only teaching and learning in traditional education systems' settings, but also information and knowledge transfer among diverse stakeholders in a given ecosystem (TEL). This understanding of TEL is then inserted in the smart city context to examine how and to what extent in the inroads of, specifically artificial intelligence (AI) and cognitive computing (CC), may foster the process of value co-creation in TEL.

1. Introduction

Advances in ICT, followed by increasing velocity of business transactions and growing market uncertainty force companies to rethink and redesign their business orientation, processes and technology management strategies.

. The adoption of an integrated set of smart technologies may lead businesses to reframe their relationships with stakeholders, the modalities of resources integration and the human- computer interaction.

AI plays the key role in enhancing value co-creation in today's ICT-ecosystem. The question that remains is how organizational structures, strategies and relational modalities should be redesigned to fully exploit the potential inherent in AI, and in AI-enhanced solutions, and thus boost the process of value co-creation in ICT-

To address this question, this paper adopts the service ecosystems' approach, and employs it in smart cities context to examine how AI- and CC-enhanced solutions foster value co-creation in BTEL.

Regarding the methodological approach, this paper is based uses empirical research, based on qualitative exploratory approach conducted through case-study analysis, i.e. AI-enhanced educational projects implemented in selected (smart) cities in Italy are investigated. The value added of this research is twofold. On the one hand, a conceptual framework apt to identify and explain factors/mechanism behind value co-creation in AI-based ecosystems is developed. This framework will add to the discussion on how organizations can effectively implement AI-based solutions to support the emergence of new values that can reframe service modalities and practices to enable the constant transformation of ecosystems. On the other hand, it will offer a critical insight into projects implemented in selected smart cities in Italy. This in turn will be of particular value for the decision- and policymaking processes.

Keywords: artificial intelligence, value co-creation, service ecosystems view, smart cities, smart education, human-computer interactions.

1. Introduction

Digital transformation is changing and disrupting the norms, rules and practices that guide value creation by reframing actors' roles and connections, their attitude and orientation, the way in which they exchange resources (Appio et al., 2020). The application of technologies to business processes can reshape (and at the same time obstruct or improve) people's interactions and enhance their skills by giving birth to the co-development of new solutions that redesign traditional service provision and advance new means to manage old problems.

The advent of Covid-19 forces private companies, public institutions and administration to comply with an imposed technological evolution, that emphasized and speeded the complex process of digitalization of business models and organizational orientation introduced in digital era.

In this complex technological ecosystem, artificial intelligence (AI) can enhance the communication between providers and customers, help companies predict market changes and understand better users' behaviour. Hence, AI can contribute to boost the process of value co-creation (Huang and Rust, 2018; Leone et al., 2020). Over the past years, several studies explored the relationship between value co-creation, digital technologies and AI. However, there is still the need to detect how human-computer interactions can disrupt resources integration modalities and value co-creation in digital ecosystems through AI solutions (Kaartemo and Helkkula, 2018).

The implementation of an integrated set of technologies based on AI can introduce significant changes in actors' behaviour and in their interactions by leading them to co-create new value and to co-develop new social practices, rules and meanings.

The service ecosystems approach (Vargo and Lusch, 2010, 2011; Akaka et al., 2013), employed in extant research to observe how digital platforms enable the transformation of businesses (Leitafa et al., 2016), can contribute to analyse how to challenge social and economic crisis (Brodie et al., 2021) by providing a systems understanding of how value co-creation process can benefit from disruption by giving birth to new resource integration practices that influence systems' overall well-being during a global emergency.

Moreover, the ecosystems' view is adopted in smart cities research to analyse the mutual generation of value in multi-levelled contexts as the capability to recreate urban structure, processes and behaviours to deal with current and future hazards (Gotham and Campanella, 2010; McPhearson et al., 2015). Considering the multi-layered and networked nature of urban contexts, the conceptualization of smart cities as ecosystems permits to shed light on the transformative role of ICT and resources integration (Akaka et al., 2019; Lytras et al., 2021) in the redefinition of the interactions among actors and between actors and technology.

In urban ecosystems technology plays a key role in the enhancement of information and knowledge management, especially in services based on the provision of culture such as education and higher education, by redesigning the processes of culture sharing, the interactions students-scholars-management, the evaluation process for students and scholars.

Thus, the study aims at investigating: 1) how AI influences the micro (individual orientation and beliefs), meso (relational level of resources exchange) and macro (collective and institutional dimension) levels of exchange in context of smart education; 2) how AI modifies the ways in which value co-creation emerges and 3) how thus, the existing rules, institutions, interaction modalities that guide the provision of education services in smart cities evolve.

The empirical research is based on a qualitative exploratory approach conducted through a content analysis as an inquiry, which investigates the key projects implemented in Italian smart cities in the field of education through AI-based solutions.

