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MARIA KARALASH & ULRIKE BAUMÖL

Abstract The ongoing societal and technological changes make it necessary for universities to modify their teaching and learning programs. Regarding the cooperation with stakeholders that have influence on how it could be designed can serve as a basis. With this article we examine the recent contributions in the field of cooperation of higher education (HE) institutions by conducting a structured literature review. A close regard in particular are the interdependences between stakeholders in order to build a basis for future curricula developments. For our conceptualization, we use the quadruple helix model to analyse the educational ecosystems. Therefore in particular the term "educational ecosystem" is taken into account. The results show that evenso that the term is used there is a lack of suitable definitions in this context. So based on the analysis of the recent literature, a definition of educational ecosystem was introduced and the quintuple helix model, which was constructed for the conceptualization of the topic, was extended by further important aspects – knowledge transfer and adaptivity.

Keywords: • Educational ecosystem • E-learning • Quadruple helix • Third mission Bled • eConference • Knowledge transfer • Adaptivity •

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1 Introduction

The digital society is driven by Information Technology (IT) based transformations in social organization and structure. This shift can be illustrated e.g. by the steadily increasing access to the internet for an ever-increasing number of people as well as by the ongoing implementation of web-based technologies into our lives. In 2018, about 55% of the current world population had access to the World Wide Web (Statista, 2018). In the workplace the use of digital technologies is also increasing, at the same time the employers expect the employees to have several skills, among them digital skills and competencies. As a result, these ongoing technological and social changes force universities to respond to new accrued challenges by introducing new study programs, realizing content modifications as well as incorporating new research focus into their portfolio. Nevertheless, according to the official data of European Commission, almost 50% of the human population have insufficient digital competencies (European Commission, 2014). Therefore, not only the industry sector but also the students have advanced requirements on the curriculum content and design. These challenges inevitable require modifications with regard to the educational structure, the learning environment and the whole business models which universities constitute in general.

The higher education (HE) paradigm shift driven by political and social requirements leads to the emergence of reconceptualization of the teaching and research process. In this regard, higher education institutions (HEIs) are faced with requirements of several stakeholders like government, industry and students. The Bologna-Process, for instance, intends the establishment of homogeneous European HE standards (BMBF, 2018). Furthermore, students have expectations of the curriculum to be as individual as possible and to be flexible concerning time and location. The industry sector expects future employees to have certain competencies, which should have been taught by the university previously. Finally, HEIs also have standards they want to keep, so compromises need to be made. To understand how such compromises can look like and how future curriculum and learning environment can be designed a foundation should be created. As a first step, we suggest looking at the interrelationships between the stakeholders by using the ecosystem approach, as it examines the different components of an interacting system separately as well as the dynamic interactions between them. Because an ecosystem is an open

boundary system, it allows adding further components or processes and therefore is well suited to represent the relations in the educational context.

The objective of the article is to provide an overview of the interrelationships of the stakeholder within the ecosystem and to develop a definition of the term "educational ecosystem", which contains all involved parties and necessary aspects. Therefore, the following research questions were developed: Which relationships exist between the stakeholders within the educational ecosystem? Is there a common understanding of the term "ecosystem" in the educational context?

This article is structured as follows: first, we specify the methodology by defining the review scope, which is based on the taxonomy of Cooper (1988). Subsequently, we layout the concept of a quadruple helix model in conformity with the ecosystem approach. We complete the chapter with a detailed documentation of the literature review. Further, we present and discuss the analysis and synthesis of the regarded literature. We finally finish the article with a conclusion and suggestions for further research.

2 Methodology

In this section the review scope of the literature review is defined and the conceptualization of the article is constructed followed by a detailed description of the literature search process.

2.1 Review Scope

In order to explore the recent research field on the term of educational ecosystems, a structured literature review was conducted. To achieve maximum transparency, the review was related to the guideline for literature reviews by vom Brocke et al. (2009). The individual steps lead to a systematically procedure, which is presented in the following.

The taxonomy of Cooper was applied to define the scope of a literature review (Cooper, 1988). As shown in the taxonomy (Figure 1), the study´s review scope focuses on the research outcomes, as the recent contributions according to the research focus will be considered and analysed to serve as a basis for an own

definition of educational ecosystem. The goals are firstly to synthesize past literature, which is related to common issues, and secondly to identify central issues to the field of educational ecosystem. The neutral perspective shall enable a representative coverage focused on peer reviewed journals and selected conferences, which are important in the subject of information systems (IS) research. The present literature results are organized in a conceptual way. The audience addressed by the review consists of general scholars as well as practitioners.

