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Towards a Value Co-Creation Process in Collaborative Environments for TVET Education

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Abstract: The appearance of the COVID disruption has proved the need for rapid innovations in education, with new value proposition(s) able to capture the new activities involving value co-creation in the education service systems. This paper introduces a conceptual framework for skills building in collaborative TVET online communities that integrates the Collaborative Knowledge Sharing Environment (CKSEnv), an ontology-based collaborative development of knowledge-intensive services, as a possible main driver for value co-creation amongst actors in the after-pandemic TVET education. CKSEnv's usability and usefulness in achieving its goals is evaluated. Quantitative and qualitative data collected through interviews have revealed respondents' interest in topics such as the sustainability, usefulness, usability, value co-creation, and technical functionality of the proposed development. Both the utility and simplicity proved to have the most significant impact on CKSEnv adoption and usage. A new service design artifact is created, the smart service model canvas in the TVET online communities, to explain the new value co-creation process, which is able to fill gaps in describing the role of ICT in supporting the TVET training cycle. This research may ground further explorations related to the development of TVET online communities, while the CKSEnv is still in the evaluation stage. The practical implications of this study express the need for new value co-creation processes with specific activities that use technology-driven innovations, able to establish such newly created value, through smart educational services.

Keywords: knowledge commons; online community; ontology; TVET education; smart service; smart citizen

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1. Introduction

Technical and vocational education and training (TVET) is a component of education that involves, in addition to traditional general education, acquiring practical skills, attitudes, understanding, and knowledge by actors in various sectors of economic and social life [1]. The field of TVET is intended to face the need for new human competencies, i.e., the requirements in the workforce while transitioning from the industrial age to the information age [2,3].

TVET, as a job-oriented education [3], has a substantial role in a country's development and prosperity. It has an important role in reducing youth unemployment and providing an opportunity for lifelong learning. It can take an important role in improving job opportunities for young people, especially for disadvantaged ones [4]. According to Eurostat [5], there are several European countries whose youth unemployment rate exceeds 20%, such as Italy, Serbia, or Turkey. At the same time, the rate of early leavers from education and training in Europe in some countries, such as Germany, Spain, Italy, Romania, and several others, has not met the targeted rate of fewer than 15% [6]. In these cases, TVET is seen as an opportunity for lifelong learning, preparing the young generation for the employment market [1].

Because of the TVET's role in youth employment, education equity and equality, and economic growth, TVET has been included in the 2030 agenda for Sustainable Development

Goals (SDGs: 4, 13) [7]. To achieve the aims of the SDGs, there is a need to implement innovative solutions able to develop cultures and agile governance, as described in the smart cities concept perspective, a construct that utilizes ICT for sustainable development through learning, creativity, innovation, and value creation [8]. Therefore, there are various attempts today to explore how smart cities initiatives may help accelerate progress towards the fulfillment of the SDGs [9–11] and how the SDGs may serve as a guiding framework for setting smart city objectives upfront [12,13]. Additionally, there is a deep need to strengthen the theoretical and methodological linkage between the smart cities concept and SDGs [8,14,15].

Education is crucial in achieving SDG-11, sustainable cities and communities [16], because it can prepare communities to manage their resources properly and to proactively participate in improving their life in their cities. Today, technology and technology acceptance are the key elements for creating smart, sustainable, resilient, and citizen-centered cities [17]. Nevertheless, it the gap between current and future skill demands that are required in the complex ecosystems of innovation and services is acknowledged today, i.e., the smart cities service ecosystem, where information and communication technologies (ICT) are used to help citizens and organizations deal with various challenges in the current society [18–21].

According to the World Economic Forum 2020, 85 million jobs will be displaced by automation and technology advances by 2025, while data analysts, machine learning specialists, and robotics engineers are the main roles envisioned for a growing number of future jobs [22–24]. Therefore, the focus in TVET should be on building digital and technical skills in this respect, as well as traditional skills, including entrepreneurship, learning how to learn, communication, foreign language, and teamwork [4,25].

Learning communities, along with competency-based education, are the most common pedagogical approaches in the smart learning environments [26]. Learning communities may offer innovative education and training opportunities for skills building to overcome the smart cities' challenge of creating a sustainable and liveable future and preparing citizens for this future [27].

1.1. Motivation for Upskilling and Reskilling in TVET

New technology comes with challenges that require new or updated skills to overcome them. The invention of the smartphone, for example, increases the demand for new sets of skills, such as mobile application development skills, skills to prepare the infrastructure supporting this technology, marketing-related skills, and skills to develop new business models that utilize and benefit from this technology. Another contemporary example is the development of electric cars, which is shifting the market toward new smart technologies able to benefit from this innovation and the change in the infrastructure. Therefore, this changes the employment market by increasing the demand for smart application development skills. Scholars predict that, in the next few years, autonomous cars will dominate the market, thus increasing the demand for technologies like IoT, AI, or communication in the 5G networks [28].

Additionally, disasters and pandemics play a role in shifting the employment market [29]. The COVID-19 pandemic, for example, has been changing the education process that became more dependent on technology. A mandatory dependency on the eLearning platforms and the online meeting applications has been created [30]. Thus, the demand for skills related to the online presentation of curriculum and study materials has increased dramatically [31]. The education process itself has been affected by the pandemic, and the skills related to maintaining students' motivation toward the education process and keeping them involved became more relevant in the current context [32]. In addition, a trend emerged toward adaptive and personalized learning technologies, learning analytics, and open educational resources technologies [33]. Furthermore, the COVID-19 pandemic revealed a knowledge gap related to technology usage, online teaching, work-based learning, and other components able to help TVET mitigate the effect of the COVID-19 pandemic upon shifting to online classes [25].

It is evident that these changes in skills are demanded over time, and this is a part of our evolution as humans. There is a constant need for learning new skills, acquiring knowledge, and using this knowledge to understand and create new technologies. Those technologies require new skills themselves, and so on, creating an "Innovation Wheel". We need skills to ***R***un the technology, so we need to ***T***ransform our available skills and acquire new ones. In this process, we discover new or better ways (technologies) to perform our activities, resulting in ***I***nnovation. Thus, the wheel keeps going on [34].

Therefore, actors in society need to learn and obtain new skills continuously, iteratively, and commit to a lifelong learning engagement, especially in domains related to information technologies [23,24]. These domains are rapidly evolving, and skills that were useful five years ago are less useful today. Of course, we do not ignore the importance of those skills in learning new skills and upskilling [24]. Each time the actor updates his or her skills makes it easy for future upskilling by reducing the gap between his available skills and the skills demanded by the employment market [35]. For example, if we could travel in time to 1980 and give a smartphone to a person, it will be harder for him to learn to use it than a person in 1990 or 2000. The smaller the gap between the actor's available skills and the contemporary required skills, the easier will be for him to learn and upskill.

1.2. Approach

Recent literature reveals the existence of a knowledge gap in describing the role of ICT in supporting the TVET training cycle, such as [23,25,30,36,37]. Moreover, there is a lack of studies that target important areas of the TVET training cycle, such as education monitoring and evaluation, teachers' training, trainee assessment, and career guidance [23]. ICT is effective in promoting cognitive skills, but seems less effective in promoting practical and psycho-motor skills [38]. This indicates a need to explore the collaborative approach in ICT-facilitated learning.

Upon our investigation, we found that there is a shortage of research addressing the role of ICT in facilitating and building communities for TVET education development [39,40]. TVET online communities seem to be effective when integrating minimal digital resources [41], despite the challenge of the availability of digital and technical skills and the availability of digital infrastructure, especially in developing countries [42,43]. Even though ICT is proven to have a substantial role in delivering knowledge to students more conveniently, there is a lack of holistic social good perspectives [44].

To support the formation of TVET online communities, this paper proposes the integration of the Collaborative Knowledge Sharing Environment (CKSEnv) from [45] into a conceptual framework for skills building, for TVET resources integration and actors collaboration, leading to the formation of digital repositories of knowledge commons.

The framework in which this endeavor is addressed integrates, as a domain theory, the service-dominant logic perspective (S-D logic) [46–48] and adopts the view of knowledge resources as the community common good [49,50]. On top of these two prospects, the conceptual framework integrates the innovation roadmap proposed in [51], which explains how various operant resources are transformed in innovation activities and how to sustain the process of innovation itself.

This paper presents empirical research that evaluates the ability of the described Collaborative Knowledge Sharing Environment (CKSEnv) to achieve the desired goals and tries to identify the driver for the TVET community to accept the CKSEnv as a digital solution, which is able to facilitate collaboration amongst the community members and the exchange of knowledge for skills building and upskilling. Section 2 presents the steps to construct the scientific approach to pursue the research problem. The conceptual framework upon which the hypotheses have been built and the method for data collection and analysis are presented in Section 3. The results are presented in Section 4. A discussion that clarifies the answer to the main research questions and the practical implications of the research results is included in Section 5. Finally, Section 6 concludes the paper by stressing the relevance of the contributions and drawing guidelines for further research.