The results allow at introducing a framework that conceptualizes the enabling factors for value co-creation in AI-based ecosystems by providing theory and management with relevant suggestions on how educational organizations can readapt their processes to comply with society's needs and evolution and to identify the strategies to engage users and orient their willingness to use technology to prevent the potential risks related to an inefficient use of these tools.

The study shows how the service ecosystem perspective provides managers with insights on the dynamics and multilayered nature of education system during a pandemic to understand how managerial flexibility, innovation, learning and knowledge sharing can provide companies with the opportunities to pursue growth after a crisis. The research advances an integrated perspective that explores how the application of AI can boost the traditional ecosystems' enablers for value co-creation (individual skills, value propositions, resource integration, institutions, etc.) to support the emergence of new values that can reframe service modalities and practices to enable the constant transformation of ecosystems.

The paper is structured as follows. In section 2, a brief overview is proposed to discuss the role of AI in value co-creation and the relevance of service ecosystems' approach as an interpretative lens

to examine value co-creation in context of technology-enhanced learning (TEL). Then, the methodology employed for the empirical research is presented. In paragraph 4, results are reported and discussed to derive a conceptual framework. Lastly, conclusion, implications and limitations of the study are introduced.

2. Theoretical background

To explore the key role of AI-based tools in the redefinition of contemporary education service, service ecosystems view is considered as the most appropriate theoretical foundation that can help redefine organizations as complex sets of resources integrating practices exchanged by co-creating actors connected through technology-mediated interactions (Polese et al., 2020a). The application of service ecosystems view can highlight the value added of systems' capabilities to adapt and pursue continuous improvement to survive environmental changes and can enhance the analysis of a variety of ICT-enhanced smart city solutions to explore human behavior including intentions, attitudes, citizens' digital competencies and willingness to use technology.

Smart cities are multi-layered systems of actors, relationships and technology embedded in urban contexts and can be reconceptualized as ecosystems to shed light on the transformative role of ICTs and AI in the processes of resources integration (Akaka et al., 2019; Lytras et al., 2021) and in the interactions among actors and between actors and technologies (Kashef et al., 2021).

For this reason, the section defines, firstly, the potential influence of the use of AI-based tools on value co-creation (paragraph 2.1) and analyzes, secondly, the impact of technology-enhanced learning solutions based on AI on value co-creation (paragraph 2.2) in smart cities, which are reframed as ecosystems (paragraph 2.3).

2.1 Artificial intelligence: the impact on service management and value co-creation

AI is a branch of computer science that introduces machines that simulate human intelligence and that are capable of analyzing their environment and taking actions with a certain degree of autonomy to achieve specific objectives (Dobrev, 2012).

AI-based systems can be based on software and can be situated in real life contexts (voice assistants, image analysis software, search engines, voice and facial recognition systems) or can be embedded in hardware (advanced robots, autonomous cars, drones or Internet of Things applications). Through AI, computers can reproduce and be engaged in human decision-making and can undertake appropriate decisions without human involvement (Syam and Sharma, 2018; Black and Van Esch, 2020).

The ability of AI-based tools to boost human actions and decisions can potentially produce relevant impacts on management and business decision-making.

Smart technologies based on AI and robots can help companies satisfy the needs of a heterogeneous set of actors (e.g., managers, co-makers, policymakers, customers) by generating virtuous value co-creation, increasing market knowledge (Paschen et al., 2019) and promoting the co-development of new solutions and service innovation (Huang and Rust, 2018).

AI-based solutions can be customer-centric (Vargo et al., 2008; Leone et al., 2021) and can mediate individuals' experience of value by improving customer journey (Følstad and Kvale, 2018) and boosting the quality and quantity of internal and external knowledge exchange through horizontal collaborations (Paschen et al., 2019). The possibility to collect and analyse in real time customers' information, data, and feedback can multiply the positive effects of AI by enriching the competencies of actors and improving the effectiveness and innovativeness of the provided solutions.

In light of the diverse benefits offered to service delivery and management, AI and cognitive computing can boost/enhance the learning and teaching processes through advanced tools and technologies that can satisfy more efficiently and promptly the growing needs of students by

providing them personalized learning experiences (Sabherwal and Becerra-Fernandez, 2013; Lytras et al., 2018).

Education service can benefit from the application of AI through a series of technologies and systems based on robotics, machine learning, augmented reality, big data analytics for the automation of teachers and students' daily activities.

In Covid era, the introduction of remote learning to comply with the mobility restrictions imposed by the pandemic shows how teachers and students need not only new technological solutions but also new digital skills, both in emergencies and in daily activities (such as tutoring, exams, evaluations, etc.). AI is applied in the educational field through the automation of administrative and routine activities and intelligent systems that administer texts and exams, update attendance and absences in real time, manage the schedule of lessons, evaluate the level of skills acquired by students and the quality of teaching. Moreover, artificial teaching assistants are able to follow the students individually, by proposing them selected contents and concepts to help them develop their skills, to deepen their knowledge, or to reduce the gap with their peers.