Characteristic	Categories			
focus	research outcomes	research methods	theories	practices or applications
goal	integration	criticism	identification of central issues	
perspective	neutral representation		espousal of position	
coverage	exhaustive	exhaustive with selective citation	representative	central or pivotal
organization	historical	conceptual	methodological	
Audience	Specialized scholars	General scholars	Practitioners or policy makers	General public

Figure 1: Taxonomy of the recent article (Cooper, 1988)

2.2 Conceptualization

The classic role of the university was extended to the third mission, which is about breaking boundaries of internal organizational actions. The third mission approach describes all societal interactions with the environment (Würmseer, 2016) consisting of all the external influences. In this regard, external influences can be other stakeholders, e.g. politicians, companies and individuals, as they also affect the teaching design and learning content. To understand and to map the relationships and interdependences between the stakeholders, we suggest the ecosystem approach, as it examines the different components of an interacting system separately as well as the dynamic interactions between them. Because an ecosystem is an open boundary system, it allows adding further components or processes and therefore has an appropriate design for the educational treatment. To make sure that an ecosystem can represent the required aspects, we want to look at existing definitions of an ecosystem first.

The term ecosystem originally refers to the ecological research field. The traditional term and concept were originally proposed by the English botanist Arthur Tansley, who describes it as *"a particular category among the physical systems that make up the universe. In an ecosystem the organisms and the inorganic factors alike are components which are in relatively stable dynamic equilibrium" (Tansley, 1935). Whereas Adner defines an ecosystem as the "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017).*

Pearce and McCoy describe the term "educational ecosystem" as the intersection of the domains education/learning, research/discovery and outreach/engagement, "where assets and interests of all stakeholders (faculty, students, industry, community) combine to achieve synergistic results that benefit all" (Pearce & McCoy, 2007). Chen et al. focus on an education ecosystem in the context of big data, which "can be represented as educational conformity of resources, user precise localization, educational flexible cooperation, novel service mode, data value excavation and complicated educational environment" (Chen, Zhang, Huang, & Chen, 2016). As the definitions differ in their content, we develop a more general definition based on the findings of this literature review.

Based on the previous findings we suggest the following definition: *"educational ecosystem is an interactional system of an educational community, its environment and stakeholders (university, government, industry and students) as well as the interdependency and mutual requirements of the stakeholders."*

According to previous explanations regarding the ecosystem concept, the conceptualization of the article leans on a model, which represents the stakeholders and their relationships in the educational context. The concept of the triple helix was initiated by Etzkowitz and Levdesdorff and concentrates on the relationships between university, industry and government (1998). Caraynnis and Campbell suggest a quadruple Helix model by developing the forth helix identified as the media- and culture-based public (2009). Following the recent knowledge of Carayannis et al. (2018) the conceptualization is constructed twofold, it combines the ecosystem approach and the quadruple/quintuple Helix approach. The fourth helix has been modified into the term "students" as shown in figure 2 in order to serve as a suitable basis for the structure, as in the

educational context we solely regard the education consumer. We added the learning environment in the middle of the helixes because of the interaction of the stakeholders, as it is of great importance to get an insight view of possible future curricula design.

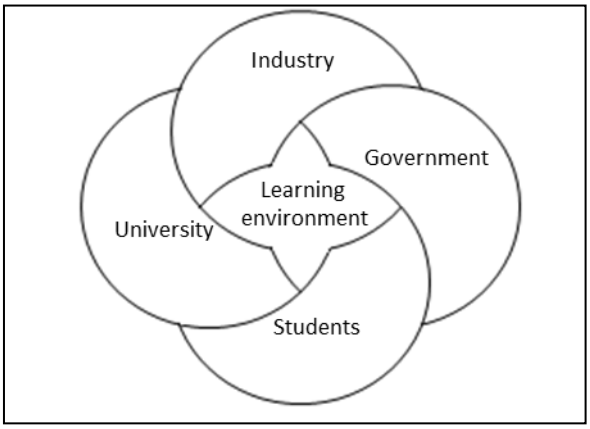

Figure 2: Conceptualization as a quintuple helix model in an ecosystem context

The configuration is alluded on the "balanced" configuration presented by Etzkowitz and Ranga (2013). In accordance to the authors, this configuration allows the most important insights for innovation as all stakeholders act in partnership and create favourable environment for innovation, which here represents the novel education program. Each helix implies requirements of the respective part, whereas the overlapping part in the middle represents the learning environment, where all parts exert influence regarding content and the environment. The single components are characterized as follows:

1. The government implies guidelines and policies, like e.g. legal conditions, university law, and data protection law. The helix also includes requirements regarding the innovation, such internalization, HE reforms, e.g. Bologna-Reform, and research and knowledge transfer.
2. The industry sector implies requirements of the employers on future employees with respect to expected qualifications and competencies, which are changing over time.
3. The students sector represents the requirements of education consumer.