2. Background and Related Work

Within the scope of this article, the concept of community is approached without diving too deep into its definition and its constituents. The abstract view of the *learning community*, as a collective group of people that share a common interest, i.e., knowledge sharing and learning [52], is used henceforth. Learning communities facilitate collaboration among their members and may contribute to effective professional development by advancing their knowledge and the knowledge of others in the community [53].

From a service ecosystem perspective [54,55], the reciprocal exchange of knowledge and information is vital for the survival of the service ecosystem and the society [56]. Further, the perspective of the *network of learning actors* is manifested in S-D logic by "service for service exchange" [54]; it matures our understanding of value, from the monetary gain to knowledge, being seen as a new valuable and vital currency [46].

From the social learning perspective, an actor with a specific set of skills and knowledge may serve as a model for other actors that may follow him to learn and may shape their thoughts and actions according to their model [57]. That is, social learning is about following a model person (actor) and learning and collaborating with him/her on various activities. This collaboration results in *upskilling* and *reskilling* of both parties [35]. One can argue that the only party that benefits from this interaction is the follower. From another point of view, the actor that plays the role of the model may benefit from the collaboration, as well, by gaining more recognition as a model that is followed by more actors. In addition to social recognition, the model may gain teaching skills from the interaction, in a win–win situation type.

From the innovation roadmap perspective [51], social learning can be seen as a ***T***ransform process. In this process, best practices are copied by learners and resources are adapted to the needs and requirements of the activities. Furthermore, resources are integrated with other available ones to create innovative solutions [34]. Through the application of the social learning perspective, one may gain insight into the process of creating resources via actors' interaction and learning.

The view of knowledge as a commons [49] helps us understand how shared resources (knowledge) are self-governed in communities [49,58]. Understanding knowledge as a commons is based on the IAD framework proposed in the work of Hess and Ostrom [49], who tried to describe how communities are created and organized and how to make decisions and create rules to sustain resources or achieve desired outcomes [49].

Commons are described "as shared resources in which each stakeholder has an equal interest" [59]. Therefore, they may be collected in a "repository of commons". Within the scope of this article, a *repository of commons* is considered as a collection of resources (knowledge), such as shared, public, or private property, following the description introduced in [58].

The main characteristics that distinguish the repository of commons from the common-pool [49] may be formulated as:

- It is easy to exclude access due to the digital means;
- Resources (knowledge) are non-rivalrous.

In the case of a non-rivalrous resource [49], the consumption of knowledge by any actor does not affect the ability of others to access the resources in the long run. For instance, ideas are free and not constrained by rules or affected by the usage of other actors [60]. That being said, ideas, information, knowledge, and skills are non-rivalrous, but the systems that facilitate the exchange of resources are rivalrous (limited and constrained) [49].

The success of creating a repository of commons depends on an active community and institutions. Institutions, as understood as the set of "humanly devised rules, norms, and beliefs that enable and constrain action and make social life predictable and meaningful" [55], help actors in the community understand the value of collaboration and its role in creating valuable resources that foster innovations. Effective collaboration requires social capital and trust, in addition to a resource system that simplifies the collaboration and supports it with the necessary resources [49,61].

Knowledge is the currency of the learning communities; it is the operant resource that is exchanged, adapted, and integrated into the value co-creation process [62]. Therefore, the repository of commons in learning communities is knowledge-centric. A repository of knowledge commons shares the same success factors as knowledge commons, i.e., the amount of available high-quality information, the usefulness of the resources, the percentage of free access to information, and the extended community [49]. Eventually, the extended community results in an increased value and utility of the repository of commons.

Using information and communication technologies (ICT) encourages *online communities* formation, which have a substantial role in community-based learning that facilitates lifelong learning and TVET education [39]. Online communities facilitate knowledge exchange, including collaborative production of information [63] and activities coordination [64,65]. Online communities facilitate knowledge generation, flow, and sharing amongst community members (actors) [65]. Online communities of learning have been presented as one of the effective TVET responses to the COVID-19 pandemic [66]. Therefore, online communities, supported by the digital repositories of commons, extend the availability of resources and knowledge and widen the access to those resources, in order to improve the value co-creation process and innovation in TVET education.

The motivation of this paper is to further elaborate on our previous work that investigates the service ecosystem perspective in TVET education [45,67,68]. The paper builds the research construct on the idea of *TVET online learning communities*, able to support value co-creation via knowledge exchange and skills building.

Ontologies and semantic reasoning have proved to be useful in supporting communities by fostering knowledge exchange, collaboration, co-learning [69], and organizing multi-domain knowledge [70]. In learning, ontologies have been used for modeling and describing learning domains and learning materials, as well as e-learning services [71]. Further, ontologies have been used in collaborative service design and resources management to create a body of domain knowledge, for example, the extended service science ontology in [72]. Here, an ontological perspective has been adopted to develop a body of knowledge in service science, management, and engineering (SSME), and it was extended via a collaborative environment using Semantic Media Wiki technologies.

A service ecosystem ontology (SeSO ontology), using the S-D Logic as a domain theory, has been introduced in [67], and it has been further evaluated in [45]. The intention behind the SeSO ontology is to understand how actors interact and collaborate in the service ecosystem to co-create value and achieve sustainable development.

Further, [68] zooms in on the education service system, using a multi-contextual framework to analyze the education service for resilience. Here, an analysis of the education service ecosystem at the micro-level (the service system level), starting with its main elements, is presented. The service ecosystem is viewed as a network of actors, where each actor represents a service system by itself and exchange resources and service for the survival of itself and the survival of the ecosystem as a whole [56]. Moreover, the article analyzes how service system elements are conceptualized in an environment that constitutes different contexts based on the sole actors' perceptions [68].

The smart service model ontology (SSModO) has been introduced in [45], and it is based on the SeSO Ontology [67]. It integrates elements of the four diamonds-of-context model of service design (4DocMod) framework [73,74]. SSModO, as a domain knowledge ontology, is a service design artifact serving as a conceptual model that explains the main concepts in a collaborative service system and the relation amongst them [45].

The Collaborative Knowledge Sharing Environment (CKSEnv), described in [45] and evaluated in this paper, exploits the ontology-based collaborative development of knowledge-intensive service framework. The CKSEnv is built using Semantic MediaWiki and Pellet semantic reasoning engine [45]. Semantic reasoning is used on the SSModO to infer new relationships and new knowledge based on instances of SSModO entities.

The CKSEnv aims to facilitate collaboration in online TVET learning communities to aid knowledge exchange and learning.

3. Working Methodology

3.1. Conceptual Framework

Online learning communities are supported today with various digital technologies. This paper aligns with this development approach and describes the value co-creation process intended to support an online community of learners, in which the students' role shifts from being "Passive", as a recipient of knowledge, to an "Active" role in the process [75]. From the active learning perspective, students may co-create knowledge and co-construct skills and be responsible for their own reskilling and/or upskilling and proficient evolution [75].

Within the scope of this paper, to achieve active learning, we apply the S-D logic lens [46] on considering *learning as a service*. In this view, "learning as service" is a value co-creation process that applies resource integration for learning purposes. According to the S-D logic, service means applying one's resources—as knowledge and skills—for the benefit of others and the benefit of himself [46].

The view of "learning as service" shall not be confused with "education or learning as a service", which refers to the provision of digital resources, such as cloud computing, in the educational and learning area [76]. "Learning as service" is a collaborative process that involves actors' learning from each other—*by doing*—in an education process [77]. In our case, actors learn from each other by participating in activities. Learning *by doing* corresponds with the project-based learning (PBL) strategy that focuses on doing projects that not only serve the community, but also improve learners' problem-solving skills and social skills [78].

Viewing information as commons [60] implies the exchange of knowledge. In this perspective, it is in the common interest to share the information to create a *repository of knowledge commons* that contains shared information. In the repository of knowledge commons, information is free and non-excludable in the sense that, if the information is obtained by many people, this will not affect the ability of more people to obtain information, and the cost (time and effort) of obtaining the information will decline, generating service sustainability and a great benefit to the community [79].

Service sustainability is recognized as the service's ability to adapt to the dynamic and complex environment [68] via integrating new resources (mostly competencies) and changing the value proposition [62]. For sure, competencies (skills and knowledge), as operant resources [46], are the most important resources because they act on other resources to create value. Additionally, they are the most rapidly changing resources, due to the dynamically evolving market, technology, and environmental factors [80]. Therefore, *the value proposition of learning as service* must adapt to these factors. It must adapt to the context through the exchange of knowledge.

