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E-Learning Ecosystem (ELES) – A Holistic Approach for the Development of more Effective Learning Environment for Small-and-Medium Sized Enterprises (SMEs)

Vanessa Chang¹ and Christian Guetl²

¹Vanessa Chang, School of Information Systems, Curtin University of Technology, Perth, Australia,
e-mail: vanessa.chang@cbs.curtin.edu.au

²Christian Guetl, Institute for Information Systems and Computer Media, Faculty of Computer Science,
Graz University of Technology, Graz, Austria
e-mail: cguetl@iicm.edu

Abstract — As e-learning and technologies advanced significantly, practitioners and academics must find new ways to make the most of this rapid development. In the past, research development in this area was mainly focused solely on technological aspects and more recently, on e-learning and technologies for individualized learning. Much work has been done in this area to enhance e-learning systems. In this research, we proposed that an ecological and holistic approach is required for an improved learning environment. To do this, the concept of ecosystem will be explained, followed by a rationalization of this application to learning and e-learning. A definition to learning ecosystem (LES) is provided and this generalized definition is further applied to the e-learning ecosystem (ELES). Hereafter an identification and examination of the e-learning ecosystem will be presented in detail. Finally, an application of the e-learning ecosystem in small-and-medium sized organisations (SMEs) will be discussed. Prior to this, an overview on the usage of e-learning in SMEs will also be given. We conclude by highlighting the need to emphasize on the ecological and holistic approach for the development of more effective learning environments.

Index Terms—ecosystem, learning ecosystem, e-learning, e-learning ecosystem, SMEs, e-learning model

I. INTRODUCTION

Although e-learning systems and technologies have evolved considerably and matured somewhat since the inception, practitioners and academics must continue to be attentive in the way they apply technology and construct e-learning contents. They must continuously consider new ideas, new learning strategies and capitalize on the modern technology in order to accommodate the preferred learning styles of the diverse student cohorts involved in e-learning. Over the past few years, many have attempted to develop e-learning systems with the aim to make learning more effective, less expensive and adaptable to the needs of the individual learner [5]. There are also some apparent failures in the use of education technology where it was expected that technology would transform teaching and learning. This systemic failure stems from the lack of understanding of the human learning process [23] and the lack of training in new technologies available to the main stakeholders responsible for e-learning [12]. We agree with [17] that inappropriate uses of technology can hinder learning. Since the early days of technology-supported learning, unfortunately too much research and development was focused solely on technological aspects. Based on the current e-learning research, it has be-

come clear that there is an increasing demand for e-learning systems and technologies to deliver individualized learning in accordance with pedagogic aspects. The Austrian research project AdeLE (Adaptive E-Learning with Eye-Tracking), where one of the authors is involved, tries to cover that demand [4], [5], [14]. However, some further research addressing AdeLE's application for learning in organizations has to be done. This motivates us to work on a completely different approach to gain insights for further improvements of the AdeLE learning platform.

To address the on-going challenge of life-long learning and to ensure learners' productivity, e-learning systems must be developed with flexibility and individualization in mind [23]. For life-long learning to be effective, pervasive and acceptable, it is imminent that an ecological and holistic approach for an improved e-learning environment is required. Based on the motivation stated so far we intend to discuss the idea of an 'e-learning ecosystem', inspired by the increasingly amount of adoption of the ecosystem model in several application domains.

The remainder of this paper is organised firstly by explaining the concept of ecosystem and rationalizing its application to learning and e-learning ecosystems. Three areas were identified in the learning ecosystem. Using the learning ecosystem (LES) components, more restrictive and specific components were examined in the e-learning ecosystem (ELES). This is followed by an overview of the use of e-learning in Small-and-Medium Sized Enterprises (SMEs). The holistic approach of ELES was then applied to e-learning in SMEs.