4. The university is the place, where all the requirements come together and must be transformed into curriculum, simultaneously trying to satisfy the needs of every part.
5. The overlapping part in the middle of the four helixes represents the learning environment, where all parts exert influence regarding content and the environment.

2.3 Literature search process

According to the conceptualization above, the keywords were defined and combined to a full search term: (("higher education" OR "third mission" OR "e-learning") AND ecosystem) OR ("education* ecosystem")).

The combination of the terms "higher education" and "ecosystem", as well as "educational ecosystem" are the main search phrases. Third mission implicates activities of HEIs, which exceed the traditional areas of responsibility research and teaching (Henke & Schmid, 2017). and is about augmenting the knowledge with societal practice knowledge, creating transdisciplinary research fields (Schneidewind, 2016). The term "e-learning" is taken into consideration in order to find out, whether the cooperation of the different stakeholders within the learning field represents a research focus or not and to examine how the future learning environment is influenced by the different parties.

In order to cover all relevant sources in the field of IS different databases are taken into account. Following search fields were limited in Ebscohost database: Applied Science & Technology Source, Business Source Ultimate, EconLit with Full Text, Library, and Information Science & Technology Abstracts. Further quality assurance was made by only considering peer-reviewed literature in the period from 01.01.2015 to 31.12.2018. The Association for Computing Machinery (ACM) Digital Library also refers to the field of computing and information technology and was searched under the same restrictions.

Conferences play an important role in the IS field, according to this the Institute of Electrical and IEEE Xplore Digital Library and Association for IS (AIS) Digital Library were explored. As Hawaii International Conference on System Sciences (HICCS) articles are not listed in the described databases after 2017, the proceedings on the website were separately taken into account. As the search

options do not allow simultaneously searching of all terms, they were searched individually and the results were proofed for redundancy. Table 1 below shows the results of considered databases.

Table 1: Results of the literature search

Database	Result all fields	Results title	Results abstract	Results full text
Ebscohost	105	17	10	7
AISeLibrary	57	15	2	0
ACM Digital Library	103	15	10	6
IEEE Digital Library	55	21	13	7
HICSS	14	6	3	2
Wirtschaftsinformatik(WI) conference	3	1	1	0
Total	337	75	39	22

The column "result all fields" shows the number of results in total after making search limitations. In the next step, all titles were regarded and articles sorted out due to topic relevance. Subsequently the abstracts of the remaining articles were perused. Finally, 22 articles were read. Worth mentioning is the fact, that many articles were sorted out, as the term "ecosystem" was only represented in the abstract. In the next chapter, the found articles are structured according the previous determined conceptualization.

3 Analysis and Discussion

This section presents the findings of the previous literature search, which are categorized as shown in table 2: first the single relationships (university-industry, university-government, university-students) are taken into account followed by insights concerning learning environment. The second part deals with triple and quadruple helix relationships.

Table 2: Concept matrix

	HEI	Government	Industry	Society/user	Learning environment
	Triple helix 9				
	Quadruple helix 10				
(Barokas and Barth 2018)	x		x		
(Rustam and van der Weide 2016)		x			x
(Vorvoreanu et al. 2015)				x	x
(Juvonen and Kurvinen 2017)	x		x		
(Hajikhani et al. 2018)	x		x		x
(Moreira et al. 2017)		x			x
(Mulhanga et al. 2016)	x	x			
(García-Peñalvo et al. 2015)	x			x	x
(Sein-Echaluce et al. 2015)					x
(Ortega-Mohedano and Rodríguez-Conde 2018)	x			x	
(Marques et al. 2015)	x				
(Birkner et al. 2017)	x			x	
(Sicilia et al. 2018)	x		x	x	
(Miller et al. 2016)	x				
(Bazhal 2015)	x				
(Chen et al. 2016)	x			x	
(Rothe and Steier 2017)	x		x	x	x
(Galán-Muros et al. 2017)	x			x	
(Amorim Silva and Braga 2018)	x			x	
(Donald et al. 2018)	x				
(Miller et al. 2018)	x				