The conceptual framework for skills building in collaborative online TVET learning communities, based on the CKSEnv that we introduce in this paper, is presented in Figure 1. The framework merges the S-D logic [46] perspective with the innovation roadmap [51] to create a big picture of how skills evolve in a community of domain expertise, for example, the TVET community for robotics education. In such a community, actors are viewed as contributors that operate inside the collaborative environment. Actors integrate resources in the value co-creation process of learning, as part of the service community [62], and this corresponds to the ***R***un process in [51], which itself is empowered via the collaborative environment.

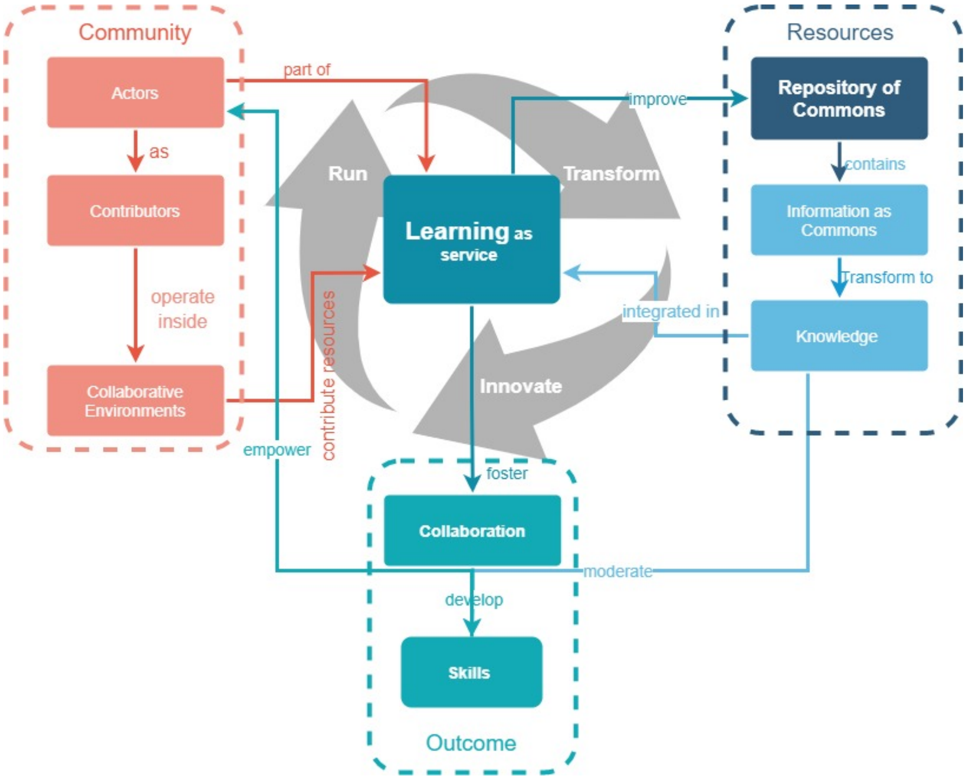

Figure 1. A conceptual framework for skills building in collaborative online TVET learning communities.

In the service community, it is important to conceptualize information as a commons [49]. This conceptualization supports the idea of creating a repository of knowledge commons. Knowledge is the proposed value to be obtained from the information integration process. A ***T***ransform process helps information (a resource) to become knowledge (another resource) analogously, such as the ***T***ransform process in [51], applied to a general type of resources. Knowledge, i.e., *knowing how to . . .* , is being considered here as the main resource; it evolves through collaboration and engagement in activities. Each time knowledge is integrated into a learning service, it increases actors' experience and helps them to acquire new skills. In this value co-creation process, the advancement of the learning community and the sustainability of the service are obtained, as described in the ***I***nnovate process in [51]. As such, sustainable service means sustainable value co-creation in the learning process.

3.2. Integrating the CKSEnv in the Conceptual Framework

Actors are the value creators in the educational service system; therefore, the study focuses on the community side of the conceptual framework depicted previously in Figure 1. Henceforth, we evaluate the digital resource management system, i.e., the Collaborative Knowledge Sharing Environment (CKSEnv), that facilitates the exchange of knowledge through collaboration between actors, as previously mentioned in the Background and Related Work, Section 2, whose goals are the following:

- Promote social learning;
- Facilitate means for the upbringing of online TVET learning communities and promote a culture of lifelong learning for all;
- Facilitate means for technical learning knowledge integration and skills building;
- Foster people's competitiveness resiliently through building the right skills for jobs (upskilling and/or reskilling);
- Foster means for the upbringing of a repository of knowledge commons for learning material and information related to the field of TVET.

To assure actors' involvement in the education service system, actors must accept and participate actively in using purposefully the Collaborative Knowledge Sharing Environment (CKSEnv) that facilitates service provision. Therefore, we argue that CKSEnv acceptance is one of the main drivers for value co-creation amongst actors in the TVET online learning community proposed in this study.

To investigate the CKSEnv acceptance, the technology acceptance model (TAM), a behavioral model that explains actors' attitudes towards technology acceptance and adoption, is applied [81]. Since the first introduction of TAM in 1989, TAM has been extended with many external factors, such as:

- In [82], a literature review on students' acceptance of e-learning technologies is presented, identifying external factors such as computer self-efficacy, social norm, perceived enjoyment, system quality, information quality, content quality, and accessibility;
- The study presented in [83], addressing students' acceptance of virtual laboratory, has assessed factors like efficiency, playfulness, and students' degree of satisfaction;
- A study regarding the acceptance of a mobile library application amongst researchers and academics is presented in [84], revealing that system quality and users' habits are factors influencing the acceptance model;
- Other papers, such as [85], have reviewed TAM in the mobile learning general context, focusing on knowledge exchange, analyzing the influence of knowledge acquisition (utility), application (accessibility), protection (risk), and knowledge sharing (operational feasibility);
- Some other authors, such as [86], have studied website's usability assessed factors, such as efficiency, effectiveness, learnability, accessibility, and satisfaction.

Although these previously mentioned factors seem to be useful for investigating technology acceptance, in the context of learning platforms, when it comes to technology skilled users, as in TVET education, these variables need to be reevaluated [87–89].

Here, TAM combined with the taxonomy described in [90] has been used within the scope of this paper to evaluate the CKSEnv's usability and usefulness in achieving previously mentioned goals. In our approach, five external variables have been added to extend TAM—being Effectiveness, Efficiency, Accessibility, Risk, and Satisfaction—to correspond with the taxonomy of the evaluation methods for information systems artifacts (EMFISA) introduced in [90], as presented in Table 1.

Table 1. Extending TAM Based on the EMFISA Taxonomy from [90].

External Variable	Indicators	EMFISA Taxonomy Criteria Adopted from [90]
Accessibility	ACCESS1	Alignment with ICT Innovation, to what extent the CKSEnv uses innovative technology.
	ACCESS1	Robustness, to what extent the CKSEnv can handle invalid inputs or stressful environmental conditions.
Efficiency	EFFICT1	Simplicity, to what degree the structure of the CKSEnv contains the minimum necessary number of functionalities and relationships between those functions to achieve its desired goals.
	EFFICT2	Style, to what degree the CKSEnv is elegant.
	EFFICT3	Consistency, to what extent the CKSEnv has a degree of uniformity, standardization, and freedom from contradiction among its functionalities.
	EFFICT4	Completeness, to what degree the processes of the CKSEnv contain all necessary elements and relationships between those elements.
	EFFICT5	Simplicity, to what extent the processes of the CKSEnv contain the minimum necessary number of elements and relationships between those elements.
	EFFICT6	Consistency, to what extent the processes of the CKSEnv have a degree of uniformity, standardization, and freedom from contradiction.
	EFFICT7	Functionality, to what extent the CKSEnv provides functions that meet stated and implied needs when is used under specified conditions.
	EFFICT8	Learning capability, to what extent the CKSEnv can learn from experience.
	EFFICT9	Completeness, to what degree the structure of the CKSEnv contains all necessary functionalities and relationships between those functions.

Table 1. *Cont.*

External Variable	Indicators	EMFISA Taxonomy Criteria Adopted from [90]
Effectiveness	EFFECT1	Effectiveness, to what degree the CKSEnv achieves its goals in a real context.
	EFFECT2	Validity, to what degree the CKSEnv works correctly to achieve its goals.
	EFFECT3	Utility, to what degree the CKSEnv provides value in achieving its goals.
Perceived Ease of use	PEOU	Ease of use, to what degree the use of the CKSEnv is free of effort.
Perceived Risk	PRISK1	Ethicality, to what degree the CKSEnv complies with ethical principles.
	PRISK2	Absence of side effects (stakeholders), the CKSEnv is free of undesirable impacts on the stakeholders in the long run.
	PRISK2	Absence of side effects (organization), the CKSEnv is free of undesirable impacts on the organization in the long run.
Perceived Usefulness	PUSEEUL	Usefulness, to what degree the CKSEnv will positively impact the task performance of its stakeholders.
Satisfaction	SAT1	Alignment with business strategy, to what degree the CKSEnv is in line with the organization and its strategy.
	SAT2	Accuracy, to what extent the output of the CKSEnv is consistent with the users' expected output.
	SAT3	Efficacy, to what degree the CKSEnv achieves its goals, without addressing the situational context.
	SAT4	Operational feasibility, stakeholders support the proposed CKSEnv, operate it, and integrate it into their daily practice.