Even if only the interactions with other humans can guarantee the effectiveness of learning processes, AI-based tools should not replace human intervention but should boost teachers' activities and teachers/students interactions by intensifying human learning and ensuring that educators themselves lead the transformation.

The use of artificial intelligence in education is promoted also through a series of international and European projects in smart cities context. Public Administration can benefit from the adoption of AI solutions in different sub-systems, from healthcare to judicial systems, public employment and security and in general in the management of relations with citizens. However, education is one of the most affected sectors that has been heavily redefined by the application of AI.

In Italy, the task force of the "Digital Italy Agency" introduced in 2018 a White Paper on Artificial Intelligence to help community understand how the spread of new AI tools and technologies can affect the building of a new relationship between the state and citizens. In particular, a lot of AI-based solutions are identified to support the digitalization of teaching and learning process to foster the development of smart education: automatic tools for evaluation; customization of teaching material; automated tutoring (with live suggestions regarding personalized in the school program); extraction of predictive indicators of the risk of school dropout. Hence, it can be noticed that AI can reframe the delivery of education service systemically: 1) in each phase of delivery: from the pre-delivery to the resources integration and post-delivery; 2) for each actor: from teachers to students to staff and administration; 3) at individual, relational and community level: from the enrichment of users' skills to redefinition of users' interactions and the creation of new rules for the community as a whole.

2.2 Technology-enhanced learning and smart education

The restrictive measures dictated to manage the spread of Covid-19 and to comply with the requirements of social distancing have emphasized new aspects of urban organization, by encouraging the research for new intelligent solutions. In particular, these disrupting changes require that organizations, businesses and public administration are able to carry out new "online" activities such as smart working, distance learning, e-commerce and the digitalization of different public services.

Hence, the digital transformation of Italian cities after the advent of the pandemic received a boost that allowed to overcome any organizational and cultural resistance to the application of technology to daily lives and work. Not only cities that were already at an advanced stage confirmed the progress in their level of smartness, but also the less smart cities (such as cities in the South of Italy) introduced new technologies by entering for the first time the Rankings of Italian smart cities (see Ernst & Young's Smart Cities Index 2020).

Smart technologies impact the different areas of smart cities, from mobility to security to healthcare and communication system. However, this study focuses on education sector, which is strictly

focused on the provision of knowledge and in which the impact of technology seems to introduce new rules for the interactions among actors. The concept of *technology-enhanced learning* (TEL, Whand and Hannafin, 2005) has been introduced to conceptualize the implementation of technology-based learning and instructional systems through which students can acquire skills or knowledge through the support of teachers or facilitators such as learning support tools and other technological resources (Aleven et al., 2003).

Service delivery in higher education can be defined as an experiential kind of learning structured in terms of students' educational experiences in organised community, which are based on interaction activities characterized by the sharing of meanings, languages and an internalized culture aimed at meeting system community goals (Erasmus and Albertyn, 2014; Lazarus, 2007).

For this reason, due to the systems and interactive features and to the cultural nature of the service offered, grounded on the exchange of knowledge, know-how, skills and capabilities, Higher Education can benefit from the application of *service ecosystems view* (Vargo and Lusch, 2010, 2016; Akaka et al., 2013). Service ecosystems view is a systems perspective introduced in Service-dominant logic (*S-D Logic*, Vargo and Lusch, 2008), which understands service as the glue of resource integration among engaged actors that, through a complex set of technology and ICTs-enabled interactions, can co-create value.

In the last decades, service theories redefined organizations as many-to-many networks (Gummesson, 2004) in which reticular interactions and multiple relationships are managed through human action and information technology (Gummesson, 2008). In line with the last development in service research, service ecosystems view (Chandler and Vargo 2011) reframes organizations as embedded systems of actors that exchange resources more easily thanks to technology and based on the constant redefinition of the institutions and rules that coordinate exchanges (Vargo and Lusch 2011; Spohrer et al. 2012) to co-create new value, new practices, innovation (Grieco and Cerruti, 2018). Value co-creation is intended as a process emerging from the combination of multi-levelled transformations at micro (individual), meso (relational) and macro (institutional) levels of exchange (Vargo et al., 2015).

In particular, the application of service ecosystems view to education sector highlights that the concept of cooperative learning can be matched with knowledge and value co-creation, the cornerstones of the entire ecosystems' architecture. Moreover, the concept of reciprocity in teaching and learning fits well with the win-win logic of mutuality that encourages ecosystems actors to co-create value and multiple benefits for the different co-creators (students, teachers/scholars, top management) engaged.