II. THE ECOSYSTEM

According to the Encyclopedia Britannica an *ecosystem* is a "complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space." The non-living or abiotic constituents of the system are addressed by the physical environment of the system, its living or biotic constituents consist of all its living members [13]. The term ecosystem was coined and a basic definition was given by the British ecologist A.G. Tansley in 1935, and the American Raymond L. Lindeman extended the definition by the aspect of energy flow [28]. However, the basic definition is described as "a biotic community or assemblage and its associated physical environment in a specific place." That early definition does not explicitly mentioned interaction and relations. However the term 'system', borrowed from the

physics domain by Tansley, implicitly highlights the interaction between biotic and abiotic components. Components themselves could also be of high complexity with internal interactions, and a nested hierarchical structure is also implicitly expressed by Tansley's definition. Also, the ecosystem can be of any size as long as organism, physical environment and interaction exists. Furthermore, the definition as such is free of narrow assumptions, such as equilibration, stability, persistence, assembly of components, and kinds of interaction [25].

The research reported in [25] on ecosystem as a multidimensional concept gives valuable insights for our application in the learning domain and this concept is depicted in the following section. The power of the generic definition of ecosystem is its applicability to any system of biotic and abiotic components interacting in a particular spatial area, but that also means that it addresses countless instances. In order to be more concrete a model for a particular application domain is needed. Some of the features of a concrete model are defined by external aspects, and other features emerge from inside the system. Various types of models in the biological science have been developed, such as models focusing on energy and nutrient as well as biodiversity modeling. In order to describe a particular instance of a model, the following characteristics have to be specified: (1) the biotic and abiotic components as well as proper level of aggregation, (2) the temporal extent and the temporal and spatial scale, (3) the physical boundaries of the system, (4) the description of type and extent of relations and interaction between identified components, and (5) constraints on system behaviors [25].

Taken these insights so far, it is apparent that the model of the ecosystem strongly emphasizes a holistic approach whereby this notion of thinking highlights the significance of each component, their behavior, relationship and interactions, as well as the environmental borders in order to examine an existing system or form an effective and successful system. According to [25], ecosystems can also include humans and their artefacts. Thus, it can be applied to studies that expose humans and human-generated processes and structures. In the past the ecosystem has been adopted in various application domains, such as in Grid Computing [29], in knowledge management as 'knowledge ecosystem' [24], in economics as business ecosystem [26] and digital ecosystem [18].

It is this fundamental ecological concept covered by the ecosystem and its applicability to various application domains as well as the exciting and interesting holistic approach that led us to transform the idea of the ecosystem in the learning domain.

III. THE LEARNING ECOSYSTEM (LES)

According to [11], the idea of a 'learning ecosystem' has been emerging over the past years. However, our own research has shown that most of the literature purely mention the term with little or no definition or explanation, and merely link it to other concepts. Some of the accessible papers addressed specific aspects, such as [21] focuses mainly on the environmental aspect, [19] investigates informal learning eco-

systems that emerge around multiplayer online games, [25] mainly focusing on the actors, [31] concentrates on the learning process, [1] addresses an evolutionary learning community ecosystem and an evolutionary learning ecosystem in the context of learning conversations and design conversations and [9] focuses on the technology viewpoint and defines a fundamental architecture. According to [4] a learning ecosystem was formed by different communities interacting within and between individuals and groups, other key aspects (environment as well as tools and artefacts) are addressed implicitly. However, the lack of a general view to learning ecosystems in literature has led us to propose a more generic definition.

Our generalized view in the learning domain was based on the abstract definition that an ecosystem is classified by biotic and abiotic components and all their interrelationships in specified physical boundaries. Transforming that to the learning domain, we proposed an abstract definition of **learning ecosystem (LES)** that consists of the stakeholders incorporating the whole chain of the learning process and the learning utilities, the learning environment, within specific boundaries, which we call learning environmental borders.