The research model that has been created within the scope of this work, taking into consideration this extension of TAM with the five external variables, is presented in Figure 2.

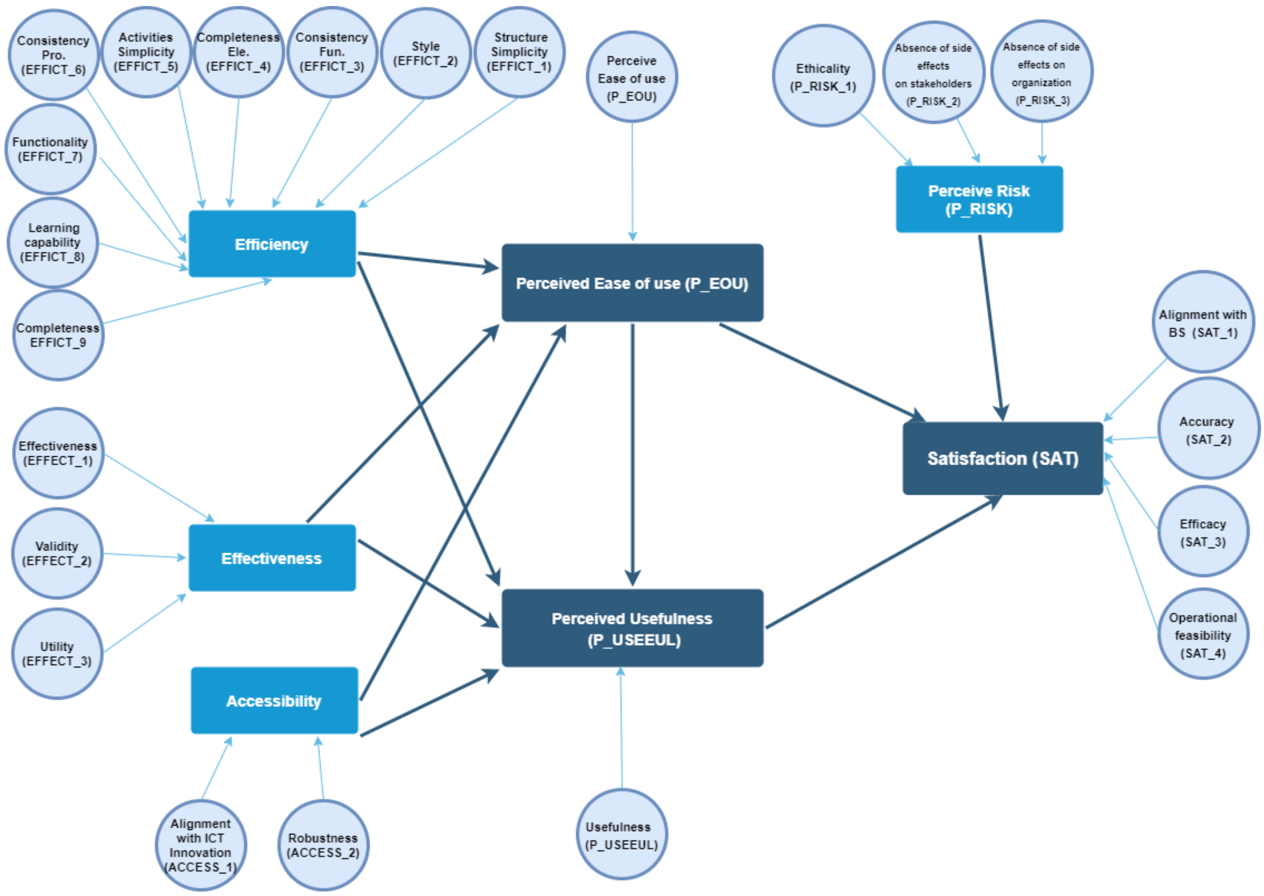

Figure 2. Building a research model based on TAM and EMFISA taxonomy [90].

Based on this research model, we hypothesize the following:

H1. *Efficiency has a positive effect on perceived usefulness.*

H2. *Efficiency has a positive effect on perceived ease of use.*

H3. *Effectiveness has a positive effect on perceived usefulness.*

H4. *Effectiveness has a positive effect on perceived ease of use.*

H5. *Accessibility has a positive effect on perceived usefulness.*

H6. *Accessibility has a positive effect on perceived ease of use.*

H7. *Perceived ease of use has a positive effect on perceived usefulness.*

H8. *Perceived risk has an effect on user satisfaction.*

H9. *Perceived usefulness has a positive effect on user satisfaction.*

H10. *Perceived ease of use has a positive effect on user satisfaction.*

3.3. Research Design

In order to test these hypotheses, data have been collected via two means: expert interviews and a questionnaire [91]. Those means of data collection helped us to gain an extensive view [92] of the CKSEnv usability and usefulness [81].

3.3.1. Expert Interviews

Expert interviews have revealed a comprehensive overview of how the user (actor) interacts with the CKSEnv. Immediate feedback on obstacles that the user may face during the interaction with the CKSEnv has been acquired. More importantly, we have gained knowledge on the CKSEnv adequacy and competence, and we have collected feedback to improve its functionality and its capability to achieve the desired goals.

To gain an insightful evaluation of the CKSEnv [90], we have conducted 13 interviews, with 3 types of participants: students, researchers, and practitioners. The distributed sample consisted of five students, three researchers, and five practitioners. According to [93,94], the sample size of 11–16 participants can discover up to 80% of the usability problems. The interview duration was 30–40 min. In the first 10 min, the research team presented the study's main goals and the CKSEnv's role in achieving the desired goals. Then, the participants have been driven through the main functionalities of the CKSEnv. During the next 10 min, the participants have been asked to create a personal profile, while the research team has been observing how the participants interacted with the CKSEnv.

The last 10 min have been devoted to a discussion between the research team and the participant. The discussion has been oriented toward evaluating the CKSEnv's usefulness, ease of use, and feedback to improve the CKSEnv. The interviews have been recorded for a more comprehensive analysis. All comments that required immediate attention have been handled accordingly and timely, before the following interview. During the interview, the participants are informed that a questionnaire will be sent to them after two weeks of using the CKSEnv for further evaluation. In addition, the participants have been asked to recruit more participants and invite them to use the CKSEnv, then notify the research team with their emails, so the research team could send them the questionnaire. Seven more participants have been recruited.

3.3.2. Questionnaire

The questionnaire was distributed to the same interview sample, as well as to the new seven recruits. The estimation of total time to take the questionnaire is about 10 min. A five-point Likert scale has been used to rate the answers; on the scale, 5 was strongly positive and 1 was strongly negative.

The questionnaire is built based on the taxonomy of evaluation methods for information system artifacts introduced in [90]. The EMFISA taxonomy is a comprehensive literature review that analyzes 121 articles, published in 8 journals of the Association for Information Systems (AIS), during the period 2005–2015. The EMFISA taxonomy investigates the objects and criteria of evaluation and how those criteria are used to evaluate information systems artifacts in the literature. The main reasons for using a questionnaire are to mitigate the bias that could be caused by interaction with the development team and obtain subjective answers in the form of quantitative data that have been analyzed further [92].

The questionnaire has been designed as follows:

- The first part of the questionnaire contains three questions, devoted to collecting data about the participants, including the academic title, level of education, and domain of specialization. These data have been processed separately to maintain the anonymity of the respondents, since the sample is small. The main intent behind collecting these data is to identify the sample distribution.
- The second part of the questionnaire contains questions aiming to measure the fulfillment of the CKSEnv's goals, i.e., assessing the efficiency, effectiveness, validity, and utility of the CKSEnv, with respect to its goals.
- The third part of the questionnaire assesses the impact of the CKSEnv on its stakeholders; it contains statements to evaluate the operational feasibility, usefulness, ease of use, ethical concerns, and absence of side effects on the stakeholders in the long run.
- The fourth part of the questionnaire is addressed only to the organization staff; it assesses the absence of undesirable impact of the CKSEnv on the organization in the long run and the alignment between the CKSEnv and the organization's strategy.
- The fifth part of the questionnaire assesses the CKSEnv's structure and functionality; it contains criteria to evaluate the completeness, simplicity, style, and consistency of the CKSEnv structure and its elements, in addition to the functionality and accuracy of its components.
- The sixth part of the questionnaire measures the CKSEnv's ability to evolve; it has three criteria, i.e., alignments with ICT Innovation, robustness, and the capability to learn from the user experience.