2.3 Reinterpreting smart cities as smart service ecosystems

Service ecosystem perspective can provide some insights into the dynamics and multilayered nature of education system during the resolution of a global emergency and can enhance the understanding of the relevance of managerial flexibility, innovation, learning and knowledge sharing, which offer the opportunities to develop resilience.

The application of ecosystems view to the analysis of smart cities can contribute to reveal the mechanisms that enable efficient strategies for emergencies management through the enhancement of technology-mediated interactions and value co-creation for the development of innovative practices (Troisi et al., 2017; Visvizi and Lytras, 2019). Moreover, the application of service ecosystems view can enable the understanding of how education can be managed as complex system in which many actors (students, teachers, researchers, managers, policymakers) interact to co-create value and engage each member as an active co-creator (Díaz-Méndez et al. 2019). Reframing smart cities as service ecosystems can allow the identification of the different kinds of technologies and human behaviours (intentions, attitude, citizens' digital competencies and willingness to use technology) that can act as key enablers for the creation of new rules to

coordinate exchanges and interactions and for the transformation of crisis into opportunities and innovative solutions.

As Figure 1 shows, the three contexts of ecosystems (Vargo et al., 2010; 2015; Akaka et al., 2019) can be applied to education service in smart cities.

The micro-level is composed of individuals' intentions, attitudes, cognitive processes, value perception, skills and resources and can be intended as a subjective sphere in which each actor has her/his cultural background, opinions, beliefs and personal meanings and develops a given attitude toward learning and co-creation and a willingness to engage and share resources and experiences. Moreover, each participant has a different degree of digital knowledge and a different predisposition for the use of technology.

The Meso-level is the intersubjective sphere of relational and social connections between actors in which students, teachers, organizations, institutions integrate resources through interactions that form and reform their mind-set, knowledge personal beliefs and values according to a constant modelling and co-creation of meanings. At this level, actors interact with each other and with technology through human-computer interactions (HCI), the two-way information transfer between human and computer-enabled smart systems (Chang et al., 2018; Streitz, 2018)

The macro-level refers to the collective sphere of the ecosystem's general community (public administration, institutions, legal system, etc.), in which the new co-created meanings, the new practices for teaching, learning and evaluation are disseminated, accepted and incorporated into the wider educational and social context to become institutionalized practices.

The transition from micro to macro context, that can be defined as an "evolution" from subjective, to intersubjective and collective value creation processes can enable the transformation of the renewed value and knowledge to develop innovation incrementally.

Figure 1. The enablers of value co-creation in smart cities ecosystems

Therefore, in the light of the reinterpretation of smart cities as service ecosystems and of smart education as a complex set of technology-enhanced learning systems that can be based on AI solutions, the study aims at addressing two key issues:

RQ1: How can AI-based tools for learning and teaching influence value co-creation in urban ecosystems at micro, meso and macro levels?

RQ2: How can AI-based tools for education modify the way in which urban ecosystems arrange and develop value co-creation practices by introducing novelties (new rules, institutions, interaction modalities) in the delivery of education service?

3. Methodology

To respond to the two research questions introduced above, the empirical research analyzes the sector of smart education in Italian cities by collecting information on the new AI-based learning and teaching tools and strategies implemented after and before Covid-19 pandemic.

Data is collected from Italian municipalities and smart cities official websites, European Union and smart cities strategic documents and official statistics available on the Internet. In particular, the “White Paper on Artificial Intelligence at the service of the citizen” edited by the Task Force of the Digital Italy Agency in 2018 and “Italy AI 2020 Strategy Report” have been analyzed and integrated with the information gathered from the single websites of Italian smart cities (such as Trento Smart City or Turin Smart City).

The work adopts an exploratory qualitative approach based on a content analysis as inquiry (Losito, 1996), which allows at extracting from the texts (the unit of analysis) a smaller number of categories and to detect some focal points and key concepts (Krippendorff, 2004) related to the different variables investigated through the application of semantic criteria established by the researchers.

The content analysis detects the main ecosystem’s enablers that can help Italian smart cities (intended as ecosystems) that employ AI-based tools survive the environmental changes through the enhancement of value co-creation processes in education (RQ1). Then, starting from the identification of the main enablers of value co-creation in the three ecosystems’ contexts, the new kind of novelties generated (RQ2) in education ecosystem are investigated. The goal is to classify some drivers that can support contemporary educational ecosystems (schools and higher education) in the management of crisis, environmental turbulence and technological and market evolutions.

Therefore, based on the key enablers of value co-creation in service ecosystems at micro, meso and macro-contexts introduced in the previous paragraph, the content analysis sketch has been designed according to the key variables and sub-variables shown in Table 1.