3.1 Single relationships of the stakeholders and learning environment

Barokas and Barth start by introducing the original term of ecosystem (2018). The projects pursue the objective of a tight cooperation between the educational and industrial sector, which results in academic courses, a training course for high school teachers and a course, developed by industry to train purposes. Based on the findings, the authors provide guidelines for creating future educational ecosystems and develop prerequisites for these. Juvonen and Kurvinen also focus on university-business collaboration by proposing collaboration with start-ups and small and medium enterprises, fostering learning through real business cases.

Thereby companies can directly participate via education activities or shared customer projects, and be used as trainers, sources of projects and tasks and as employers during students practice training (Juvonen & Kurvinen, 2018). Hajikhani et al. distinguish platforms and ecosystems and describe their similarities such as interdependence and network effects. Further, they present a platform as a "focal factor" within the ecosystem, which increases the system value by increasing number of participants and derived necessary conditions for such cooperation. The platform shall support the multi-disciplinary discovery relationships and explore the positive impact of innovative use of communication technologies on human experience (Hajikhani, Russell, Alexanyan, Young, & Wilmot, 2018). In order to explore the perceptions concerning the importance of digital competences and teaching progress in HEIs, Sicilia et al. conduct a study. According to other studies on digital competences the authors point out that the measurement of achieved level on digital skills is still insufficient from the employers view. The HEI focus group stresses that there is a lack of a systematic curricular approach on digital competences. In this regard, situated learning, which takes place in the context of real setting, plays an important role. So an approach with workplace is needed to develop a systematic training in the curriculum. Rothe and Steier present Udacity as a case study and example of collaboration between business and students, where MOOC platforms with lectures from private companies disrupt boundaries of conventional education (2017). The cooperation between the educational and industrial sector is of high importance, as it allows the students to encounter and to confront concerns, which are relevant in practice. Such cooperation is profitable for both parts, as the industry sector, as the future employer, can influence the teaching content to form their future employees. Students can gain industrial experience via internships and be more prepared before starting their careers. In keeping with Sicilia et al. universities should invest more in teaching digital competences, due to an increasing demand by industry. The platform concept proposed by Hajikhani et al. (2018)can serve as a suitable medium to facilitate knowledge transfer and knowledge sharing.

Even the university-government cooperation is not treated extensive, Mulhanga et al. point out some important issues concerning the government role in the ecosystem. Of particular note are the government strategies for science and their implementations, financial resources as well as national and international science developing programs (Mulhanga, Lima, & Massingue, 2016). Since there are

many political pressure and structure guidelines the university has to comply; the government should also be regarded as an important stakeholder within the educational ecosystem.

The article of García-Peñalvo et al. deals with the integration of students into the creation process of learning environments. Having an individual learning environment, students can use tools, which are more suitable for them and they can learn independent of the institutional location or period of time (García-Peñalvo et al., 2015). In this regard, the authors utter that the current learning management system (LMS) as only part of the educational and technological innovation strategy is not valid any more, since the limitations are almost known and seem not to be attractive for the user. Learning analytics is necessary to foster the adaptive knowledge management systems. Hereby, adaptability can e.g. be accumulated with gamification aspects to engage the students in the learning process. In order to solve the problem, the authors propose the technological learning ecosystem as a framework, which supports renewed educational processes and must comply with the knowledge management strategy and contain a series of interoperable key elements (García-Peñalvo et al., 2015). Based on a literature study, Ortega-Mohedano and Rodríges-Conde define education as a service in economical context considering students as clients, who are participated in the production (co-producer). Amorim Silva and Braga design a "system of systems" to support the interaction between the core elements of an educational Internet of Everything ecosystem (Amorim Silva & Braga, 2018). There is an agreement in the recent research concerning necessity to involve the user in the production process, as students have to participate in the construction of their learning environment. Gamification aspects can be used to foster the perception of progress. The data about the preferences and learning habits of the students in turn can be used to improve the curriculum. Insofar, the students represent an indispensable component in the educational ecosystem, as they shall participate in the design of the learning environment. Consistent with the third mission approach, the university has to open boundaries and cooperate with the other stakeholders to improve the study offer and the quality of the curriculum thus strengthens the competitiveness.

Taking for granted the phenomenon of the transformation to a digital society, in particular e-learning was examined in the ecosystem context. The majority of the articles examine the digital learning environment, e.g. in the form of MOOCs.