Finally, at the end of the questionnaire, two questions have been added to capture the respondents' opinions on the CKSEnv and suggestions for future improvements.

4. Results

4.1. Interviews' Results

Interviews recordings have been transcribed, and transcript text was split into statements, with each statement containing a specific idea. Further, technical feedback statements have been excluded. The technical feedback statements contain information about technical issues in the CKSEnv, such as font size, errors, CKSEnv structure, etc. These statements have been resolved by the development team. The rest of the statements were prepared for sentiment analysis using natural language processing tools (TextBlob [95], WordCloud [96], and LdaModel [97]). The analysis has been conducted as described below.

4.1.1. Word Cloud

The word cloud represents the most frequent words in the statements and the size of the words represents the frequency [96]. In Figure 3, four main patterns can be observed:

- (P1), the pattern that highlights the importance of actors' collaboration represented in words like (actor, user, people, connected, collaboration);
- (P2), the pattern that highlights the future implications of the CKSEnv represented in words like (will, ability, make, time, idea, value, usefulness, see);
- (P3), the pattern that highlights the CKSEnv's ability to achieve its goals represented in words like (knowledge, skills, learn);
- (P4), the pattern that highlights usability (easy to use) represented in words like (easy use, easy, use, good).

Figure 3. Word Cloud to analyze the CKSEnv's usability and usefulness in achieving its goals.

4.1.2. Polarity and Subjectivity

The analysis has been advanced with a sentiment analysis step, which is required to clean the collected statements from unnecessary data. The cleaning process was conducted using the Natural Language Toolkit (nltk) [98]. The cleaning process removed stopwords, numbers, and unnecessary spaces, and converted upper-case letters to lowercase.

The polarity and subjectivity of each statement were calculated using TextBlob tool in Python. Subjectivity refers to the degree to which the statement represents the respondent's opinion. Polarity (N-P polarity classification) refers to the degree to which the sentiment in the statement is positive, negative, or neutral [99]. Figure 4 shows that 44 statements out of 59 are positives (75%), while 7 are negative (11.5%), and 8 are neutral (13.5%).

Figure 5 presents the distribution of the statements concerning polarity (N-P polarity classification, N-P polarity of the sentiment) and subjectivity (objectivity-subjectivity polarity, and O-S polarity for sentiment detection) [100]. The green dots represent positive or neutral statements while red dots represent negative statements.

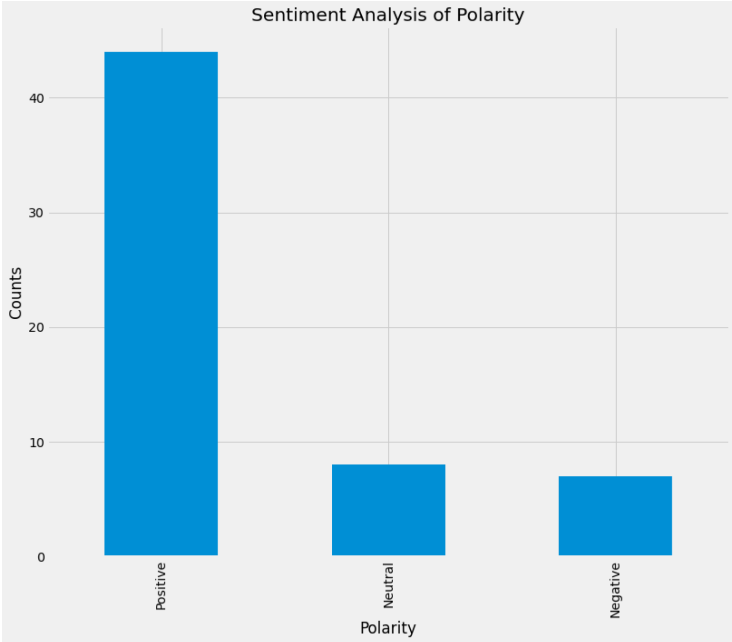

Figure 4. Statements' N-P Polarity evaluation.

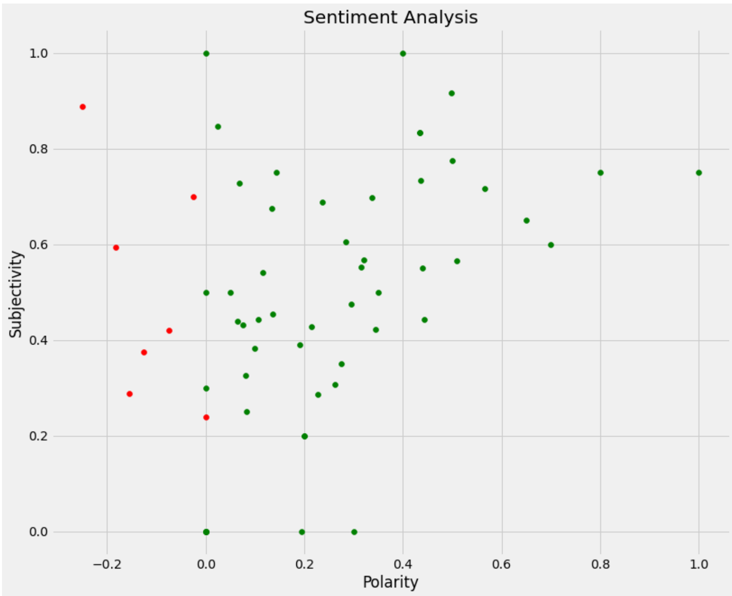

Figure 5. The distribution of the statements, based on Subjectivity Score and Polarity Score.

4.1.3. Topic Modeling

After calculating the statements' polarity and subjectivity scores, each statement has been converted into a list of words. The lists of words have been further used to create a dictionary using Gensim, the Gensim corpora dictionary, a Python open-source machine learning library [101]. The total number of words in the dictionary is 701. The dictionary has been used further to create the matrix of the appearance of the words in the statements.

A latent Dirichlet allocation model (LdaModel) [97] using the Python's Gensim package has been created with five topics, as per Table 2.

Table 2. Topic Modeling.

Cluster No.	Topics	Positive	Neutral	Negative	Total
1	Sustainability	9	3	2	14
2	Usefulness	6	0	0	6
3	Usability	13	0	3	16
4	Value co-creation	9	2	3	14
5	Technical statements	11	2	0	13
				Total	63

The LdaModel generates a matrix with five clusters and lists the probability of each statement to be classified under each cluster; for example, the first statement's probabilities are ((0, 0.02540076), (1, 0.025052793), (2, 0.025049374), (3, 0.8993012), and (4, 0.02519587)). In the example, the probability of the first statement to be classified in cluster (0) is 0.02540076, in cluster (1) is 0.025052793, and so on. After the matrix has been created for all statements, the threshold has been set to 0.2, in order to minimize the probability that the statements could be classified under multiple clusters [102]. In the previous example, the statement has been classified under cluster (3), because the probability to be classified under cluster (3) is $0.8993012 > 0.2$. With the threshold at this value, only four statements have been classified under more than one cluster. This explains why the sum of the number of statements in Table 2 is 63, while the original number is 59.

Each cluster has a list of words that help us understand its topic. The following is a list of topics and a list of significant words that help identify their meaning:

- The sustainability of the CKSEnv (time, future, make, would, suggestion, able, evolution, probably, and period);
- Usefulness, the CKSEnv's ability to achieve its goals (actor, learn, useful, use, skill, knowledge, usefulness, activity, service, create, value, and working);
- Usability (easy to use) (easy, use, show, used, search, navigate, find, hard, see, form, table, and good);
- Value co-creation, The CKSEnv's ability to create value through collaboration (people, actors, social, community, help, norm, motivation, commons, collaboration, together, connecting, and service);
- Technical statements, statements related to how the CKSEnv works at a technical level (ontology, domain, technology, support, digital, MediaWiki, populated, structured, functionality, and educational).

The results from this topic modeling correspond with the patterns observed in the words cloud, as follows.

- Sustainability corresponds with (P2), the pattern that highlights the future implications of the CKSEnv;
- Usefulness corresponds with (P3), the pattern that highlights CKSEnv's ability to achieve its goals;
- Usability corresponds with (P4), the pattern that highlights usability (easy to use);
- Value co-creation corresponds with (P1), the pattern that highlights the importance of actors' collaboration;
- An additional topic has been discovered, technical statements about CKSEnv's functionality.

The cross-analysis between sentiment analysis and topic modeling, presented in Table 2, shows each topic and the number of positive, neutral, and negative statements that belong to each topic. This analysis helps evaluate participants' opinions about each topic. It may be observed that most statements are positive. For example, topic 1: (sustainability) discusses CKSEnv's ability to evolve, and it has nine positive statements, three neutral statements, and two negatives. This means that approximately 14% of the statements negatively perceive this topic, while 86% perceive it positively or are general comments about the topic. This analysis applies to the rest of the topics.