Table 1. Variables, keywords and content analysis sketch

Variables	Keywords	Content analysis sketch
RQ1: MICRO-LEVEL		
	Individual Beliefs Skills Attitude Participation Willingness to engage	1) Do the engaged actors own proper digital skills? 2) Do the actors engaged own a smart attitude? 3) Are the actors engaged in a cultural background based on smart 4) Are the actors favourable to the use of smart technologies?
	Technologies Information and communication technologies Big data analytics Cloud computing systems Data mining Recommendation systems	1) Which are the key technologies based on Artificial intelligence employed to foster individual’s transactions? 2) Which are the key technologies based on Artificial intelligence employed to improve individual’s digital skills? 3) Which are the key technologies based on Artificial intelligence employed to improve individual’s willingness to engage?
RQ1: MESO-LEVEL		
	Interactions Social connections Experience Resource integration Engagement Collaborative decision-making Co-development/Co- design	1) Do the engaged actors interact with each other to exchange resources and knowledge? 2) Are actors (students) involved in the co-design of the offering and/or in the co-development of educational service? 3) Are actors co-creators of other actor’s (students/teachers) learning experience?
	Technologies/ ICTs Big data analytics Platforms Learning experience Augmented reality	1) Which are the key technologies based on Artificial intelligence employed to foster students/teachers experience? 2) Which are the key technologies based on Artificial intelligence employed to improve the delivery of education service (lessons, courses, exams)? 3) Which are the key technology based on AI

		employed to simplify the relationship between humans and computers (HCI)?
RQ1: MACRO-LEVEL		
	Educational value Smart culture Learning and teaching culture Learning approach Social inclusion Digital democracy	1) Are the values of the entire educational community enriched and renewed after the development of the smart project based on Artificial intelligence? 2) Do the actors re-design their culture and enrich their digital skills through the mutual exchange of knowledge? 3) Are the digital culture of community and the access to technology improved after the development of the smart project based on Artificial intelligence?
	Mobile devices, sensors and applications Gamification	1) Which are the key technologies based on Artificial intelligence employed to foster the digital culture of the educational community? 2) Which are the key technologies based on Artificial intelligence that support the removal of barriers to digital access? 3) Which are the key technologies based on Artificial intelligence that support the introduction of new learning practices?
RQ2: NOVELTIES CO-CREATED IN THE ECOSYSTEM		New or improved:
Micro- level	Potential kinds of innovation at an individual level	-Individual skills -Willingness to adopt smart technologies -Attitude toward technology
Meso-level	Potential kinds of innovation at an intersubjective level	- Modalities of actors-to- actors interactions and HCI - Ways to experience learning/ teaching service - Modalities for resources integration
Macro-level	Potential kinds of innovation at a collective level	- Smart culture for technology-enhanced learning - Rules for teaching and learning - Educational mind-set

Regarding the first research question, the main enablers of value co-creation in service ecosystems (discussed in paragraph 2.2) are employed as macro-variables that can guide content analysis. The outcomes of the co-creation are then investigated (DR2) to detect the new values (interaction modalities, rules, etc.) produced within the education ecosystem. For the investigation of the different types of novelties generated, the sub-dimensions identified in the literature review (reported in paragraph 2.2), i.e. new attitude for organizations, new interaction modalities, new skills for people, new capabilities are considered as enabling factors for the emergence of innovation (Troisi et al., 2021).

The texts have been explored through complex process of semantic interpretation. The variables investigated have been sub-divided into keywords to facilitate the search for topics and sub-topics within the text, which are then further specified in some sub-dimensions for each variable. The textual units are coded independently by three researchers based on a substruction process (Dulock and Holzemer 1991), which follows a synthesis approach that mediates between deduction (from general variables to specific keywords) and induction (from keywords to further specific sub-dimensions).

4. Findings

4.1 RQ1: Value co-creation through AI-based tools

The main results obtained from the analysis of the textual units collected through data gathering have been interpreted by researchers in order to classify the different technological tools based on AI that are employed in current smart education system in Italy to renew the value co-creation practices in teaching and learning process.

4.1.1 Micro-level: Access to technology and digital skills/attitude

At micro- level, the smart education ecosystem employs a set of technology aimed at engaging students and at providing them with training activities to use digital tools and with psychological support, through live chat for assistance and for student orientation.

The delivery of education service online requires changes not only in the methods of provision but also in the rethinking of service/business digitally, as a new way of doing education and culture. The technology employed to engage students are AI-based tools that support individual study, as self-assessment tools through the automatic drafting of additional exercises and virtual queries.

Through “Leonardo Project”, a fundraising for Group employees in Italy with the aim of supporting a broad program of digitization, Italian schools have been equipped with new personal computers and tablets for children and young people that will continue and start lessons through distance learning.

Moreover, multisensory technologies, such as social robotics are used to promote learning and relationships in children with autism spectrum disorders, with Special Educational Needs (BSE) and Specific Learning Disorders (SLD).

