A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin, Ramon Daniëls

> *"Coming together is a beginning; keeping together is a progress; working together is success."*
>
> Henry Ford

As society changes rapidly, there is a need to educate professionals who contribute to innovation and complex adaptations in organizations. As part of this education, companies, governmental bodies and other stakeholders have sought collaboration on complex issues in "living labs". Living labs are recognized as educational environments to prepare students in higher education for future roles. The aim of this article is to explore the nature and extent of the scientific literature about living labs in which actors in higher education actively participate. In total, 21 articles were included in this scoping review. Research into this topic appears to be relatively new. Definitions of "living labs" are mostly in line with the definition used by the European Network of Living Labs (ENoLL), with its large variation of lab locations. Few results about organization and governance were identified. Different lessons learned regarding processes, interaction and requirements for successful living labs were found. The design of learning is mostly described by learning activities. Learning outcomes are described in generic and specific competences and assessments in living labs are rarely described. The authors recommend more detailed studies into aspects of the successful participation of higher education to gain knowledge about enhancing learning outcomes, and the effects of educational activities within living lab environments.

Introduction

The world is changing rapidly, leading to complex societal challenges. Continuous social changes affect the types of competences needed for professionals to contribute to innovation. Employers expect professionals to be lifelong learners and to constantly update their expertise in accordance with societal and professional demands. Complex societal challenges call for groups of collaborating experts with different backgrounds and contexts (Cremers et al., 2016). Consequently, there is a need to educate professionals who think and work in an interdisciplinary fashion, who contribute to innovation, and who achieve complex adaptations in organizations. Higher education prepares a substantial group of professionals for "real life", although it is questionable if traditional classroom courses are preparing students sufficiently for the challenges of the future. According to Zitter, Hoeve, and De Bruijn (2016), the traditional and scholarly approach of higher education is too limited. It does not fit within the "Zeitgeist" of the current era, does not resonate with the preferences of students, and collides with the demands of professional practice (Zitter et al., 2016). For example, in the Netherlands, Zuyd University of Applied Sciences focuses specifically on developing students into professionals with skills that are relevant for the region. Thus, their main pillars include integrating research into education and embedding education in practice (Zuyd University of Applied Sciences, 2019).

Increasingly, companies, governmental bodies, civil societies, and other stakeholders seek collaboration on actual complex issues in so-called "living labs". This concept offers opportunities for higher education to work closely with professional practice with the emphasis on innovation research in "real life". In the literature, the "living lab" concept is increasingly gaining attention (Schuurman et al., 2015). The European Network of Living Labs (ENoLL) defines living labs as "user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" (ENoLL, 2020). Real-life setting, co-creation, active user involvement, multi-stakeholder participation, and multi-method approach

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

are the five major elements of a living lab (ENoLL, 2020). According to ENoLL, no single living lab methodology holds across the broad; all living labs combine and customize different user-centred, co-creation methodologies to best fit their purpose (multi-method approach). The building blocks of exploration, experimentation, and evaluation get performed in iterations, emphasizing the importance of coming to know the current state, designing possible future states of innovations, real-life testing, and assessing the experimental impact by means of user-feedback (Malmberg & Vaittinen, 2019).

Although the concept of living labs has been emerging in the scientific literature and the number of living labs in different areas is increasing, much greater understanding is needed about how to run a living lab successfully. Several aspects of living labs have been the subject of study in recent years, for example, studies into types of living labs and user roles within living labs (Leminen, 2015). In their systematic review, Schuurman et al. (2015) confirmed the increasing number of papers about living labs since 2006, meanwhile the theoretical foundation of the concept lags behind the increasing number of experiences people are having with living labs in practice around the world.

A study into living labs in the Netherlands highlighted the potential value of living labs, though also indicates the current early stage of living labs, and the need for further study (Maas et al., 2017). While the concept of a "living lab" is gaining recognition as an innovative approach for higher education to prepare students for their future roles (Maas et al., 2017), not enough is yet known regarding how to successfully integrate higher education and living labs. Interdisciplinary collaboration poses challenges to all stakeholders involved, such as dealing with differences in professional language and professional culture (Hummels & Vinke, 2010), or shaping the involvement of users in the innovation process (Grove, 2018). Embedding higher education into living labs has its own challenges, including how to merge the dynamics of education and innovation processes into real-life settings, and to match the competences of students with required expertise in the field. Insights gained from reported experiences and lessons learned about how to integrate higher education and living labs , how to facilitate students' learning in living labs, and how to deal with the challenges it brings along, could provide guidance for future living labs. The aim of this article is therefore *to explore the nature and extent of the scientific literature about living labs in which actors in higher education (for example, students and faculty) actively participate*. To retrieve this information, a scoping review was conducted using the following research question for framing: *What is known about the role of higher education in living labs in scientific literature and about the factors that influence integration of higher education and living labs?*

Methods

Study design

We reviewed the literature on living labs by means of a scoping review. To accumulate as much information as possible about the concept, our main focus was on article relevance. We used the five-stage approach of Arksey and O'Malley (2003).

Identifying the research sub-questions

We formulated the following research sub-questions for background context:

- What kind of studies are conducted regarding living labs that include higher education?
- How are living labs defined and which models and approaches are used as theoretical underpinnings of the living labs?
- What are features of living labs in which higher education participates?
- What are lessons have been learned regarding integration of higher education in living labs?
- How is learning designed (for example, learning outcomes, learning activities and assessment) in the living labs?

Identifying relevant studies

Our study's search included two concepts: "learning environment" and "living lab" (Figure 1). Using a literature discovery service from Ebsco Host, we searched 29 different databases simultaneously (including ScienceDirect, CINAHL, Psychology and Behavioral Sciences Collection, PsycARTICLES, Science Citation Index, IEEE Xplore Digital Library, Cochrane Database of Systematic Reviews, ERIC).

The search was limited to publications in Dutch and English published between 2000 and June 2021. In addition to searching electronic databases, we checked the reference lists of relevant articles. We also searched

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

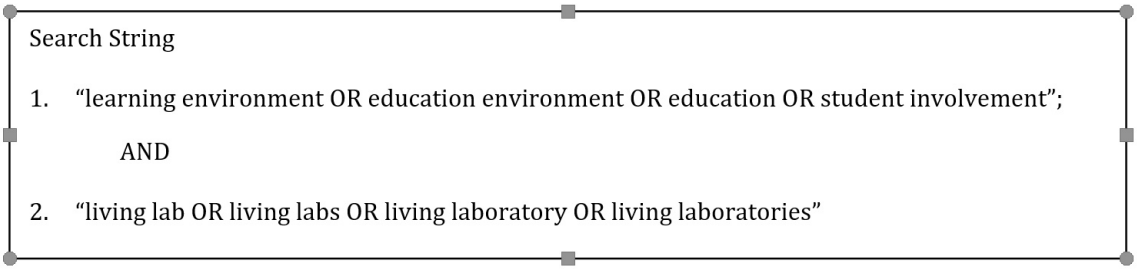

Figure 1. Search string

for journal articles as well as conference papers.

Study selection
The selection of papers based on paper titles was done independently by two reviewers (RvdH and RD). Papers with titles referring to both "living labs" and "education" were given a score of 2, papers with titles referring either to "living labs" or "education" were scored with a 1, and papers on topics that were not relevant to our study were scored with a 0. When the score of the two reviewers together was >2, the abstracts were screened. Screening was performed by one reviewer (RvdH). Articles were included if both "living labs" and "education" were mentioned in the abstract. When the concept of "living labs" was not explicitly mentioned, the article was not included, because this study specifically focused on environments that are called a "living lab". Other similar concepts may be partly comparable but were also not included because of small nuances between the concepts. Where there was doubt the full text was screened, and the reviewers discussed inclusion or exclusion of the remaining sources together.