As such, the utilization of these two levels of analysis has helped validate the topic modeling against human observation and to discover a new topic that was not been observed from the beginning.

4.2. Questionnaire Results

4.2.1. Sample Distribution

The total number of responses to the questionnaire is 20. Figure 6 depicts the education level of the questionnaire respondents. The sample represents the diversity of potential users, and it ranges from students to university professors. The majority of the respondents have a university degree, most of them are working in universities and hold a Ph.D. or a higher university degree, and 5% of the respondents are students. The questionnaire has been mainly distributed within an environment oriented towards the participants in the NITRO Clubs EU—Network of ICT Robo Clubs Erasmus+ Project (https://nitroclubs.eu/ (accessed on 8 March 2022)), a project dedicated to TVET education with a robotic case study. Table 3 depicts the respondents' specialization map.

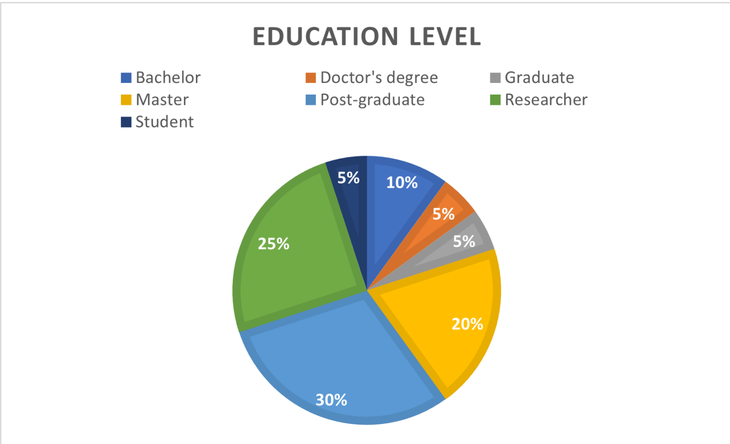

Figure 6. Sample Distribution.

Table 3. Specialization and number of respondents.

No.	Specialization	Number of Respondents
1	Information Systems	9
2	Robotics	9
3	Software Engineering	8
4	Informatics	7
5	Artificial Intelligence	6
6	Control Engineering	6
7	Programming Languages	6
8	Systems Engineering	6
9	Databases	5
10	Management	5
11	Project Management	5
12	Algorithms	4
13	Electronics	4
14	Entrepreneurship	4
15	Business Administration	3
16	Technology Management	3
17	Knowledge Management	3
18	Artificial Neural Networkp	2
19	Big Data	2
20	Mechanics	2

Table 3. *Cont.*

No.	Specialization	Number of Respondents
21	Data Mining	1
22	Data Structures	1
23	Human Resource Management	1
24	Machine Learning	1
25	Risk Management	1
26	Telecommunications Engineering	1

The respondents' opinion about CKSEnv's ability to achieve its goals is presented in Figure 7, based on the factors connected to (see Table 1):

- Effectiveness: Effectiveness (EFFECT1), validity (EFFECT1), and utility (EFFECT3);
- Satisfaction: Efficacy (SAT3).

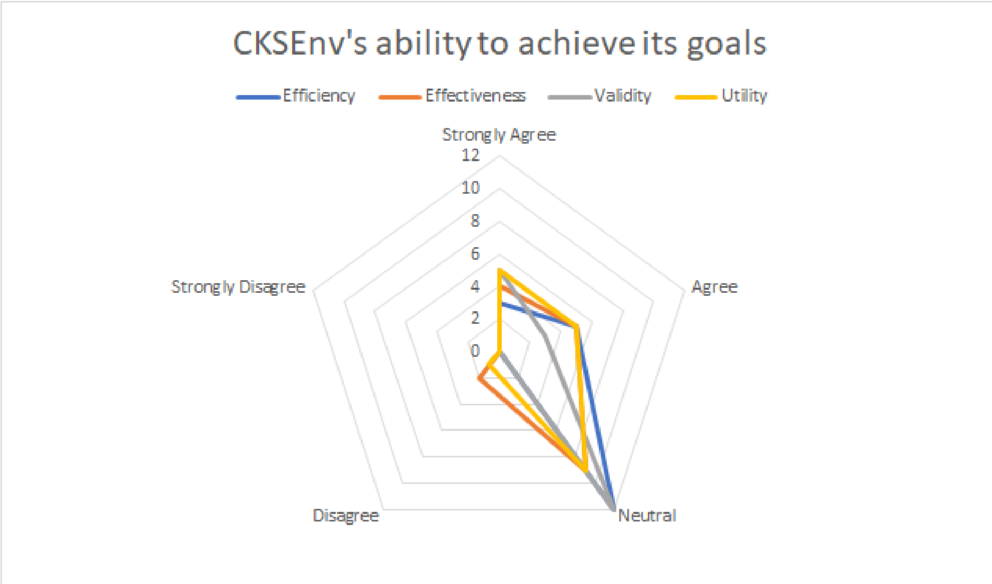

Figure 7. CKSEnv's ability to achieve its goals.

As it may be observed in Figure 7, the majority of the respondents' answers related to efficiency, effectiveness, validity, and utility, lay between neutral and strongly agree. This may indicate that the respondents' attitudes toward CKSEnv's ability to achieve its goals are positive. Results show that the respondents believe that the CKSEnv scope is fairly general (5% believe that it is very general, 60% believe that it is general, and 35% believe that it is general to a fair degree). This means that the CKSEnv is general enough to work in different contexts [103]. This view could widen the use of the CKSEnv and mitigate the risk of using the CKSEnv for narrow purposes.

4.2.2. Research Model Evaluation

After the questionnaire data have been coded and prepared according to the research model presented in Figure 2 and described in Table 1, the optimization technique of partial least squares (PLS) has been used to analyze the regression of the latent variables using the SmartPLS 3.3.2 [104,105]. The data have been analyzed multiple times in SmartPLS to reduce the residual variance of the research model's dependent variables [83,105]. The analysis resulted in excluding the items that did not have a significant statistical impact on the model's construct, which are:

- EFFICT3, the consistency of the CKSEnv functionalities, that is similar to the consistency of the processes, EFFICT6; instead, EFFICT6 has a significant impact on the model's construct.
- EFFICT4, the completeness of the CKSEnv elements and the relationship between its elements, because the respondents could not identify all the necessary elements.
- EFFICT8, the learning capability of the CKSEnv, because the respondents could not identify the learning capability of the CKSEnv.
- SAT1, Alignment with business strategy, because a significant amount of respondents were not familiar with the organization strategy.

The final results of this evaluation are presented in Figure 8.

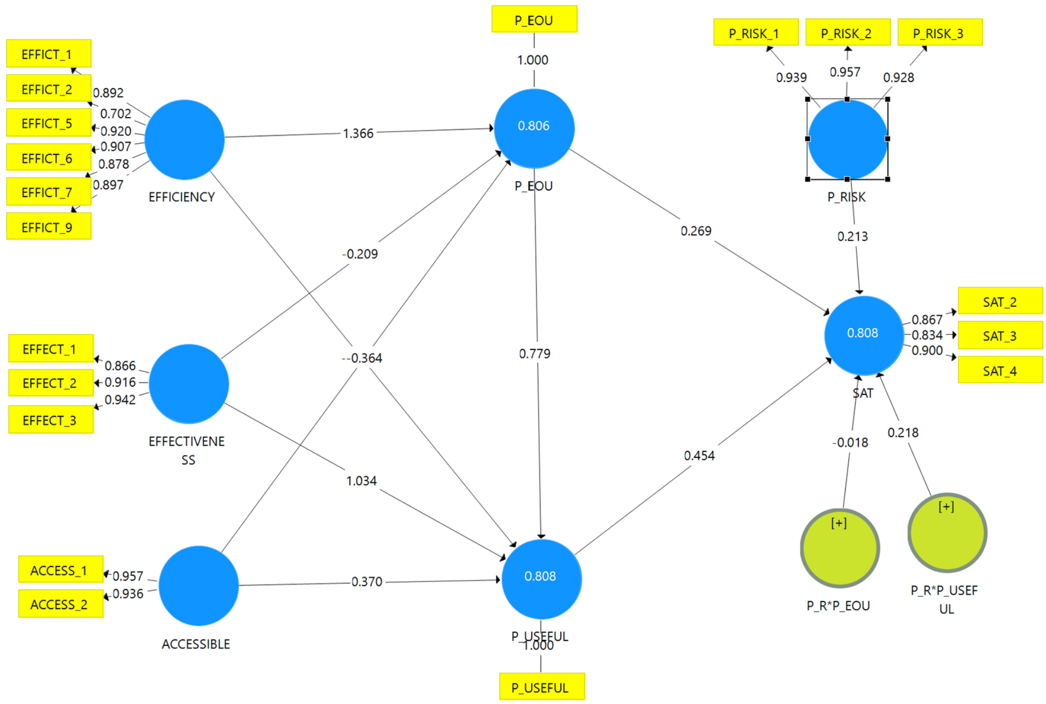

Figure 8. Validated research model: a SmartPLS analysis [105].