Rustam and van der Weide propose an IT platform, where courses from different universities and MOOCs are jointed together with the goal to offer suitable courses for students independent of the physical location of the university. Furthermore in this way, universities can share their knowledge country-wide, which still can be controlled by the government (Rustam & van der Weide, 2016). García-Peñalvo et al. also emphasize the importance of the possibility to learn independent of the institutional location or period of time. As mentioned in the prior section, the authors propose the use of learning analytics to improve adaptive knowledge management systems (García-Peñalvo et al., 2015). Moreira et al. underline the importance of using data from online courses, social platforms and other LMS in order to improve teaching and implement adaptive teaching (Moreira, Gonçalves, Martins, Branco, & Au-Yong-Oliveira, 2017). Keeping it with the previous authors, Sein-Echaluce et al. also examine adaptive learning at HE, particularly the adaptivity in MOOCs and moodle courses regarding the adjustment of teams, which perform work . Finally, Rothe and Steier claim that MOOC platforms are about to disrupt university boundaries and may pose a risk for HEIs (2017).

3.2 Triple helix and quadruple helix relationships

The articles from Bazhal and Marques et al. deal with the cooperation and interaction between HEIs, government and business. Bazhal uses the triple helix model to improve the development of innovation activities in an Ukrainian university (Bazhal, 2015) whereas Marques et al. focus on creating synergies between the stakeholders in an entrepreneurial context. The authors emphasize that HEIs play an important role in developing student skills in order to promote their employability. They also stress that the enterprises by collaborating with HEIs maximize the development of their employees, increase the competitive advantage, and introduce a project to point out the importance of non-formal and informal entrepreneurial learning in the academic context in Portugal (Marques, Moreira, & Ramos, 2015).

McAdam et al. consider university incubation models in the quadruple helix context. University incubation can be seen as an interactive process, which shall integrate mentoring and knowledge exchange between the stakeholders (2016). In keeping with Carayannis and Rakhmatullin (2014), the authors suggest an extension of the triple helix model by introducing innovation users as a forth

helix. Miller et al. define the fourth helix in form of the "societal based innovation users", as further stakeholder with committed involvement, participation and influence throughout the university technology transfer (UTT) process (2018). In this regard following aspects could be identified as relevant: paying attention to tensions between the various stakeholders, developing stakeholder relationships, the "soft infrastructures" like networking, knowledge transfer; the difficulties in UTT performance measurements; the need of an open organizational structure, which allows knowledge transfer and exchange. Birkner et al. also expand the triple helix model with a further helix underlining the role of the civil society and fifth helix emphasizing the ecological aspect. The authors utter that universities are permanently under pressure by involved parties for satisfying their needs and demands. On the one hand, the universities seem to adopt a third mission apart from research and education and on the other hand, universities benefit from the cooperation, as industrial research leads the way for academic research. Insofar it is possible to adjust the learning materials beforehand to meet the demands of industry (Birkner, Máhr, & Berkes, 2017). Donald et al. examine students' perception of benefits from HE on future employability as well as the perception of future university and careers preparedness for entering the global labor market. Therefore, the authors examine the perceived use of career services. Findings are: perceived employability improvement and life aspirations due to HE, benefits highlighted were personal development, future career and life aspiration. Lecturers could be identified as key players providing career advice; a need for greater collaboration between universities and employers was also identified. Therefore, the authors constructed a career advised model to show the complexity and interrelations between stakeholders. Furthermore, the authors found out that it is important for the government to work together with organizations in order to address the market requirements and create new jobs (Donald, Ashleigh, & Baruch, 2018).

The literature review shows that a general definition of the term "ecosystem" in the educational context does not exist, even though the term is used in this research field. Pilinkienė and Mačiulis compare different ecosystem analogies in the economical context (2014). The authors identify several analogies e.g. "industrial ecosystem" or "innovation ecosystem" and others, but the analogy of "educational ecosystem" is missing. Regarding this point, the literature review reveals the necessity for an ecosystem definition in the educational context. Therefore we suggest the following ecosystem definition based on the insights

of the articles: *an ecosystem is an interactional system of an educational community, its environment and stakeholders (university, government, industry and students) as well as the interdependency and mutual requirements of the stakeholders.*

The discussed dependences show that just considering the triple helix relationship is insufficient. At least the stakeholders of the quadruple helix and their relationships should be taken into account in educational context. The quadruple helix perspective shows that an open organization structure is needed to allow knowledge exchange and knowledge sharing between the stakeholders. The second important point is the necessity of adaptive aspects by designing the learning environment (adaptive gamification, adaptive knowledge management system, etc.). In this regard, the initial conceptualization needs to be extended to these important characteristics "knowledge transfer" and "adaptivity" (Figure 3). The arrows in figure 3 represent the ongoing interaction between the stakeholders, which builds the fundament for the knowledge transfer and possibility to adapt new content. The dashed line represents the open blundered environment, which allows extending the model with new components.