Given the abstract definition stated above, a first generic model for learning situations is outlined as follows, see also Fig. 1. As the biotic units in the ecosystem the *learning communities and other stakeholders* such as teachers, tutors, content providers, instructional designers and pedagogical experts, form the living parts of the learning ecosystem. The *learning utilities* comparable to the abiotic units (or the *learning environment* comparable to the physical environment) represent the non-living parts, which include the learning media (content and pedagogical aspects), technology, and tools applied in traditional teaching methods. The *learning environmental boundaries*, an analogy to the specified physical boundaries of the ecosystem defines the

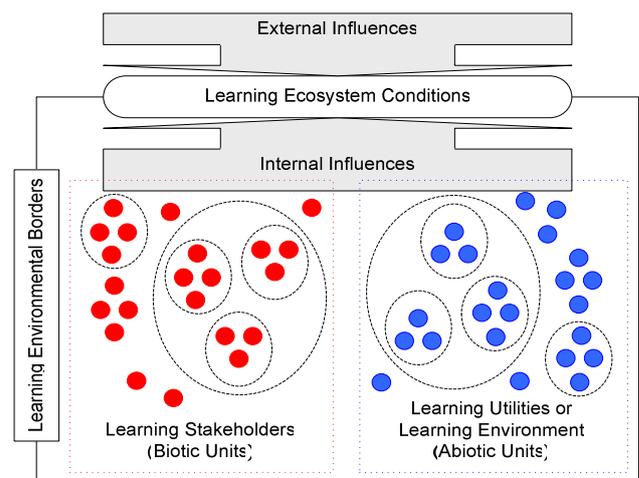


Fig.1 Simplified representation for the learning ecosystem (LES)

physical and logical borders of the learning system. That is one of the system's characteristics, which are in common specified as the *learning ecosystem conditions*. These conditions are determined by external and internal influences, such as evolution of knowledge, educational goals, learning tasks, cultural and sociological aspects, and expectations by

society, private industry and business organizations, the government, public service and not-for-profit organizations. Finally, in order to define a concrete model according to [25], the temporal extent and the temporal and spatial scale of the system has to be specified.

The main interests in the learning domain are relationships and interactions related to the information flow as well as knowledge transfer and transformation. In light of this, some conclusions are identified. Like a biological ecosystem, in a learning ecosystem, individuals can form groups spontaneously and can interact with each other or with learning utilities at the individual or group level. They also can perform, change or adapt specific behaviors in order to contribute to or perturb to the success of the learning ecosystem. Changes in the learning ecosystem conditions influence the “behavior” of the system and its components. To be successful and to be valuable for the system, each individual and group must adapt to the environmental conditions to find their niches. In order to fit them all together, proper learning utilities must also be available.

Taking this into consideration, we are claiming that the generic view of the learning ecosystem can be applied to any learning situation, such as traditional face-to-face teaching in classrooms or e-learning in business environments. This is to assert that we need to consider in any learning situation biotic and abiotic components or cluster of components, their relationships and interactions together with the ecosystem’s conditions. Furthermore, the biotic and abiotic components as well as the learning environmental borders and the other conditions of the learning ecosystem are in principle dynamic. This generic view helps us to get a better picture about a specific learning situation, and allows us to achieve a more holistic approach for the development of more effective learning.

IV. THE E-LEARNING ECOSYSTEM (ELES)

By restricting the system’s conditions of our proposed learning ecosystem to the e-learning domain we are able to narrow down to an *e-learning ecosystem (ELES)*. This allows us to identify and examine (A) the specifics of the learning communities and other stakeholders, (B) the more specific learning utilities, and (C) the more restricted learning ecosystem conditions. The following sections will explain each of the three items listed above, followed by a discussion about the integrated view of them.

A. Specifics of the Learning Communities and Other Stakeholders in E-Learning Ecosystem

The learning communities can either be individual or groups of individuals who can interact and collaborate synchronously and asynchronously with one another. The individual’s learning attributes include the learning styles, learning strategies, learning preferences, learner’s pre-knowledge and competency level, and other learning characteristics specifically related to the individual. Other stakeholders are those who play significant roles related to teaching and learning, specifically they are the teachers, tutors, knowledge experts, content providers and pedagogical experts who

oversee the pedagogical aspects of learning and the instructional designers who handle the information and design of the content. Associated with these stakeholders are the IT support group who provide the IT infrastructure and platform for the e-learning activities. They also administer and manage the IT to support the teaching and learning group.