4.2.3. Reliability and Validity Test

Along with the evaluation of the research model with SmartPLS, Cronbach's alpha, α, has been calculated to examine the reliability of the model, whose value for each construct should be more than 0.7 [106]. As can be seen in Table 4, the Cronbach's alpha for each construct exceeds 0.7, meaning that the questions that belong to each construct are reliable.

To assess convergent validity, three tests have been conducted in SmartPLS: loading factors, average variance extracted (AVE), and composite reliability (CR). The recommended values for these three tests are the following: loading factor for each item greater than 0.7, AVE for each construct greater than 0.5, and a CR value for each construct greater than 0.7 [86,106]. In Table 4, it can be observed that the values of these tests exceed the recommended values, which indicates that the model passes the convergent validity test. Moreover, since R squared is 0.80, it indicates that the determinant explanatory variables are acceptable.

Table 4. Reliability and Validity.

Construct	Item	Loading Weight	Cronbach's alpha	AVE	CR
Accessibility	ACCESS1 ACCESS2	0.957 0.936	0.886	0.946	0.911
Efficiency	EFFICT1 EFFICT2 EFFICT5 EFFICT6 EFFICT7 EFFICT9	0.892 0.702 0.920 0.907 0.878 0.897	0.934	0.755	0.948
Effectiveness	EFFECT1 EFFECT2 EFFECT3	0.866 0.916 0.942	0.886	0.897	0.946
Perceived Ease of use	PEOU	1	1	1	1
Perceived Risk	PRISK1 PRISK2 PRISK3	0.939 0.957 0.928	0.935	0.886	0.959
Perceived Usefulness	PUSEEUL	1	1	1	1
Satisfaction	SAT1 SAT2 SAT3	0.867 0.834 0.900	0.835	0.753	0.901

To determine the supported hypotheses, the path values and T statistics have been calculated, and the hypotheses with *P*-value < 0.05, *T*-statistics > 2 or *T*-statistics < −2 will be accepted [106]. Figure 9 presents the supported hypotheses fulfilling these conditions (in green), while the rest of the hypotheses have no significant statistical support.

Path Coefficients

Mean, STDEV, T-Values, P-V... | Confidence Intervals | Confidence Intervals Bias C... | Samples | Copy to Clipboard:

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
ACCESSIBLE -> P_EOU	-0.364	-0.388	0.226	1.608	0.109
ACCESSIBLE -> P_USEFUL	0.370	0.339	0.265	1.396	0.163
EFFECTIVENESS -> P_EOU	-0.209	-0.249	0.258	0.809	0.419
EFFECTIVENESS -> P_USEFUL	1.034	0.937	0.336	3.082	0.002
EFFICIENCY -> P_EOU	1.366	1.431	0.332	4.113	0.000
EFFICIENCY -> P_USEFUL	-1.178	-1.049	0.581	2.027	0.043
P_EOU -> P_USEFUL	0.779	0.766	0.289	2.695	0.007
P_EOU -> SAT	0.269	0.251	0.755	0.357	0.721
P_R*P_EOU -> SAT	-0.018	-0.050	0.681	0.026	0.979
P_R*P_USEFUL -> SAT	0.218	0.229	0.771	0.283	0.777
P_RISK -> SAT	0.213	0.235	0.334	0.637	0.524
P_USEFUL -> SAT	0.454	0.439	0.827	0.549	0.583

Figure 9. Path Coefficients.

Overall, efficiency is the strongest hypothesis; it has the highest value of *T* and the *P*-value < 0.005. This means that efficiency has a great influence on "perceived ease of use", thus influencing the adoption and use of the CKSEnv. Further, this corresponds with the finding from Figure 7, interpreted as CKSEnv being efficient and, therefore, able to achieve its goals.

According to Table 4, simplicity (EFFICT5) and utility (EFFECT3) are the items with the most significant load related to identified hypotheses. The findings may be interpreted as:

simplicity is the factor that affects efficiency, and utility is the factor that affects effectiveness. Both efficiency and effectiveness affect the perceived ease of use and usefulness.

According to the technology acceptance model (TAM), the acceptance of an information system depends on two factors: perceived usefulness and perceived ease of use [81]. Usefulness and ease of use are both important factors leading to the intention behavior (intention to use) and the actual behavior (the adoption and acceptance of a new information system).

Therefore, we may acknowledge that the system's effectiveness and efficiency answer the question of what makes an information system useful and easy to use. Simplicity is an external factor that directly affects efficiency, in the sense that a system that is easy to use does not waste valuable resources, such as time. Moreover, utility is directly connected to effectiveness, as the ability to obtain the desired outcome.

In conclusion, both utility and simplicity have the most significant impact on information system adoption and usage.

5. Discussion

Within the scope of this study, a service system perspective to create TVET education services, as a configuration of actors, technology, and resources [107], is presented. This perspective is dedicated to the creation of a resourceful environment, in which the actors interact for mutual value co-creation and development of their value proposition to society, here for sustainable and resilient education.

Following the obtained results on the evaluation of the Collaborative Knowledge Sharing Environment (CKSEnv), in order to explain the *new value co-creation process*, *able to fill gaps in describing the role of ICT in supporting the TVET training cycle*, we apply the smart service model canvas (SSModC) [108] to interpret our findings along with the conceptual framework described in Section 3. A new service design artifact is created within this respect, the smart service model canvas in TVET online communities, presented in Figure 10. Consequently, we clarify the answer to the main research questions on *how the value is co-created in the online TVET learning communities* and what factors influence the actors' acceptance of the technology that facilitates knowledge exchange in these communities.

5.1. Co-Creation

Value co-creation, as the co-creation of mutual value for the involved parties [55], emerges through resource integration and service exchange in a self-governed self-adjusted service ecosystem [109]. Value co-creation is facilitated and coordinated via institutions and institutional arrangements [55,109].

Learning is a resource integration process, where actors adopt and integrate resources (information) with other resources, to create new resources (knowledge). These may be further integrated into a new resources integration process, leading to a sustainable service provision and innovation [51,62]. Thus, value co-creation has a systemic nature [110].

The proposed *ontology-based collaborative knowledge sharing environment, able to formalize the domain expertise and support the formation of TVET online communities*, may be viewed as a modular construct that provides structure and functionality to facilitate resources integration, to govern actors' interactions, and to aid the value co-creation process [111].

Findings show that the simplicity and utility of this construct are the factors that influence actors' attitudes toward CKSEnv acceptance and use.

Simplicity reflects the simplicity of the value co-creation process, gaining the benefit with minimal effort. As a respondent said: *"In the future, if you want to add functionalities keep it simple and don't add too many functionalities to make it complicated."*

Utility reflects on the quality of the value proposition, i.e., the value that is expected to be gained from the interaction [112]. When the value proposition is motivating, the actors are prompted to integrate their resources into the value co-creation process [112]. As a respondent said: *"When people will try the CKSEnv, they will see the value of connecting the people."*