For instance, Mathisis (Managing Affective learning through intelligent atoms and smart interaction) is a project that involves Italian public schools of first and second degree funded by the European Commission under the “Horizon 2020” program and includes 18 European countries.

A support platform is created through to boost teaching for children with ASD, ADHD, autism spectrum and multiple disabilities. The platform, connected to a webcam, a tool for motion recognition and a gyroscope, using AI techniques of affective computing recognizes the moods and attention levels of students and, based on these, increases or decreases the degree of difficulty of the exercise. The project was tested on a sample of Italian public schools from first and second grade, involving just under a hundred students. According to the first results of the experiment, the use of this platform has improved the route of the app. In the last advancements of the projects in 2020, the platform has been employed for distance learning and for students online orientation.

4.1.2 Meso-level: improvement of learning experience and human-computer interactions

At the intersubjective meso-level, Italian smart cities employ a series of integrated technologies that permit teachers to support students in the fulfillment of daily activities (courses, exams, thesis elaboration, etc.) towards the accomplishment of shared goals.

The technologies adopted to improve actors-to-actors and human-computer interactions are experiencing tools, such as platforms and mobile applications for synchronous online teaching and learning in real-time that overcomes any restrictions of time and distance. The learning technology tools for course interaction (such as Teams, Zoom), that can support teacher and students in creating an interactive atmosphere in class during and after the lesson, can be boosted through AI.

To simplify human-computer interactions, AI-enabled learning management systems (LMS) can deploy surveys to categorize individuals into distinct learning buckets (e.g. visual, auditory, text), which can provide effective and targeted content that fits with each preferred learning style.

For instance, Brainly is an online platform where students can easily collaborate and work together by sharing knowledge, answering each other’s questions, and helping solve difficult problems. Brainly personalizes the tech-powered setting to create a classroom-like environment.

Moreover, in Italian education system Century Tech, a platform for teaching and learning through artificial intelligence, is widely employed in schools and universities. The platform is based on artificial intelligence, neuroscience and learning sciences to create constantly pathways for students and provide useful assessment data for teachers. Century Tech offers free support to all schools closed due to the Coronavirus epidemic. Students can have access to a lot of resources for learning English, math and science, with the support of artificial intelligence engine that creates personalized learning paths for each student, identifies gaps and correct errors.

IRS platforms permit students to answer questions by raising their hands and to respond to teacher’s questions. Moreover, statistical data can be generated in real-time to allow students at evaluating the learning status of teachers through reviews and improving the teaching efficiency. After students answer questions through the IRS system, the teacher can present the results in a visual chart; in this way, not only the single students can improve learning, but also other students can clarify the concepts.

IRS platforms based on AI are capable of processing user questions and answering them in real time, by offering reasoning, advice and clarification to these questions. In addition, Artificial Intelligence will help users discover new teaching materials, by suggesting various training assets and eliminating the manual activities necessary to carry out this task.

In addition to automating processes, Artificial Intelligence can provide students with new training contents for a specific type of user, by analyzing the information available through online systems, such as video platforms (eg Youtube, Vimeo) and online marketplaces for training and teaching (eg LinkedIn Learning). AI is able to scan social platforms (e.g. Slack) and learn how specific Q&A content or threads have generated positive results that can be applied to new tasks, providing users with new personalized training opportunities.

There are a lot of IRS-based tools that can enable value co-creation among students and between students and teachers. For instance, “Kahoot!AS” and “Menti” are used to collect students’ qualitative and quantitative ideas in the classes. By providing their insights and by visualizing other students’ suggestions, a process of co-innovation can start in which each member can improve the service. This is an automatized version of the “raising hand” activity which permits to collect simultaneously ideas from every student, to store them and to re-elaborate them for the proposal of new service, extension of the programme.

Lastly, augmented reality provides the possibility of creating new innovative, inclusive and engaging educational environments, capable of encouraging interaction with and between students, by combining training needs and technological innovation.

4.1.3 Macro-level: monitoring and control for continuous improvement

At macro- level, the learning technology tools for teaching and course evaluation permit students and teachers to self-evaluate performance and enhance continuous improvement. In this way, new teaching, learning and evaluation practices for scholars and students can be developed to catch constantly opportunities for service innovation and continuous improvement

The tools employed to assess students’ and teachers’ performances and students’ opinion on the education service allow at administering online surveys on the satisfaction of courses and exams, at monitoring students access in user areas, at tracking users’ behaviour on internet, at collecting data on students and on teachers’ performance.