B. Specifics of the Learning Utilities in E-Learning Ecosystem

The learning utilities include the static and dynamic learning media that contain the content and pedagogical aspects. In addition, background knowledge in the form of external sources such as wikipedia, digital libraries, and others are also part of the learning utilities. The technology may include the infrastructure and learning platform for the management, delivery and tracking of e-learning in the form of learning content management system (LCMS), learning management system (LMS) and content delivery system (CDS). Laptops, desktop computers, podcasting, PDA are also examples of some of the learning utilities.

C. Restricted Learning Ecosystem Conditions of E-Learning Ecosystem

The learning ecosystem conditions characterize important parts of an ecosystem learning system and they are affected by external and internal influences. In general these conditions are dynamic and ever-changing, but potential impacts on the system depend on the lifecycle of the examined system. The conditions may be driven by the industry to employ workers with outstanding skills, influenced by domain knowledge and government policy such as changes to the educational learning strategy or changes in course curriculum. Challenges that affect the core of the e-learning ecosystem must be addressed. There are also other factors such as cultural and sociological influences that must be considered.

To clarify our picture, let us consider how to define a concrete model from the generic e-learning ecosystem, and based on that some concluding remarks are given. Applying ELES to the generic view of LES as shown in Figure 1 we need to ascertain ELES’ biotic and abiotic components or cluster of components, their relationships and interactions as well as the ecosystem’s internal and external environmental influences. As an example, we are interested in examining effective knowledge acquisition. In that context relationships and interactions are of interest, which are exposing collaboration, the information flow as well as knowledge transfer and transformation. Based on that, we can concentrate on the biotic components, which are formed by the learning stakeholders. For learning to be successful and effective, the learning community may work as an individual or in groups. Likewise, in this biotic component, we can consider the learners’ learning strategies, styles, and preferences, their competency level plus many other attributes. The teaching group may need to adapt and personalize their content to suit the need and ability of the learner community. Coupled with these are the abiotic components. These abiotic components are linked closely in a symbiotic relationship with the biotic component. Linked with the learning community’s attributes

and the response from the teaching and learning group, the abiotic components include the use of dynamic learning utilities and media. Specific LCMS, LMS, CDS, and other learning utilities may be used. The interactions between the biotic and abiotic components are also controlled by internal and external environmental conditions. As learning patterns are controlled by the learners, they may contribute to the internal influences in the form of interaction and collaboration among learners. External conditions such as the evolution and innovation of the application system and technology, plus other cultural and sociological aspects may cause a change in the use of the application and technology; and in effect the course content. They may also be external e-learning ecosystems that may interact and impact the internal system. It must be realized that in any ecosystem like ELES, a disconnection to a component may be detrimental to the success of the e-learning ecosystem. It is vital that all components of ELES must integrate and work harmoniously and there must be a balance in the utilization of each component.

This concept of ELES and the extension to concrete ELES models can be applied to many different e-learning situations. In this study, a model for e-learning ecosystem in SMEs is constructed to support e-learning in SMEs. Much has been reported in the literature [3, 15, 17] for the need of models and frameworks to support e-learning in SMEs.

V. E-LEARNING IN SMALL-AND-MEDIUM SIZED ENTREPRISES (SMEs)

A recent study carried out by Cedefop ICT Research Network [8] reported that “e-learning, although a widely accepted training method, still faces resistance among SMEs due to a perceived lack of direction to those who use it and what it is used for.” A number of definition existed in the literature in an attempt to increase the usage of e-learning in SMEs. Becta Research Group [3] adopted Pollard and Hillage’s definition of e-learning in SMEs as “*the delivery and administration of learning opportunities and support via computer, networked and web-based technology to help individual performance and development*”, they have also narrowed down the definition of e-learning to *work-based learning* whereby “*learning that is undertaken in or linked to the workplace*” [10]. E-learning in SMEs is classified into formal training and vocational training [17]. Formal training is “*a training that is organised and packaged to cover a given subject, with clearly defined topics, eventually leading to the delivery of a certification*” whereas vocational training relates to “*the training costs are supported by the company and the topics are related to the job of the individual*”.