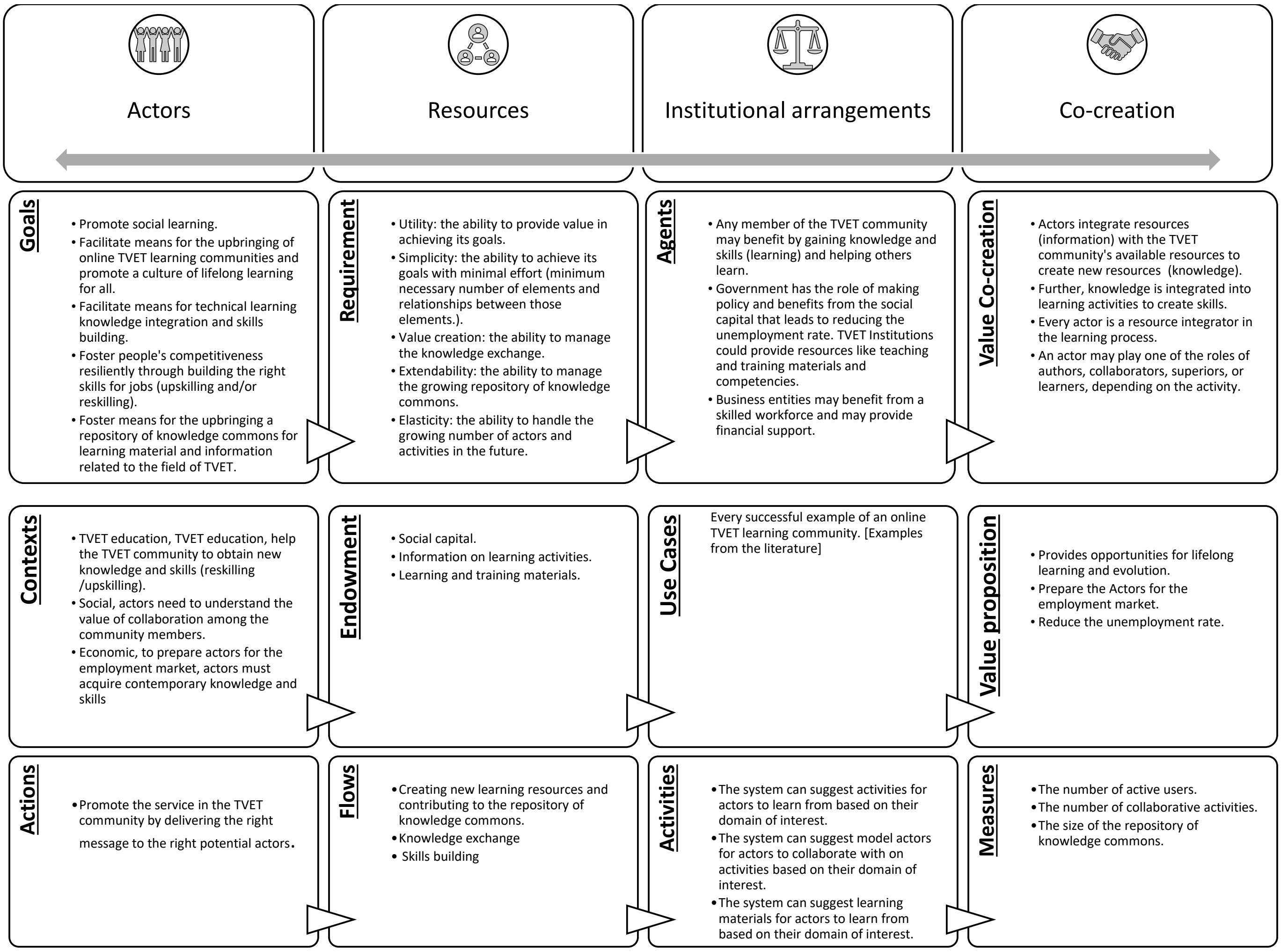

Figure 10. Smart Service Model Canvas in TVET online communities.

5.2. Actors

In the S-D logic perspective, actors are resource integrators [55]. The more users, the more the collaborative knowledge-sharing environment, through its *digital repository of knowledge commons*, is provided, with more sources of resources that facilitate actors' reskilling (i.e., obtaining new knowledge and skills). The intended outcome is to create professional actors and prepare them for the employment market.

As a respondent said *"the value of any system increases with the increase of its users"*.

Most of the participants agree on the necessity of opening the shared environment to a larger public, as *"the more people subscribe, the greater the value will become"*. This statement corresponds with the view of information as commons [49] because the common good perspective, viewing information (as service) consumed by one party, does not jeopardize the ability of other parties to consume the same service [49]. On the contrary, more users mean more resources and more activities to learn from.

Another respondent highlighted the importance of building communities and the role of communities in providing the necessary resources and developing the necessary skills. The respondent said: *"This is a project that has to do with building a community for actors to collaborate based on their interests. In this case, the project aids collaboration and embraces the value of connecting the actors together"*.

The community may be pictured as a network of resource providers based on S-D logic [113]. This network creates the repositories of knowledge commons that are utilized in "learning as Service". As a respondent said: *"The utility of the CKSEnv could be improved* *by expanding the base of beneficiaries through a quality network of specialized or professional actors"*. Each actor has a role in the value co-creation process of learning, and actors collaborate on educational activities and subsume their roles as authors, collaborators, superiors, or learners [45].

5.3. Resources

Resources are not valuable by themselves, but they gain value from the context in which they are applied [114]. Considering the TVET education service, resources gain value when they are applied and integrated with other resources to generate new knowledge and skills. In TVET education, for example, knowledge, such as knowing how to create an artifact, is useful when the artifact is produced and other actors may learn from that artifact, or when the artifact is co-produced and actors may learn from the co-production process.

The process of transforming available resources into new resources leads to innovation [51]. Innovation is a continuous process of regenerating knowledge and skills through collaboration among actors within the learning service.

Service digitization creates opportunities for innovation through the liquefaction of resources [113]. Digital resources are easy to access, adapt, and integrate. Service digitization increases resource density, i.e., the right resources at the right time and place and with the right actor [113]. To put this in the "learning as service" perspective, the actor's available resources are integrated with the TVET community's available resources in a learning resource integration process. This process helps actors build new skills (reskilling and upskilling) and prepare them for the employment market.

A respondent said: *The CKSEnv's ability to grow and achieve its goals is based on its ability to attract a wide variety of people from different domains and the willingness of these people to collaborate and participate in the service. It also depends on the ability to create a community and social institutions—social norms—that govern the use and the distribution of resources. These social norms help actors understand the benefit and value of the service exchange.*

5.4. Institutional Arrangement

Institutions, as shared norms, are important in linking actors' agency with the social structures in the community [55]. Institutions define the meaning of what is valuable and set the rules that govern actors' interactions [80]. A respondent highlighted the importance of reaching the right audience: *"It is important to promote the CKSEnv in the right way to reach as many stakeholders as possible"*.

The ability to reach the right stakeholders, with the right message and the right value proposition, helps to create social awareness, as a form of institution, addressing the value of collaboration in the TVET community; more importantly, social awareness helps to understand the role of community's members in knowledge exchange and skills building.

Another way to create new institutions is through service exchange. Every successful example of the TVET learning community (such as in [41,115–117] and others) produces an experience and guidelines for success, therefore producing institutions. Thus, service exchange creates the institutional structure that, in turn, enables and constrains service exchange [110].

Institutional arrangements are contextual, and each set of institutions is applicable in a certain context. For example, institutional arrangements at universities differ from the ones in the community. At the university level, institutional arrangements are influenced by the university's policy and the government's policy. On the other hand, in the community, institutional arrangements are influenced by the common interest, as well as the actors' sole interest.

6. Conclusions

The employment market is constantly changing, due to technological evolution and unexpected crises. TVET education and lifelong learning promises to reduce the unemployment rate and increase the prosperity of society. Recent literature highlights a gap in describing the role of ICT in supporting the TVET training cycle.

Through this article, we have argued for the role of TVET online learning communities in knowledge exchange and skills building. Therefore, we have described a conceptual framework for value co-creation in TVET online learning communities. Using this framework, we can demonstrate how information is integrated to create knowledge and how knowledge is transformed into new skills in a collaborative learning environment. Moreover, the ontology-based collaborative knowledge-sharing environment (CKSEnv) has been integrated into this framework, to facilitate the exchange of knowledge through collaboration between actors. As well, it fosters the capacity of being able to formalize the domain expertise and support the formation of TVET online communities, leading to the formation of digital repositories of knowledge commons. The CKSEnv, described further as a smart service design activity using the smart service model canvas, may generate sustainable resources (skilled citizens) to overcome the effect of an unexpected crisis, thus improving the resilience of the society as a whole.

The findings reveal the community's interest in value co-creation and sustainability, facilitated through a large number of community members with wide expertise, that serve as knowledge providers to create a repository of knowledge commons. The availability of resources as knowledge is equally important as the characteristic of the education service system that facilitates resource integration for value co-creation. This is manifested through the results, which show that usefulness and usability, aided via both utility and simplicity, have the most significant impact on the Collaborative Knowledge Sharing Environment (CKSEnv) adoption and usage. Furthermore, the CKSEnv, supported by an active online TVET community, paves the way for smart citizens that are capable of effective and positive handling of digital technologies and of active and responsible participation in the TVET community at all levels.

Our study has been evaluated in a relatively small, concentrated community, with a relevant interest in the domain of TVET education. The main participants in our study are involved in a TVET education project, with a case study in mobile robotics, used as an educational technology, aligned to the EU Industrial Policy Strategy that defines robotics as an integral part of the key enabling technologies (KETs). The utilization and integration of robots into the lives of young people and their education focuses a greater attention today; therefore, new, updated skills and competencies must be formed in the vocational education and training domain.

Even though it may be considered widely ambitious to present these findings as a contribution to the extension of the TAM model, due to the current sample size limitation—at least, these findings could be considered an area of future research. Further exploration of the conceptual framework with other case studies in TVET education and the creation of TVET online communities is another path to pursue in future research. Therefore, extending and applying the smart service model canvas in TVET online communities may reveal new value co-creation processes in the development of smart city services.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Conflicts of Interest: The authors declare no conflict of interest.

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