For instance, “110 Cum Laude” is a software based on MorphCast AI-based neural networks that works directly from the Web. It allows at monitoring the class during online lessons. The teacher can check in real time if students are distracted, if there is an identity fraud or if there is a lack of attention. Through a digital dashboard the wholeclass is always monitored in real time, without the need to record the lesson. On the other hand, the tool allows to detect whether students are cheating during an online exam session. The app makes it possible to detect the presence of a prompter near the student, the position of the head and the trajectory of the look, perhaps in the direction of hidden notes. The possibility of discovering prompts not framed by the webcam, through the recognition of the tone of voice typical of the whisperer, is also being developed. The platform has been designed in such a way as to be as flexible as possible to process quickly also data from future consultations.

The availability of Small Data support teachers in the identification of the strengths and weaknesses of student learning and in the creation personalized contents. For students, having data would mean increasing awareness of their progress and self-knowledge in relation to the work done. Big Data and predictive analysis play a key role in the elaboration of educational policies and can strengthen education systems by intensifying the digital skills required in the world of future work.

4.2 RQ2: The different kinds of new co-created value

The key findings reported to address allow at identifying a series of AI-based tools that can improve technology-enhanced learning and teaching by encouraging engagement, experience, co-learning and boosting value co-creation and co-learning process.

The implementation of the different technologies detected in the previous paragraph fosters the development of novelties in Italian smart education ecosystem at micro, meso and macro-levels.

At micro-level, an integrated set of AI-based tools can enhance the ability-propensity of students and teachers in the use of technologies based on the enrichment of their digital background and of their level of digitization by trying to remove any possible resistance in the use of digital tools for learning.

At meso, level, the use of AI-based learning management systems can deepen learning experience and encourage the sharing of knowledge to obtain new knowledge and co-create learning (*co-learning*). The use of these platforms can deliver learners' feedback to teachers by helping them gain real-time perceptions of the students' understanding of the course and enhance students' motivation. Cooperative learning, a common concept in education, can be translated into co-learning (co-created learning) according to the principles of service ecosystems view. In this way, new ways of exchanging knowledge and creating new knowledge are generated. Students and digital natives can provide teachers with their experience due to their familiarity with the Internet and with ICTs. Thus, these tools can permit the full realization of the essence of co-learning: education does not imply the unidirectional sharing of knowledge (from teachers to students) but empowers the enrichment of both students and teachers experience, know-how, tacit knowledge, culture and beliefs.

At macro-level, the introduction of new automatized teaching, learning and evaluation practices for scholars and students can develop constantly the opportunities to promote innovation and pursue continuous improvement. The novelties emerged at macro-level can be: 1) new approaches to the delivery of education service, that can become stable practices over time and can be maintained even after the restarting of teaching in presence; 2) a new smart culture for training and learning that redefines languages and shared meanings between students and teachers. Starting from the collection of students' opinions and behaviours, teachers can make decisions based on data and adjust teaching according to the information extracted. Data on teachers' and students' performance is also stored and analyzed through data mining techniques to discover and obtain knowledge from databases, to support the analysis of student learning processes and the evaluation of the effectiveness and usability of online courses.

Hence, it can be noticed that the continuous improvement of the smart educational ecosystems can lead to the re-institutionalization of the new rules and modalities for interactions and service delivery that can lead to the emergence of innovation by allowing organizations at transforming the limitations posed by global crisis into an opportunity for innovation.

5. Discussion

The results obtained through content analysis show how the use of AI-based tools for smart learning can help educational organizations overcome the limitations posed by global emergency through a constant re-adaptation of interactions, relational modalities and value. The constant state of transformation in educational ecosystem ensures, on the one hand, systems continuity and establishes, on the other hand, a proactive tension to innovation (Baccarani and Golinelli, 2014).

As discussed above, the redefinition of value co-creation through the introduction of Artificial intelligence can reframe the education ecosystem at micro, meso and macro-levels. At micro-level, actors' digital attitude, skills and willingness to use technology are improved. Then, at meso-level new modalities of teaching and learning emerge from processes of co-learning and co-creation of new knowledge. Lastly, at macro-level, the new emerging modalities, practices and rules are re-institutionalized and accepted as established ecosystem's elements guidelines (macro).

After a new modality of provision and of interactions is accepted at meso-level, it becomes institutionalized (at a macro-level) and can be turned into a permanent practice, by enriching users'

beliefs and improving their attitude toward technology program (at micro-level) and can become a commonly shared practice within the entire education ecosystem.

In Italian education ecosystem, new ways for designing, planning and delivering the educational offering, for interacting with students and for improving teacher's performance have been introduced to challenge the emergency and respond to the crisis. These novel practices, advanced at first as contingent "tactics", can be considered unexpectedly as "better" than the old ones. For instance, online teaching can be more immediate and can guarantee more simple interactions with students and colleagues, can help the reduction of costs for travels, increase students' attention during the lessons and their capability to boost their ability to learn concepts (with the opportunity to listen to the recordings of the lesson).