As suggested by Hughes and Attwell, e-learning in the workplace cannot be excluded from SMEs [17]. E-learning is regarded as a training tool and a means to enhance continuous learning for SMEs’ employees. To administer this, e-learning facilitation and infrastructure must be incorporated in the workplace. Also, SMEs need to examine the knowledge and skills required for e-learning in the workplace and how to apply the skills gained from the e-learning activities. Effective pedagogies with reliable materials and resources all play important parts in SMEs e-learning. In addition, there is also

a need to consider how the e-learning materials in SMEs adapt or fit with the learning needs.

Nyhan et al, suggest that apart from the normal working environment, learning in a workplace also occurs in social events and in everyday activities [2]. This means that the work is also carried out in various social settings where employees collaborate and interact on specific subjects and in SMEs this plays a vital role in employee’s lives. Therefore, according to Nyhan et al, SMEs have to integrate learning from the ‘economic, human and social’ perspectives [2].

In order to promote staff development, employees may attend training courses, workshops, seminars, conferences and others. With the advancement in technology, organizations are engaging the use of e-learning and other learning media as tools to develop the employee’s skills and knowledge. In addition, increasingly learning on the job and situation-based learning (learning on demand) has to be considered in our fast changing knowledge society.

Some of the challenges reported in literature [3, 15, 17] with respect to e-learning in SMEs lie in the ability to handle the number of “variables which potentially impact on the effectiveness of e-learning and deciding what constitutes dependent, independent and irrelevant variables in a given situation.” This is where the application of ELES is helpful.

VI. APPLYING E-LEARNING ECOSYSTEM (ELES) TO SMEs’ E-LEARNING

As described previously, ELES is divided into (A) the specifics of the learning communities and other stakeholders, (B) the more specific learning utilities, and (C) the more restricted learning ecosystem conditions. The following sections explain how ELES is applied to e-Learning in SMEs. This means that a first approach towards a concrete model restricts the generic ELES typically by the characteristics given in SMEs learning situations. Based on this, our research results and assumption are summarized in the remainder of this section.

A. Specifics of the Learning Communities and Other Stakeholders in SMEs

For the individual learner, learning styles, learning strategies, learning preferences, learner’s pre-knowledge and competency level, and other learning characteristics specifically related to the individual must be taken into account in the workplace. Specifically, in ELES, this may include the learner’s gender, age, location, experiences with previous learning history, duration and attainment level of previous learning experience, learner’s motivation and familiarity with technology. The individual learner would also want to use e-learning in a way that would maximize to use of their time, effort, and resource. The learner’s objectives of using the e-learning materials must also be clear. In terms of the pedagogical aspects, the content experts and instructional designers must consider the level and aim of the e-learning material. They must consider the appropriate methodology to use when developing the e-learning material. The methodology used must be aligned with the learner’s

attributes and characteristics. They must also consider the support (for example, is this for formal or vocational training) that the learner is seeking. Other stakeholders such as the IT support group must exist to provide the IT infrastructure and platform for the e-learning activities. Especially in working environments also collaborative activities and acquisition of tacit knowledge, skills and best practices from experts are important.

B. Specifics of the Learning Utilities in E-Learning Ecosystem in SMEs

The learning utilities according to ELES include static and dynamic learning media that contain the content and pedagogical aspects. This includes any form of media that carries the relevant content to the learner. The media may be in the form of webinar, podcasting of synchronous materials, digital libraries, in-house or vendor developed e-learning and many others. In order for SMEs to maximize the use of e-learning, SMEs may need to establish collaborative e-learning support networks in and around the workplace region [32]. E-learning collaboration with partnerships with other organizations and fostering strategic alliances can provide the advantages and economies of scale to SMEs [32]. Successful e-learning collaboration is a critical part of the organization culture. Pedagogically this is regarded as work process knowledge where the networked collaboration integrates the acquisition of knowledge and the practice of skills with work processes [20]. The recent development and advancement of the digital networked economy has increased the level of accessibility to multimedia thus enhancing opportunities to leverage on this.