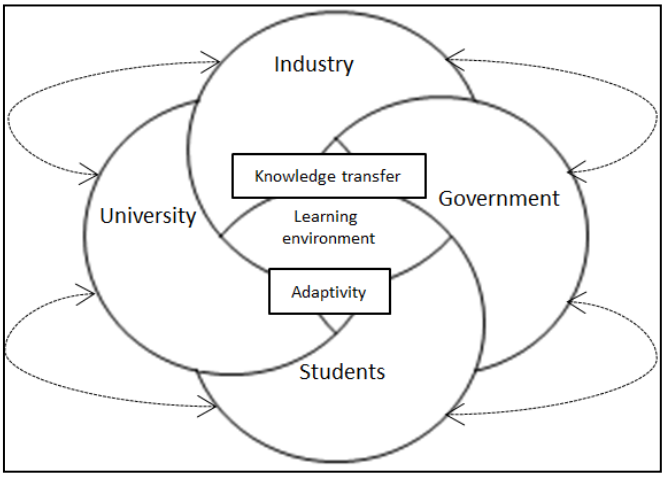

Figure 3: Modified conceptualization

By means of the literature review the learning environment could be augmented with two important processes which need to be taken into account by constructing novel curriculum designs. Adaptivity shall improve the efficiency of educational ecosystems, where social and technical aspects come together. Based

on the different backgrounds, abilities and habits of the students adaptive mechanisms can provide personalized features of the curriculum design (Morrison, Balasubramaniam, & Falkner, 2008). Optimizing knowledge transfer strategies between the stakeholders but also within universities can lead to improvements in knowledge involved processes.

4 Conclusion and further research

With the literature review we examined the relationships between the stakeholders of the quadruple helix model and whether there is a common understanding of the term "educational ecosystem" in the field of IS. The analysis shows that mostly single relationships between two stakeholders are regarded. Only in the quadruple helix perspective, all four parties are considered together. Relationships between the university and the industry are e.g. the technology transfer from the university on the one hand and coaching from industry practitioners or the possibility for internships, on the other hand. The relationship between the university and the government is characterized by legal guidelines and international research partnerships. Finally, comprehensive teaching and research identify the university-students relationship. However, all relationships have the necessity of knowledge transfer in common otherwise no relationship could exist. In addition, we could identify "adaptivity" as an important aspect for developing the learning environment. Therefore, the initial conceptualization was modified and extended with these findings.

Furthermore, the results show that even if the regarded articles include the term "ecosystem" in the abstract or full text, mostly neither the definition of ecosystem was introduced nor the approach has been consistently pursued. Although the ecosystem approach seems to be well suited to map the relationships between the stakeholders of the ecosystem and its environment, the use of the approach is insufficient in this research field. In conclusion, we suggest a definition of "educational ecosystem", which in our opinion can serve as a fundament for further research.

With regard to the limitations of this approach, we firstly have to mention that the literature search was limited towards articles, which deal with education in the context of ecosystem, by excluding all of them, which do not contain the term "ecosystem". Therefore, it is possible that there are articles describing the

relationships between the previously mentioned stakeholders, which were not taken into account. Secondly, we use the term "e-learning" to examine possible future learning environment(s) without considering other learning alternatives as we claim that traditional learning becomes less important in the future of digital society.

Future research in the context of educational ecosystems should focus on clearly defining the stakeholders of the ecosystem and their interrelationships. Therefore, an ontology could be constructed. Such an ontology can be seen as a specification of an abstract worldview describing and defining the elements of a particular area and their relations (Dong & Hussain, 2007). Another important research focus should be the examination of knowledge sharing and knowledge transfer since there is a flood of information, which has to be managed between the stakeholders and within the particular environments. Furthermore, the integration of adaptivity aspects in the learning environment can be analysed from a socio-technical system perspective. Finally, in the next step a comprehensive educational ecosystem can be modelled.

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