Charting the data
A descriptive summary of each study was created in a spreadsheet to map the article's citation information, general article information (type of publication, number of living labs discussed, domain of the study, subject of innovation, and aim of the study), definitions, key elements and theoretical underpinnings of living labs used by the authors, information on various features, lessons learned, and specific information about how learning is designed within the living labs. First, five articles were independently charted and discussed by two reviewers (RvdH and SB). The results were then discussed with a third researcher, RD. Subsequently, one of the reviewers (RdvH) continued with the other 15 articles.

Collating summarizing and reporting the results
Initial reading and preliminary content analysis led to the main categories described to structure the findings. After creating the table, the results were summarized, reported and discussed by the authors in order to cluster results and draw conclusions.

Results

The search was performed on June 1st, 2021, resulting in 427 hits. After reading the titles, abstracts, and full texts, and correcting for duplicates, 21 full texts matching the inclusion criteria were selected. Figure 2 shows the selection flow chart of the inclusion and exclusion process. Excluded papers did not meet the inclusion criteria during the screening of the title or abstract because the topics "living lab" and "higher education" were not explicitly mentioned, as described in the Methods section.

Table 1 (supplementary material) gives an overview of all included articles. The first column shows the article reference (citation information). The second column provides general information about the type of study, the number of living labs involved in the study, the domain in which the living lab is situated, the subject of innovation and the aim of the study. The third column reports the definition of living labs as described in the article, often with additional key elements. The fourth column describes the theoretical underpinnings (models and/or approaches) of living labs as reported in the articles. The fifth column identifies the context and features of the living lab (environment), the stakeholders involved, and also the roles and governance structure within the living lab. Column six reports lessons learned involving initiation, evaluation, and sustainability of the living lab, including any success factors and challenges described in the papers. The seventh and last column shows specific information about educational aspects with an emphasis on learning outcomes, learning methods, and types of assessment, which is based on Biggs (2003).

General article information
The selected articles were published between 2007 and

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

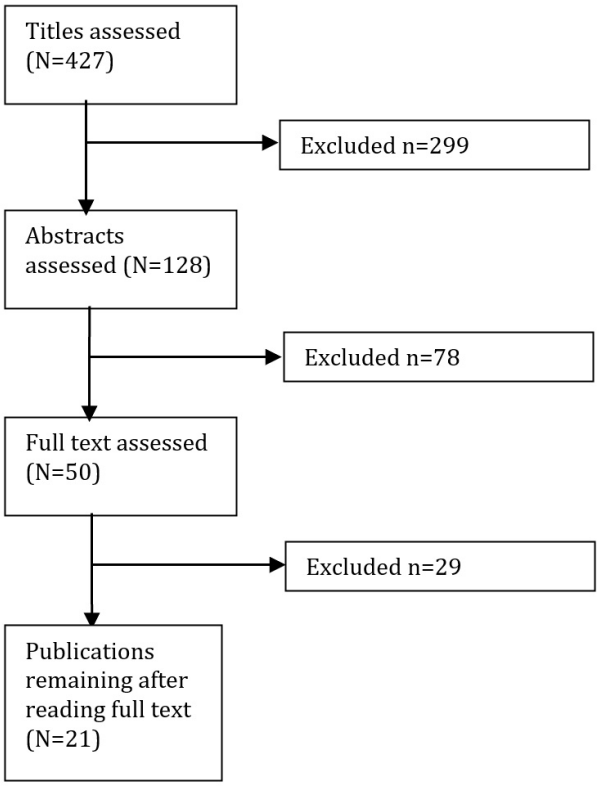

Figure 2. Flow chart of included and excluded articles

2019. The living labs were situated in various domains, including ICT, education, healthcare (occupational therapy, gerontology), industrial design, sustainability, service business development, engineering, tourism, ambient intelligence, and architecture. For example, a living lab in architecture (Masseck, 2017) focused on renewable energy and nearly zero-energy buildings. An example from healthcare is a living lab to establish age-friendly services in co-creation with older adults (Van den Berg et al., 2019).

Aims of the studies ranged from evaluating the experiences of participants in living labs, to exploring or developing the theoretical foundations of living labs, or studying elements of living labs, for example, knowledge management (De Jager et al., 2012). Other aims included what is called "designed serendipity", as well as the financial sustainability of living labs. For example, Santally et al. (2014) described the theoretical foundations needed to create a framework for a living lab that focuses on classroom education for the future. Van den Berg et al. (2019) studied the experiences of their living lab participants (older adults and undergraduate students) in a way that revealed the importance of equality and shared responsibility. Students were interpreted as "stakeholders" in all of the studies. Education was explicitly mentioned as the aim of the study in eleven of the articles. For example, Beecroft (2018) describes the interrelations between real world labs and higher education using a social practice perspective.

The types of studies varied. Five articles were qualitative studies or evaluations of living labs, another five described living lab cases/case studies, two were literature studies, and the majority were knowledge syntheses (n=9). Where articles combined several types of study, for example, a literature review together with one or more case studies, the main type of study is reported in Table 1. The number of living labs described in each article varied from one to five. However, most articles discussed a single living lab, often containing several different projects or educational courses related to this lab context.

Definitions, key elements, and theoretical underpinnings

Each article defined living labs differently, although they often used similar wording in their description. For example, "active user involvement" was referred to as "user-centred innovation", "user-involvement", "active

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

participation", or "collaborative development". All five major elements as described by ENoLL frequently showed up: co-creation, real-life setting, multi-stakeholder participation, multi-method approach, and active user involvement, together with the accompanying building blocks: exploration, experimentation, and evaluation (Malmberg & Vaittinen, 2019). Callaghan and Herselman (2015) defined co-creation in living labs as input from users as co-creators utilized to research the context of ICT use (in this specific case), find new uses, and evaluate new solutions within everyday contexts. Masseck (2017) describes variation in *real-life settings* in architecture, which can range from small-scale knowledge dissemination and "experience homes", up to city platforms for social innovation regarding sustainability, or a city itself with its buildings and inhabitants perceived as a supporting ecosystem for user-centred innovation. De Jager et al. (2012) highlighted the involvement of *multiple stakeholders*, describing a living lab as an "innovation platform" that engages all stakeholders, such as end users, researchers, industrialists, and policy makers at an early stage of the innovation process. Gualandi and Romme (2019) explained that a living lab can contribute to every phase of the innovation process by orchestrating and coordinating the activities of exploration, co-creation, experimentation, and evaluation. A living lab generates value to the entire supply chain and can explore and assess the environmental, social, and economic effects of new products or services created and tested in the living lab.

Two of the most distinct differences in the definitions of living labs concern specific references to research, learning, and education. Ten definitions explicitly include the element of research in their definition or key elements. An example of a definition explicitly mentioning research is the definition of Era and Landoni (2014) used by Grove (2018): "A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting". Additionally, the learning or educational aspect is described in six living lab definitions, for example, in the definition of Jernsand (2019) who describes living labs as spaces for open innovation, co-creation and experimentation in real-life settings with students. In their definition, Van den Berg et al. (2019) state that, *"In an educational setting, a living lab enables different stakeholders, including students, to learn how to work on user-driven innovation".*

Because theoretical underpinnings can play an important role in a living lab's operationalisation, and therefore influence the role of higher education, we searched for the theoretical foundations or approaches of each living lab. One article did not explicitly mention a theoretical foundation (Falk-Kessler et al., 2007). In the remaining twenty articles, a broad range of models were described as theoretical argumentation to start a living lab in the first place. Most of these models or approaches focused on processes such as social interaction, pedagogics, or design. Examples involving living labs and higher education include activity theory (Santally et al., 2014), appreciative inquiry (Callaghan & Herselman, 2015), design thinking (Jernsand, 2019), and service learning (Hansen, 2017). Some papers used a very detailed description of their approach, while others only mentioned the model, but did not elaborate on the application details.