C. Restricted Learning Ecosystem Conditions of E-Learning Ecosystem in SMEs

The learning ecosystem conditions are affected by internal and external influences and challenges such as economic, political, technological, social and human knowledge and competence [2]. These challenges may be inspired by the individual desire to learn within the workplace and there may also exist learning opportunities on the accreditation and recognition of individual achievement [3, 15, 17]. Employees may also want to be recognized for their learning and training for their career progression. Funding may become available to the organization to pursue e-learning. As employees and organizations are driven by uncertain conditions, the holistic view of ELES provides an avenue for SMEs to consider all of these influences and challenges.

Applying the holistic view of ELES to SMEs, an assessment of the learning community must be carried out to assess the learner's personalization or adaptive learning approaches, which in turn integrate organizational and personal development. At the end of this assessment, the learner is able to select the e-learning materials that are most suitable for him/her. For example, the learner may require information and knowledge about a certain product and the 'just-in-time' timing of the e-learning usage may coincide with this. Learners may also consider using the e-learning material for accreditation and the material is seen as training e-resources

and this may be significant in the employee's career advancement.

Where e-learning is practised in SMEs, the learners must be able to access the materials and technologies in which the e-learning takes place. After spending time to learn the e-learning materials, the learners must be given the opportunity to apply the recently acquired knowledge and skills within the workplace. This is aligned with Nyhan, et al assertion that it is important that "work roles, work processes and work environments" are integrated rather than be seen as separate entity. In the ELES model, and as applied to in Figure 1, SMEs are attentive to the external conditions, concurrently concentrating with its own learning system, and at the same time trying to capture and understand the interactions between the external and internal influences. As stated previously, by [2] learning in SMEs is also "dependent on social relations between employees within the SME" and "between networks and social relations with other SMEs" [2]. E-learning collaboration with partnerships and strategic alliances can provide an added advantage to SMEs. Partnerships and alliances are reliant on the interaction between the learning communities. Whilst this networking is based on the associations and relationships between the learning communities they are also dependent on the internal and external influences.

VII. THE EXPERIENCE WITH ECOSYSTEM-BASED DEVELOPMENT

As reflected in the definition of ecosystem, learning ecosystem and e-learning ecosystem, it can be summed up that the idea of ecosystem can be applied to any learning and e-learning ecosystems; and as presented here the e-learning ecosystem in SMEs. We have learned that the components surrounding an ecosystem, such as learning or e-learning, are dynamic and mutually exclusive. With this realization this paper attempts to highlight an e-learning ecosystem with a strong emphasis on a holistic approach for the development of more effective learning environments. To achieve this, the strategy to develop a more effective e-learning environment is to continually improve the ecosystem as a whole. In practice, an e-learning ecosystem is realized by incorporating user-centric collaborative learning, pedagogical aspects, content and learning design, technological innovation and environmental considerations such as social and cultural factors that help learners respond to new and uncertain conditions. Through consideration of the human endeavours within the ecosystem based e-learning environment, we come closer to understand the ways in which e-learning system's communication can enhance learning, knowledge enhancement, social and cultural development.

VIII. CONCLUSIONS AND FUTURE WORK

This research is to continue and further effort to advance the development of theoretical framework to guide further practical e-learning ecosystem development will be made. The researchers anticipate that case studies will be conducted to apply ELES to SMEs. A deeper understanding of technological development and advancement for better learning

management systems (LMS) and learning content management system (LCMS) will also be pursued. Consequently, the results will also be considered in the enhancement of the AdeLE architecture and its components functionality.

In a further research step, we also want to merge our proposed e-learning ecosystem with digital business ecosystems. As a result, this might help to understand and put forward development endeavours of self-organizing learning systems. In addition this also might inspire research to integrate technology based learning in conventional digital business ecosystem.

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