Therefore, the findings obtained allow at elaborating a conceptual framework, depicted in Figure 2. The process of re-institutionalization is represented through the bidirectional arrows that connect the three ecosystems' contexts, the so-called downward effect (Peters, 2016). At the beginning, the emergence of online delivery method for lessons and exams is tactical, forced by contingencies (at meso-level); then, it is institutionalized at the macro-level and becomes an established practice that can "come back" to the micro-level, in which it can become an integral part of the education service.

Figure 2. The enablers of value co-creation in smart education

At the end of the process, innovation ecosystems can attain distinctiveness through systematic co-learning (Austin and Hopkins, 2004) and the continuous renewal of knowledge. The new attitudes, services (micro), relational modalities or institutions (meso-macro) produced can reshape and change the ecosystem as a whole, from a technological, cultural and social point of view to establish a constant proactive status in which the new knowledge and social values created are "stored" as new data within the systems, re-elaborated and transformed into new rules and institutions (Sitaloppi et al., 2016; Troisi et al., 2020).

Hence, as Figure 2 shows, innovation is spread across ecosystem's contexts, by enveloping individual intentions and orientation (micro-level), social networks of interactions (meso-level) and ecosystem culture (macro-level). Therefore, proactiveness and transformative state in ecosystems can act as engines for changes and continuous improvement.

6. Theoretical and managerial implications

The framework introduced can help management, practitioners and scholars understand: 1) how technologies based on AI (which kind of tools) are employed to challenge pandemic and perform online teaching and learning in education ecosystem; 2) how ecosystems adaptation can lead to the introduction of new practices and institutions for teaching and learning that can change durably (in the long- term) the relational modalities of education service.

The work advances theoretical advancements on the classification of the different technological tools that can support the provision of education services in the different moments of service provision and across the different resource integration and knowledge exchange involved in value co-creation and co-learning processes.

The identification of the enablers of societal changes and of the potential new interaction modalities and main strategies to challenge the pandemic can help scholars and practitioners identify the key drivers to overcome social and economic crisis. Moreover, the elaboration of a framework that analyzes how technology can redefine humans' interactions and human-computer interactions and can address a gap in literature related to the absence of studies exploring the role of technologies in reframing social connections within a community (Lytras and Visvizi, 2018).

Thus, the framework proposed can help identify how social, economic and health emergencies can enable the achievement of continuous transformations and changes within ecosystems by developing multiple innovation processes to be regenerated over time (Polese et al., 2020b). In detail education managers can understand: 1) how the use of different kind of technologies can help redefine the interaction modalities between and among students, teachers and community to challenge the global epidemic; 2) the key ecosystem's enablers for social changes and the development of different innovation opportunities through crisis resolution.

7. Conclusion

The economic, relational and social transformations determined by the active resolution of Covid-19 can change, probably definitively, the nature of interactions and collaborations between users and providers (Velotti and Murphy, 2020), citizens and public organizations by emphasizing that the application of technology (Ugolini, 1999), properly combined with human intervention (Azoulay and Jones, 2020), is the only way to manage unexpected phenomena.

To clarify the opportunity and challenges deriving from Covid-19 management through technology, the findings of the study show how ecosystems (multi-levelled and network) organizations can overcome the sanitary emergency through AI-based tools by investing in relationships and value creation strategies that can give birth to the creation of new knowledge, rules and institutions (Gummesson, 2017a; Gervilla et al., 2020).

The study explores the key enablers for the redesign of actor's interactions, service provision modalities and technology use in contemporary organizations which aim at complying with the challenges posed by Covid-19.

Through the interpretative lens of service ecosystems view, the context of smart education is analyzed to detect: 1) the main drivers for ecosystems re-adaptation to challenge the technological requirements imposed by the mounting technological evolution; 3) how these drivers can be activated to enable innovation as a result of the complex transformation of the crisis into innovation opportunities.

The adoption of ecosystem perspective allows to investigate: 1) the "which" dimension: what are the different technologies, interactive methods, knowledge, skills, orientation to technology use capable of transforming the crisis into opportunities; 2) the "how" dimension: the way in which the

enablers can be combined to develop a proactive attitude, which mediates between propensity for change and consolidation of practices, between flexibility and elasticity (over time), in order to allow the transition from the challenge to global emergency to the emergence of innovation. Thus, ecosystems view permits not only to grasp the different types of technologies and institutions that can enable innovation but also to grasp the most appropriate strategies for the exchange of resources and for the continuous readaptation of organizations.

Further studies can employ the framework proposed through grounded theory according to a constructivist approach, a method usually employed in education sector, which provides researchers with the possibility to explore how the enrichment of knowledge can be enhanced gradually through multiple research steps and different phases of observation, in which the new knowledge acquired and the changes in the relationships between actors can be assessed in each step according to an incremental methodological procedure.

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