Living lab features

All articles described the contexts in which living lab activities took place. Approximately half of the papers described living labs situated in a university department (n=9), sometimes combined with a virtual or web environment. Topics in living labs located at university departments included the future of teaching (Conruyt et al., 2014), as well as sustainability (climate change and urban sustainability, for example, at campus buildings (Evans et al., 2015)). In these examples, a clear relationship is visible between a living lab's main topic and its location being a real-life environment close to users (in these cases students, lecturers, and others). Other contexts in which living labs were situated involve public spaces, community sites, and cities (n=9). Subjects of these living labs included sustainable tourism (Jernsand, 2019), library services (Kröse et al., 2012), and age-friendly services (Van den Berg et al, 2019). Two articles described a digital/web context, without a physical component, that is, a knowledge management application (De Jager et al., 2012; Grove, 2018). In one article, the living lab environment was labelled as a human-machine interactive environment (Peng, 2010).

Many different stakeholders were involved in the living labs. Two articles described collaboration in the form of a Public-Private-People-Partnership (De Jager et al., 2012; Santally et al., 2014). Hence, living labs can bring together diverse public and private actors. These partnerships include: companies, industry, associations, students (differing study levels and differing study programmes), academics, teachers, researchers, policy makers, end users (for example, older adults), citizens,

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

service providers, and healthcare organizations. The roles and the composition of stakeholders can differ in each phase of exploration, experimentation, evaluation.

Some articles explicated the roles of the stakeholders. For example, students can play various roles, including learners, peer observers, project leaders, data collectors, analysts, and/or presenters. The roles of students can change over time (Falk-Kessler et al., 2007). Lecturers often provided guidance, coaching, and instruction, while end users were able to share their insights or function as mentors or trainers. Some articles emphasized the importance of social equality within the living labs (Van den Berg et al., 2019; Jernsand, 2019). Jernsand (2019) described "flat leadership" as a teaching style employed in their living lab of sustainable tourism, in which lecturers are mentors who listen and advise, rather than only giving directions.

Hardly any information was provided in the articles about the organization or governance of living labs, along with the conditions for sustainability in living labs. In their article, Gualandi and Romme (2019) addressed the financial sustainability of living labs by stressing the acquisition of funding and creation of value, as these are important conditions for living labs to become financially sustainable.

Design of learning

Our main interest was to ascertain if articles addressed the contribution of education to a living lab, and if so, how they designed learning in these labs. We searched for information on the following topics: learning outcomes of students and, where applicable, other stakeholders, if and how activities to enhance learning were described, and if and how articles reported on the assessment of learning in living lab contexts. 14 of the 21 articles mentioned learning outcomes of students in their study. The described outcomes can be divided into the disciplines of generic learning outcomes and specific learning outcomes. Generic learning outcomes were usually more broadly formulated and concerned topics such as professional development, clinical reasoning through lived experiences, reflection (learning-by-interaction), self-regulation of learning, taking responsibility, learning from experience, self-assessment, social awareness, innovation, and collaboration. Examples of discipline-specific outcomes were knowledge of and skills relevant to the development and implementation of age-friendly services (Van den berg et al., 2019), and specific sustainability development competences (Masseck, 2017).

Learning and teaching activities were not described in detail, however, examples of activities presented in this way included "fun learning", which uses cartoons or story-telling cartoon movies, as well as gaming-to-learn, where learning-by-playing and serious gaming account for an important role in teaching and student learning (Santally et al., 2014). Doing research with others (not only students and teachers), rather than on others (van den Berg, 2019) are other examples of teaching and learning activities in a living lab. These include, developing creative innovations that answer the needs of users, teams working on parallel projects of their own choice, and observing and assessing assignments during lab activities (Falk-Kessler et al., 2007). Hummels and Vinke (2010) connect the term "individual curriculum" to their living lab, giving students an opportunity to select their own learning activities at the start of a semester, thus catering to their individual learning needs. Learning by doing, edutainment, using social media tools, placed-based learning, participatory methods, and workshops are other examples of teaching and learning activities in the context of living labs. Real-life environments that involve users engaging in co-creation are also essential elements in living lab learning activities.

The articles rarely discussed the assessment of learning in living labs. Only three articles described how students are assessed within the living labs; the forms of assessment used were presentations, qualitative assessments during and after activities (reflection seminars, group discussions, course evaluations), progress reports, student blogs, future-driven self-assessment (focus on utilising the programme of study to prepare students to develop sustainable self-assessment ability), exhibitions, and showcases in which students present their work, while coaches and fellow students act as peer reviewers (Hummels & Vinke, 2010). One article reported experiences regarding the assessment of learning in living labs, in which the authors concluded that "there seems to be less competitive pressure" in assessments in a living lab context than in regular assessments in the curricula (Hwawk et al., 2012).

Lessons learned

The articles in our study often addressed lessons learned (including success factors and challenges) regarding initiation, evaluation, and sustainability of living labs. Generally, the lessons learned concern processes and

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

interactions in living labs, as well as preconditions for successful living labs. Regarding the process, van den Berg et al. (2019) found a tension between what is beneficial for a user-driven living lab and what is appropriate for an educational system that focuses on control and prediction. It is deemed necessary in resolving this tension to find the right balance between "freedom and frameworks". Furthermore, these authors learned about the value of investing time and effort in building relationships between co-creators. Hummels and Vinke (2010) indicate that an attitude of lifelong learning among all participants is essential for creating the right environment in a living lab. According to Grove (2018), "designed serendipity" (unexpectedness, insightfulness, and value added quality) is a success factor as it leads to useful findings and fits within a living lab approach that seeks to elicit unforeseen user ideas and behaviours to enhance product innovation.

Considering interaction in living labs, flat leadership and less competitive pressure amongst living lab participants tend to help to create a successful living lab (Hawk et al., 2012). Using social media tools such as blogs, wikis, Really Simple Syndication (RSS) feeds, sharing content, tagging and social networking were experienced to stimulate the success of a living lab (De Jager et al. 2012).

Requirements for successful living labs include a supportive logistic infrastructure. Falk-Kessler and colleagues (2007) describe the importance of coping with logistical barriers and establishing a community site willing and able to accommodate students during educational activities. Furthermore, building a sense of closeness between stakeholders, including firms and end-users, is seen as a precondition for a successful living lab. Jernsand (2019) also found "neutral places" to be of significance for living labs as they reduce the risk of participants being hampered by institutional "lock-in effects" such as incorporated norms, cultures, and working methods.

Discussion

The aim of this article was to explore the scientific literature on living labs in which higher education actors (for example students and lecturers) actively participates. Potential results could guide higher education programmes and their networks in how to set up sustainable and meaningful collaborations for innovative educational courses, both together with and in the real world. Just as living labs are a relatively new phenomenon, this study also shows that research into living labs with the active participation of higher education appears to be new. The majority of the papers we studied were published recently, and the number of papers is limited. The *kind of studies* included were mainly descriptive and explorative in nature, reflecting the state of the art in living lab research. Schuurman et al. (2015) also found the number of empirical, quantitative, and comparative studies focusing on the added value of living labs as still rather limited. In our review, we found no studies that focused directly on the effects of learning in living labs.

Definitions of living labs generally involve the main aspects of ENoLL's definition, meaning a real-life setting, co-creation, active user involvement, multi-stakeholder participation, and a multi-method approach (ENoLL, 2020). This might imply that a consensus exists about what constitutes the core of living labs. Some articles added terms related to education and research in their definition, which, from the perspective of universities, appears to be a logical addition. The fact that most articles do not explicitly mention research associated with living labs might be related to existing perceptions about the process of innovation that research is an inherent part of innovation. A similar assumption can be made about learning in living labs, since one cannot innovate without learning.

However, the inclusion of both students and teachers in living labs calls for active learning, and active learning is of importance for all stakeholders involved. Veeckman et al. (2013) linked living labs to "communities of interest" and "communities of practice", following the work of Wenger et al. (2002). In these communities, stakeholders are informally connected by what they do together and by what they have learned through their mutual engagement in these activities (Veeckman et al., 2013). This perspective calls for discussion about incorporating learning as one of the core elements of future living lab definitions. Consequently, we can see how giving attention to learning in real life contexts might also impact the *theoretical underpinnings* of living labs. The available body of knowledge about communities (Wenger et al., 2002) and hybrid learning environments (Bouw et al., 2019) support the embeddedness of higher education actors in living labs. Wals, Lans and Kupper (2012) defined a hybrid learning environment as a social practice around ill-defined, authentic tasks or issues, whose resolution requires transboundary learning. For example, available knowledge exists about how to assess students in hybrid learning environments. Zitter et al. (2016) emphasized the crucial role of participants from

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

practice or business in the assessment of students. The selected papers addressed various features of living labs sometimes in detail, and other times generally.

This study revealed that almost half of living labs are situated at universities. This could well reflect the state of the art in the development of living labs in higher education, with universities themselves as both founders and organizers. This circumstance also provokes discussion about the real-life element of living labs versus the merely "academic". However, the topics of the living labs situated at universities, for example, IT, sustainability, and education, all link to topics studied in which the users of the living lab are themselves users at universities. From an educational perspective, the real-life element of living labs is an innovative aspect for education, offering students experiences outside the classroom.

In her comment about neutral places, Jernsand (2019) emphasized the impact of the location on the success of living labs. Thus, conducting further research into real-life aspects of living labs, including their location, the intensity of interaction between students and users, and the learning experiences of students would be a useful line of approach. It is notable that this study found few research results about the organization and governance of living labs involving higher education. One article concerning innovation networks implies that collaboration in these networks requires clear and SMART goals from the beginning, as well as continuous management of the main elements of the network, and investment in information and communication technology to improve information sharing and formal coordination (van Tomme et al., 2011). In an article on innovation management, the authors stress the importance of a strategy to guide the approach that steers the innovation, the processes, the portfolio, and the projects in the innovation funnel, as well as leadership, resources, and the competences of staff (Igartua & Albors, 2011). The lack of information ascertained by this study might relate to the locations of living labs at universities. In short, the attempt to embed higher education within living labs situated outside of universities may lead to other challenges than those faced by living labs embedded in higher education institutions.

We found several *lessons learned* regarding processes and interactions in living labs, as well as and requirements for successful living labs, including the importance of balance between freedom and frameworks. Furthermore, the literature shows it is crucial to invest in relationships between co-creators. Likewise, less competition and flat leadership with a living lab help to create a successful environment. Moreover, a living lab needs a supportive logistic infrastructure and closeness between stakeholders.

When focusing on *how learning is designed* in living labs, a distinction has been made between generic competences and specific competences. As expected, the specific competences differ between labs depending on their domains and subjects studied. Commonalities among generic living lab competences include co-creation, cooperation, clinical reasoning, and reflection, along with innovativeness and the ability to learn from experience. These competences match the key elements of living labs according to ENoLL, which are a real-life setting, co-creation, active user involvement, multi-stakeholder participation, and a multi-method approach (ENoLL, 2020). The learning activities identified in living labs seemed to be more innovative and interactive in contrast with more classical learning activities. Only three papers reported on assessments in living labs. Although education was part of most research objectives found in our study, we also discovered that none of the studies focused on the effects of educational activities in living labs on the competences of students.

Our aim was to explore the nature and extent of the scientific literature about living labs in which higher education actors actively participate. Other non-scientific papers that discuss this subject were not part of the selection, therefore this review does not capture the full body of knowledge in this domain. It is possible scientific studies that may be relevant could have been missed because of our selection of databases and use of search terms. Our search and selection specifically focused on articles addressing the concept of the "living lab", as it seems to be an internationally accepted concept, and other reviews of living labs literature have already been conducted as referred to in our introduction. Our finding that all of the articles referred mostly to the same or similar aspects of living labs (as described by ENoLL) supports the assumption that this review capture the concept we were searching for.

Conclusion

Based on this scoping review, we conclude that research on embedding higher education in living labs is still at an early stage. More detailed studies into the participatory aspects of higher education are

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

recommended in order to gain knowledge about enhancing learning outcomes, and the effects of educational activities including assessments within living lab environments.

In addition, knowledge appears to be lacking about conditions, organization, and governance of living labs, and further study would certainly be worthwhile. More emphasis on learning as a crucial aspect of living labs may steer the research and the theoretical foundations that support the embeddedness of higher education in living labs.

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A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

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A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

About the Authors

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Appendix 1. Supplementary Materials (six pages)

Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education		
						Learning outcomes	Teaching and self-study methods	Examination methods
Santally et al., 2014	• Type of publication: knowledge synthesis • Number of Living labs discussed: 5 • Domain: ICT and education • Subject of innovation: Classroom based education • Aim: Set up a framework for the establishment of a living lab	• Definition: environment for user-centered innovation, based on the observation of every-day user practice and experience for solving problems, but also based on their active participation, with an approach that facilitates their influence in the open and distributed innovation process (participatory design). • Key elements: 4 major elements (ENOLL): Co-Creation, Exploration, Experimentation, Evaluation	• Model: Activity theory, Change laboratory method, Action-research • Approach: 4P innovation: Public-Private-People-Partnership. Participatory design and user-centric approaches are key elements.	• Context: referring to Living Labs as both a milieu (environment, arena) and an approach (methodology, innovation approach). • Stakeholders: Public and private actors, companies, associations, individual actors, students, academics, research, policy • Roles: - • Governance: -	• Lessons Learned: practitioner-oriented → research and development essentially become the drivers for practice-oriented enquiries to improve the teaching and learning systems. → field experimentation to test new practices → formalized into teaching methods that can be cascaded down to the educators for classroom application (success factor).	Focus on skills development and competency building (activity-based approach)	• Innovative training of teachers in all stages of their career • Microsoft PIL program: promote integration and use of ICT in the classroom • Fun learning • Gaming-to-learn and learning by playing • Learners as co-creators of knowledge	-
van den Berg et al., 2019	• Type of publication: Qualitative explorative study • Number of living labs: 1 • Domain: education living lab (courses in gerontology) • Subject of innovation: age-friendly services and products • Aim: gain insight into experiences of participants in living lab	• Definition: In an educational setting, a living lab enables different stakeholders, including students, to learn how to work on user-driven innovation. A living lab aims to develop and create high-quality, creative innovations that answer the needs and aspirations of a particular group of end-users. • Key elements: Applied research and innovation based on co-creation, real world context and impact, partnerships, user involvement	• Model: Appreciative inquiry principles - Openness, Continuity, Realism, Spontaneity • Approach: Co-creation approach	• Context: Two Dutch Universities, Educational setting • Stakeholders: faculty, retired faculty member, students, older adults, service providers, researchers, healthcare organizations, and members of local businesses • Roles: Students - different roles: project leader, data collector and analyst, and presenter Lecturer: support and guidance Older adults: providers of insights, networkers and in some cases mentors and trainers. • Governance: -	• Lessons learned: - Finding the right balance between freedom and frameworks is necessary (succesfactor) - Invest time in building relationships between co-creators (succesfactor) - Maintaining equality in co-creation (succesfactor) - Tension between what is beneficial for a user-driven living lab and what is appropriate for an educational system (challenge) - Right balance between distance and proximity (challenge) - Insecurity paradox: inconvenient, but shared feeling of insecurity → shared responsibility	Five core competences: • development and implementation of age-friendly services; • applying knowledge of the ageing process; • co-creation, connecting and cooperating; • identifying and utilizing opportunities; • professionalization.	• Four projects = student assignments • doing research with rather than on others	-
Beecroft, 2018	• Type of publication: Knowledge synthesis and qualitative analysis • Number of living labs: 1 (6 courses) • Domain: Sustainability • Subject of innovation: embedding education in real world living labs • Aim: use a social practice perspective to map out the interrelations between RwL and higher education.	• Definition: Real-world Lab (RwL): institutionalized interfaces between science and society. A framework to address goals relating to research, practice, and education. Transformative approach and goals that are socially legitimated, ethically founded, and oriented towards the common good. Urban transition lab: hybrid, flexible and transdisciplinary platform that provides space and time for learning, reflection, and development of alternative solutions. Urban Living Lab: Framework for co-creation, but in a rather holistic and non-specific way as "urban innovation ecosystems". Learning in a lab: A lab offers a learning environment for different actors, jointly engaging in a real-world issue, the lab supports cyclical learning processes that combine different forms of learning. • Key elements: Research-orientation Normativity Transdisciplinarity Transformative approach Inclusion of civil society Long-term orientation Lab character	• Model: Social practice theory offers a medium scale understanding of social interaction and change. • Approach: From typical management and structural perspectives to a user perspective. Supportive infrastructure → learning-oriented activity can be embedded.	• Context: real-world environment city district Oststadt • Stakeholders: experts, co-designers, facilitators, teachers • Roles: - The RwL and its team contribute from the beginning (a).: both the didactical skills of teaching the course and the transdisciplinary skills of finding the right approach for a topic are part of the overall skills. - Practice partners (b) contribute mainly in terms of images, primarily in phase I–III. - Students (c) are not part of the process in phase I, mostly receptive in phase II and only some remain active in phase IV, therefore student contributions take place almost only in III–V. They contribute images throughout, use their skills during phase IV. In some cases, the results presented are "stuff", but not always. • Governance: -	• Lessons Learned: - Phase I. Preparation: Mutual Trust from the Beginning - Phase II. Introduction: Sustainability and Transdisciplinarity as Key Images from the RwL - Phase III. Proposal: Skills and Images on Tap in a Creative Learning Environment - Phase IV. Project Work: All in the Hands of Students - Phase V. Results: Presenting to the Right Audience - Phase VI. Phase-Out: Various Activities Call for Flexible Action.	• images have a high relevance throughout the process, least so in the phase-out. • The relevance of skills grows to reach a maximum in the project work phase, dropping with the presentation of the results, a major shift in the style of working together that needs to be managed carefully. • Stuff plays a minor role in the process, but rarely drops out completely • Networks have highest importance at the beginning and the end	• Phase I. Preparation • Phase II. Introduction: • Phase III. Proposal • Phase IV. Project work • Phase V. Results • Phase VI .Phase-Out	-
Falk-Kessler et al., 2007	• Type of publication: qualitative evaluation • Number of living labs discussed: 1 • Domain: Occupational Therapy Education • Subject of innovation: educational methods	• Definition: Moving the traditional on campus lab to a community site requiring the students to work with clients currently receiving occupational therapy services. • Key elements: -	• Model: - • Approach: -	• Context: Community sites with client receiving occupational therapy services – private school for children with disabilities • Stakeholders: students, children with disabilities, instructors, Classroom staff, lab assistant • Roles:	• Lessons learned: - Establishment of a community site that was willing and able to accommodate a group of students (Challenge) - Insurance and increased accountability (challenge) - Logistical barriers (challenge) - Immediately apply theoretical concepts discussed in class in real situations	• To apply theories in a therapeutic setting • Increase professional development and clinical reasoning	• See and undergo first what students learn on paper and in class • Lab assignment	-

Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education		
						Learning outcomes	Teaching and self-study methods	Examination methods
	• Aim: qualitative evaluation of teaching-learning experience during a living lab.			Students → roles changed weekly: peer observers, group leaders Staff observers → instructors, lab assistant, OT staff from school • Governance: -				
Hummels & Vinke. (2010).	Type of publication: knowledge synthesis Number of living labs discussed: 2 Domain: Industrial design Subject of innovation: New technologies – networks of interaction Aim: present mechanism to facilitate expertise and community building in living labs	• Definition: - • Key elements: - Reflection and action are essential elements - Identity building - Expertise building - Community building	• Model: Transformative theoretical framework essential for education future designers • Approach: Meaning is created in interaction (ecological theory of perception and phenomenology)	• Context: Industrial design department • Stakeholders: students, staff, clients (industry, commerce, non-profit organisations), government and users • Roles: Different participants all have their role within the theme: initiator (champ), partner, link, supplier, or user • Governance: -	• Lessons learned: - Organization that supports the construct – unconstruct – reconstruct process (success factor) - Attitude of lifelong learning (success factor) - Infrastructure that supports information sharing and collaboration between the different stakeholders (success factor) - Close collaboration in projects is a powerful mechanism to learn and to understand each other and to benefit from each other's expertise (success factor) - It is essential that themes cover different areas of expertise, include coaches form our different capacity groups and include design practitioners and experts from industry (success factor). - Variety of backgrounds (hard to speak each other's language) (challenge) - Close cooperation in projects (challenge) - Integration of research and education (challenge)	Students need to develop the ability to reflect, to self-regulate their learning, to take responsibility, to learn from experience and to assess themselves.	• Attitude plays an important role • Students create own individual curriculum • Staff members shift from teacher-focused to learning-focused and from being an authorative source of knowledge to facilitating students' learning. • During and at the conclusion of learning activities, students reflect on their activities, and they invite staff members involved to provide them with (written) feedback on their process and outcomes. • Learn by doing • Reciprocal relationship between thinking and doing/making	Showcase at the end of semester 4 exhibitions per year
Conruyt et al. (2014)	• Type of publication: Knowledge synthesis • Number of living labs discussed: 1 (2 examples) • Domain: ICT • Subject of innovation: ICT Living Labs for Education → codesigning e-services • Aim: application of vision of sign-based society to education in an ICT living lab	• Definition: A living lab (LL) is both a real and virtual environment for user-centred innovation, based on the observation of every-day user practice and experience for solving problems, but also based on their active participation, with an approach that facilitates their influence in the open and distributed innovation process (participatory design). It engages all concerned partners in the real-life contexts and aims to create sustainable usage values. • Key elements: 4P innovation process – Public-Private Partnership with People First step: ideation Second step: co-design Third step: formalize a solution	• Model: Sign-based society • Approach: 3D tetrahedon model → The Living Lab stands at the centre of the tetrahedron for communication purpose and ICT is fuelling the convergence of Research, Education and Business with a new signification process.	• Context: Real educational context - Creativity platform = co-working, co-learning, and communication space (physical and virtual) • Stakeholders: Public and private actors, companies, associations, individual actors • Roles: - • Governance: -	• Lessons learned: The need to facilitate the creation and maintenance of new content on the platform (challenge)	-	• Game-based learning • Edutainment • Tool → IKBS platform (Iterative Knowledge Base System), ISBS • Teachers and learners can play together to share their interpretations of observations	Assessments of future e-services are made by considering the usage side of the project: end-users have their own identities, activities, tasks and give meaning to the obtained results
De Jager et al., 2012	• Type of publication: in depth research, case studies and grounded theory • Number of living labs discussed: 1 • Domain: Higher education • Subject of innovation: Living labs for Knowledge management • Aim: present a framework for Knowledge Management processes and using social media tools in a living lab environment	• Definition: LLs as environments for collaborative innovation and discovering knowledge. One of the main objectives of a LL is to use knowledge for further innovation. The general objective of a LL is to be a real-life collaborative development platform. LL is a tool organisations use within a cloud. They make integration, collaboration, and optimisation possible. • Key elements/principles: - Knowledge objects: any artefacts that knowledge seekers could use to learn, or expand their current knowledge about a topic - Open innovation and co-creation are core activities and processes	• Model: Knowledge management • Approach: LL as a thinking an rethinking support environment - systems thinking - multidisciplinary and collective intelligence thinking - critical thinking - performance thinking - process thinking	• Context: web enabled living lab • Stakeholders: end users, researchers, industrialists, and policy makers • Roles: - • Governance: -	• Lessons learned: - control the various thinking processes and to manage the subsequent processes to ensure manageable deliverables (success factor) - Include social media tools, web 2.0 technologies (success factor) - Work smarter, not harder (success factor)	-	• Knowledge objects (KO) are any artefacts that knowledge seekers could use to learn, or expand their current knowledge, about a topic. Variety of formats, ranging from digital media to web 2.0 mashed objects. • Web 2.0 technologies (social media tools)	-

Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education		
						Learning outcomes	Teaching and self-study methods	Examination methods
Evans et al., 2015	• Type of publication: Knowledge synthesis • Number of Living Labs discussed: 1 campus as living lab, more living lab projects • Domain: sustainability • Subject of innovation: applied sustainability challenges • Aim: identifying the key strengths of the living lab approach and the challenges of applying it more broadly	• Definition: JPI Urban Europe defines living labs as: "a forum for innovating. . . [and] the development of new products, systems, services, and processes, employing working methods to integrate people into the entire development process as users and co-creators, to explore, examine, experiment, test and evaluate new ideas, scenarios, processes, systems, concepts and creative solutions in complex and real contexts". • Key elements: Cycle: develop, test, implement and evaluate - Geographically or institutionally bounded space - Conduct experiments that make social and/or material alterations - Incorporate an explicit element of iterative learning	• Model: - • Approach: - The Manchester Method: working with non-academic stakeholders to develop real-world skills - Systems approach	• Context: University of Manchester Campus • Stakeholders: researchers, students, external stakeholders (NGOs, SMEs), environmental consultants, university estates and facilities staff. • Roles: Students in the role of planning team • Governance: -	• Lessons learned: Living labs have the potential to strategically frame coproduction processes in two ways. - consulting users and stakeholders allows complementary sets of projects to be strategically planned that offer holistic solutions to sustainability challenges. - emphasising the iterative process of experimenting and learning from year to year they provide a more coherent basis for action over time. - Bridging the divide between the social sciences and physical sciences (challenge) - Parcelling the opportunities into manageable projects that can be executed in the short-term using resources available within the university community while feeding into tight schedules for design and construction (challenge)	-	• Net positive: a tool an online questionnaire about their interaction with the institution and the city, students receive constructive advice on how they can reduce their carbon footprint. • Sustainability exercise	-
Peng et al., 2010	• Type of publication: Evaluation study • Number of living labs discussed: 1 • Domain: Telecom operation and management teaching • Subject of innovation: Living lab as experiental learning environment • Aim: application of the technology innovation model concept of living lab to the construction of the experiential learning environment	• Definition: Massachusetts Institute of Technology of United States in 1995: As a response to the opportunities and challenges of information society and knowledge society, Living Lab runs on city-wide open experimental space, provides a condition and environment for users to participate easily and involve actively in designing innovative solutions, it relies on various types of users who live and work in cities, provides real-time prototype design and test platform for innovative applications. • Key elements: Experiential learning circle model, 4 iterative stages: - concrete experience - reflective observation - abstraction - mobile applications 4-point circular pattern: - theoretical research - the development of products and services - the practical application of testing the commercial promotion	• Model: Living Lab Model proposed by Massachusetts Institute of Technology → Technology innovation model • Approach: Experiental Teaching → student centred, students' dominant position during teaching process Based on: - Dewey's experience philosophy - Jean Piaget's cognition development theory - Lewin's experiential learning model	• Context: a human machine interactive environment • Stakeholders: education, various types of users who live and work in cities • Roles: - • Governance: -	• Lessons Learned: -	Teaching purpose: 1. students must see themselves as the target user group 2. students must see themselves as the market pioneer 3. students must see themselves as operators	Experiential teaching: variety of scenarios to guide students to experience the educational scenario from passive to active, from dependence to independence, from acceptance to creativity, and learn to avoid, defeat and transform the negative emotions and the wrong understandings, learn to develop, enjoy and use of positive emotions and the right awareness, to enable students to fully experience the joy and pleasure stored in the teaching activities, so as to achieve the purposes of the promotion of students' self-development. Four iterative stages (Cooper): - concrete experience - reflective observation - abstraction - mobile applications	
Goodlad & Leonard, 2018	• Type of publication: Literature review, survey, and interview study • Number of Living Labs: Lab General Education Seminar → 30 participating departments • Domain: Place based learning (PBL) • Subject of innovation: • Living lab as pedagogical model in PBL • Aim: To study the influence of the fellowship on the design of place-based learning activities (in LL) and perceived levels of student engagement.	-	• Model: Pedagogical model of the living lab → broad access to high quality technological and professional education for a diverse urban population. • Approach: Kolb's experiental learning spiral – experiencing, reflecting, thinking, and acting	• Context: 30 academic departments • Stakeholders: students, teachers, field • Roles: In the first semester of the seminar, the work of the fellows was to take the role of learner • Governance: -	• Lessons Learned: -	Discipline specific and general education learning outcomes	• Include PBL as part of their teaching practice • Workshops, presentations, shared readings, field visits. • Includes PBL in their assignments	
Grove, 2018	• Type of publication: case study analysis • Number of living labs: 2 living labs • Domain: Field of information systems • Subject of innovation: the role of Living labs in facilitating and enabling designed serendipity, two case studies in the field of information systems (IS) • Aim: analysis of the causal mechanisms and contextual factors that combine to create designed serendipity within the context of the cases evaluated and within platform design.	• Definition: A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting. An emerging public–private partnership (PPP) concept in which firms, public authorities and citizens work together to create, prototype, validate and test new services, businesses, markets, and technologies in real-life contexts, such as cities, city regions, rural areas, and collaborative virtual networks between public and private players.	• Model: Critical Realism has been viewed as an approach that can play a role in advancing the development of IS knowledge through Design Research. Critical Realism proposes a focus on causal mechanisms and contextual assumptions, or what researchers call generative mechanisms. • Approach: Co-design process where students and staff	• Context: digital platforms (Afrikan context) • Stakeholders: higher education • Roles: - • Governance: -	• Lessons learned: - Occurrence of Serendipity ((i) unexpectedness, (ii) insightfulness, and (iii) value) (success factor) - The mechanisms, methods and techniques of the LL approach seem to offer potential in terms of empowering users to increase the likelihood of unsought findings. (succesfactor) - Involving users in the innovation process (Challenge) Three elements of a successful platform: • Connection	-	Living Lab Design Approach	

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

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						Learning outcomes	Teaching and self-study methods	Examination methods
		• Key elements: 1. contextualization 2. concretization 3. implementation 4. feedback and evaluation	participate collaboratively in the user needs identification and iterative user testing phases.		• Gravity • Flow			
Hansen, 2017	• Type of publication: Effectiveness study • Number of Living Labs discussed: 1 (more living laboratory academies projects) • Domain: Sustainability education • Subject of innovation: Education for sustainable development • Aim: effectiveness of one living laboratory case study at Macalester College in St. Paul, Minnesota, USA	• Definition: - • Key elements/principles: - Using the campus buildings and grounds as explicit educational tools for sustainability education - Using new education buildings as living laboratories is relatively common in the architecture field - multidisciplinary learning - Applied research - Practical work	• Model: Service learning → combination of community service and academic learning where students work on community volunteer projects as part of educational experience. • Approach: -	• Context: Living Laboratory Campus Macalester College • Stakeholders: students, macalester college, environmental studies faculty, industry, staff, sustainability manager • Roles: - Students that actively participate • Governance: -	• Lessons learned: Eight elements to building a campus living laboratory: 1. Engage the right campus participants 2. ID key collegiate programs 3. Build credibility through engagement and data 4. Integrate into curriculum 5. Expand beyond individual program of study 6. Build partnerships with industry 7. Engage support beyond campus 8. Open your labs to the community - Continue to seek out industry and grant support - Suggested language for individual course instructors - Look for ways to engage with other departments - Actively engage upper administration to highlight the results of the living laboratory projects - Look for ways to link the campus living laboratory with the work already underway in the community - Expand on current interdisciplinary projects to incorporate other disciplines, not currently working within the LL program		• Adding key sustainable development issues into teaching and learning • Participatory methods that empower learners to change their behaviour and act for sustainable development • Teaching classes	
Hawk et al., 2012	• Type of publication: Knowledge synthesis • Number of Living Labs discussed: 1 (Lutakko Living Lab) • Domain: service business development • Subject of innovation: service and experience design, service development for private companies and public institutions in tourism, and the creative and well-being sector. • Aim: the relationship between the LLs and a variety of stakeholders is discussed	• Definition: A living lab should be seen as a research concept and is user centred. It is often linked to, or operates in, a city or a region, and frequently involves communities, not as observers but as participants – as a source of creation. Living labs aim at changing users from observers to cocreators and to explorers of innovative concepts. In LLs, research is focused on capturing evidence and data from end-users involved in the LL case. LLs encourage users and developers to work very closely together and the evidence from "real life" testing is used to improve the resulting products and services. • Key elements: -	• Model: - • Approach: Nordic countries believe in a flat leadership style as being the most effective model for encouraging the growth and sustainability of living labs.	• Context: Lutakko Living Lab, city district • Stakeholders: universities, businesses, organizations, researchers, government entities, community members, and customer end-users • Roles: students collaborate with stakeholders, instructors are mentors to listen and advice, more equal relationship between professors/instructor and students. Students are at the core of any relevant learning experience, and effective leadership in education may often have fundamental impact on these experiences. Leaders should be able to handle tension and problems effectively in an unpredictable setting. • Governance: -	• Lessons learned: - Living labs based on win-win mentality (success factor) - Less competitive pressure (success factor) - Flat leadership (success factor)	Depending on the goals and content of the LL, specific students from relevant disciplines are chosen to participate.	Provide relevant opportunities for real learning experiences for students as well as for community stakeholders	Less competitive pressure
Gualandi & Romme, 2019	• Type of publication: case description • Number of living labs discussed: 3 cases (Stratumseind Living Lab, Amsterdam Field Labs, Textile & Clothing Living Lab) • Domain: Engineering • Subject of innovation: Realisation of different kinds of value • Aim: to develop a framework of various funding options which can be employed by any LL that seeks to become more financially sustainable	• Definition: The so-called Living Lab (LL) is an emergent methodology that can be instrumental in bridging the gap between new technologies developed in corporate or university research labs and the actual adoption of (products and services based on) these technologies by users • Key elements: exploration, co-creation, experimentation, and evaluation	• Model: According to ENoLL (2016), LLs are "user-centered, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real-life communities and settings". • Approach: -	• Context: urban environments • Stakeholders: public administration, education institutes, companies, and citizens. • Roles: - • Governance: -	• Lessons Learned: Each LL should define its optimal funding mix, with the following guidelines in mind: - The LL should explicitly distinguish between strategic and project partners - The LL needs to explicitly classify the kind of value created - Funding can be generated from the stakeholder-partners in the LL, but also from external actors - Most of the funding (to be) acquired is linked to the mission of the LL - Public and private funding are very different in nature and modality and tend to imply fundamentally different requirements and expectations.			

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Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education		
						Learning outcomes	Teaching and self-study methods	Examination methods
Jukema et al. 2017	• Type of publication: Combination knowledge synthesis and qualitative evaluation study • Number of Living Labs: 1 living lab: Living Lab Applied Gerontology • Domain: Applied gerontology programme for Dutch undergraduates • Subject of innovation: development and implementation of age-friendly services and the design of a powerful learning environment • Aim: to present the design of a powerful learning environment and to discuss its value for nurturing the students' intrinsic motivation for co-creation based on focusgroup evaluation	• Definition: - • Key elements/principles: Real life contexts Five successive phases: Define, discover, dream, design, destiny Aim to nurture intrinsic motivation: need for autonomy, need for awareness of competence, need for a sense of relatedness.	• Model: - • Approach: based on the principles of appreciative inquiry, design thinking and self-determination theory	• Context: realistic powerful learning environment applied gerontology – neighbourhood • Stakeholders: Companies, organizations, and other entities, older adults, gerontologists • Roles: students – autonomy/freedom, lecturer – provided structure older adults – asked the students critical questions and taught them to see and experience the world from a different perspective • Governance: -	• Lessons learned: - Balance freedom – structure (Succesfactor) - Importance of interest shown by the lecturer (succesfactor) - Realistic learning tasks essential for intrinsic motivation (Succesfactor) - Impact of older adults seems to be bigger than impact of lecturers (Succesfactor) - A learning environment that includes older adults as partners in realistic learning tasks for gerontology students is essential in nurturing students' intrinsic motivation to develop competencies in cocreation.	• The degree to which students develop competencies is determined by their intrinsic motivation. • To train gerontologists as leading professionals in the cocreation of age-friendly services (innovativeness and collaboration) • Competence levels of cocreation: - Competent level - Advanced beginner level - Novice level	-	-
Jernsand, 2019	• Type of publication: literature review and case descriptions • Number of Living Labs discussed: 5 • Domain: sustainable tourism research, education, and practice • Subject of innovation: living labs in relation to education, innovation, and sustainable tourism • Aim: explore sustainable tourism in relation to the concept of student living labs	• Definition: Student living labs, defined as spaces for open innovation, co-creation, and experimentation in real-life settings with students. • Key elements: Open innovation, Co-creation, Experimentation	• Model: Massachusetss Institute of Technology (MIT) - The group integrated design and technology approaches to improve cities' resource efficiency and responsiveness to inhabitants needs and desires • Approach: Design approach/design thinking, participatory design, co-design, user-centred design	• Context: LLs mainly act in a defined context such as a city or a region. • Stakeholders: Triple, quadriple or penta helix model for stakeholder involvement often used Master's students, municipality, idea-based sector, residents, local business, ex-students, start-ups, business coaches, creative industry businesses, academy, PhD students, peers, international research knowledge centre, local organizations, experts in each discipline • Roles: Living labs can be hosted by universities, public authorities, or private sector organisations. Lecturers are mentors who listen and advice rather than set directions (flat leadership) • Governance: -	• Lessons learned: - importance of 'neutral' spaces for living labs (succesfactor). - Closeness between firms and end-users, knowledge from customers and employees drives innovation (success factor) - An essential point of departure for co-creation is learning (success factor) - Project timeframes (challenge) - Documentation and information (challenge) - Equality among participants (challenge) - The size of the student groups (challenge) - The resources of the university (challenge)	An experiential approach goes in line with the change of emphasis based on the Bologna declaration for education, focusing on learning outcomes and competences through meeting the needs of the labour market (employability) and a transition from a teaching to a learning approach	• case studies → opportunities and challenges of a real-world setting → collaborate with other stakeholders, • Active, participatory learning means emotional involvement or commitment • Conversation, feedback, and critical reflection • Using an experimental approach, the students can explore various perspectives, navigate in the social situation of working with others, reflect on their own learning and enrich the educational outcomes continuum of experiential co-created learning theories, approaches, styles, and methods	
Kröse et al. 2012	• Type of publication: Knowledge synthesis, case descriptions and evaluation • Number of living labs discussed: 3 • Domain: ambient intelligence • Subject of innovation: library 2.0 services, monitoring ADL in assisted living apartments, interactive wall in psychogeriatric ward of nursing home • Aim: present the way that the Amsterdam University of Applies Sciences (HvA) incorporates living labs in its educational program and share lessons learned	• Definition: A new way of innovating requires a new research methodology that enables co-creation, early testing, and iterative evaluation in real-world settings = the living lab methodology. An approach that represents a user-centric methodology for sensing, prototyping, validating, and refining complex solutions in evolving real life contexts. • Key elements: - An environment where partners are jointly involved in research & design - A setting that exposes users to novel (ICT) solutions - A (semi) realistic context - Suitable for long-term experiments - A place for the evaluation of new developments as well as for the discovery of new possibilities	• Model: The living lab methodology (MIT) • Approach: -	• Context: Public spaces and health lab (2 locations) • Stakeholders: Lecturers, Students, Researchers, Companies, End users, Technology providers and System designers • Roles: - • Governance: -	• Lessons learned: - Engage the stakeholders - Take care of sufficient technical support - Improve the student skillset - Embedding in the school calendar - Evaluation of the student work - Students learn to do research hands on - Use multidisciplinary groups - interdisciplinary approach needs some extra support from the supervisors in the beginning	• Courses with creativity and innovation as its core elements • Conducting practical and applied research • Improvement and innovation of the professional practice	• Real life research questions • Students are confronted with the entire cycle of user analysis, design, prototyping and user studies • Projects/assignments	
Masseck, 2017	• Type of publication: case description • Number of living labs discussed: 1 • Domain: Architecture • Subject of innovation: Living labs in architecture as new tools for a holistic Education for Sustainable development, focus renewable energies (in higher education) • Aim: highlight the importance of living labs as innovation infrastructures in higher education en presents the specific education experience	• Definition: The concept of Living Lab LOW3 is influenced by the concept of user involvement in research and innovation, derived from the definition of Living Labs, as well as the co-creation and open innovation in real-life settings through a multi stakeholder approach (academia, companies, and research entities but also local administration), understanding both students, researchers as well as citizens as the "users" of this newly generated platform. • Key elements: -	• Model: Concept of user involvement in research and innovation • Approach: -	• Context: solar house living lab for sustainable architecture • Stakeholders: academia, companies, and research entities but also local administration • Roles: Stakeholders can participate in a community of users beyond established academic structures, with transversality from high school students up to senior researchers. • Governance: -	• Lessons learned: immediate relation to the daily life of people (success factor)	• Social awareness • Generic SD knowledge • Generic competences • Specific knowledge • Specific SD competences • Innovation	• General educational and research activities referring to a huge number of diverse activities regarding teaching and learning as well as research and innovation at an university campus • Specific Living Lab teaching formats regarding innovative approaches to sustainability education	

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							- Monitoring energy consumption - Assessing water consumption - Measuring waste production - Assessing indoor comfort - Reporting about food habits - Calculating the overall ecological footprint of the inhabitants	
McCormick & Kiss, 2015	• Type of publication: case description and evaluation • Number of living labs discussed: 1 • Domain: diverse real-time learning environments in a local context • Subject of innovation: learning environments • Aim: investigates the relevant hands-on challenges creating a supportive learning environment when projects in sustainable urban renewal are used for educational activities	-	• Model: Malmö Innovation Platform (MIP): brings together municipal, business, academic and community actors to build a joint innovation capacity in the renovation of existing apartment buildings. • Approach: -	• Context: Local/urban context • Stakeholders: Students, teachers • Roles: Students and teachers often enter the scene as equal; teachers often serve as facilitators for learning by providing useful frameworks, enabling access to experts, facilitating team interactions, and guiding reflection, and due to the innovative nature of projects also co-learning with students • Governance: -	• Lessons learned: - Many positive impacts for the MIP, students, and teachers (success factor) - The assessment of the intended learning outcomes (challenge) - Undefined and constantly changing nature of innovation and 'experimental' sustainability projects (challenge) - Economic push and policy support are weak (challenge)	• Evaluation exercises (learning-by-researching, learning-by-interacting) • Master thesis projects (learning-by-researching, learning-by-interacting) • Research project related group assignments (learning-by-researching, learning-by-interacting, learning-by-experimenting) • Role-play debate exercises (learning-by-researching, learning-by-interacting) • Collaborative education (learning-by-researching, learning-by-interacting, learning-by-experimenting) • Reflection seminars (learning-by-interacting)	• Hands-on lessons for learners (students) and learning professionals and participants (teachers and stakeholders): • equal and enthusiastic co-learners (project partners, teachers), • challenging and changing but rich content • novel educational activities and tasks • considerable level of uncertainty • Learning activities are more fluid and outcomes are less defined.	• Learning processes and the 'study approaches' important indicators for describing the extent learning outcomes have been achieved. • Assessment is integral in the interactions of teaching and learning. • Reflection seminars, group discussions and course evaluations → qualitative assessment of learning outcomes
Cremers et al., 2014	• Type of publication: knowledge synthesis • Number of living labs discussed: 1 • Domain: Hybrid learning • Subject of innovation: learning • Aim: develop a set of design guidelines for an intervention that would strengthen students' capacity for self-directed lifelong learning within a hybrid learning configuration	• Definition: In this study we define a hybrid learning configuration as a social practice situated at the interface of school and workplace in which working and learning are integrated. Learning is typically trans-boundary in nature and it is embedded in ill-structured, authentic tasks such as assignments for real-life clients or other stakeholders in the community. • Key elements: -	• Model: Model of Educational Design Research (EDR), four main stages: - Diagnosis and agenda setting - Analysis and exploration - Design, implementation, and evaluation - Developing knowledge and consolidation • Approach: -	• Context: hybrid learning configuration at a university of applied sciences in the Netherlands. • Stakeholders: students (different study programmes, different levels), • Roles: - • Governance: -	• Lessons learned: - Provide opportunities to engage in two or more cycles of self-directed lifelong learning - Provide educational support consisting of instruction, a professional profile and feedback - Pay attention to emotional and motivational aspects - Treat self-directed lifelong learning as a social learning process - Share learning goals and results from early in the course - Provide and atmosphere of safety and trust - Position self-directed lifelong learning as a self-evident, integrated part of the course. - Involve all lecturers and assistant-coaches in the process of self-directed lifelong learning.	Students vary in prior knowledge, interests, and ambitions. Although they all aim to master similar professional tasks, each student encounters their own challenges and must learn from them in the process.	Workshops and a study guide	• Progress reports • student blogs • Future driven self-assessment
Callaghan & Herselman, 2015	• Type of publication: Knowledge synthesis • Number of living labs discussed: 1 • Domain: ICT and human computer interaction • Subject of innovation: education/innovative teaching living lab • Aim: discusses and outlines the elements of Living Labs, and how these have played a role in the establishment of a new Education Living Lab	• Definition: Environments, a methodology or an approach which caters for user-driven open innovation within real-life rural and urban settings/communities, where users can collaborate with multiple committed stakeholders in one or more locations, to become co-creators or co-designers of innovative ideas, processes, or products within multidisciplinary environments. • Key elements: - Is driven by: Users; - Involves: Real-life communities and multiple stakeholders; - Is focused on: Collaboration and co-creation; - Is aimed at: Multi-disciplinary open innovation;	• Model: Living Lab paradigm is applied to act as a catalyst to address complex challenges in Education whilst working towards the Department of Science and Technology's (DST) Vision for ICT innovation The Living Lab paradigm creates inter-disciplinary spaces where participants or stakeholders can co-create solutions to challenges. • Approach: The living lab can be both an environment as well as an approach The idea of 'open innovation' in one of the core principles	• Context: academic department • Stakeholders: academia, industry, students and other stakeholders, different sectors (public and private), as well as research communities, communities, researchers, public entities, private companies, individuals, communities of practice, other LLs; • Roles: - • Governance: -	• Lessons learned: - Co-creation of a commonly owned vision (success factor) - Strong, focused leadership (success factor) - Self-sustainable from inception (success factor) - A strong sense of challenges and the ability to be nimble and responsive to stakeholder needs (success factor) - Regular face-to-face interactions (success factor) - Hosting or co-locating the LL network within an existing strong organization (success factor) - Support for sustainability (success factor)	-	-	-

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						Learning outcomes	Teaching and self-study methods	Examination methods
		- Results in: Improved or new products/processes that are replicable and sustainable; - Impacts: The socio-economic environment (capacity building, development, empowerment).	Appreciative Inquiry (AI) phases: Discovery, Dream, Design and Delivery					