

# Data in Educational Living Labs

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**Abstract.** Living lab (or design-based research) in educational field is an iterative process where different stakeholders work together to design and test new digital tools for learning or teaching. Current literature review aims to describe how popular was living lab (design-based research) in educational research during 2010-2020 and what type of technological interventions were studied. The main focus was on types of data that were most often collected and how this data was analysed. We show that the number of education related living lab papers has increased compared to the years 2000-2010. Most of the data collected was descriptive and allowed descriptive analysis. About one third of studies mentioned data types and analyses types that are truly quantitative. Learning analytics was used in 4% of studies that was somewhat surprising for the educational field. There is lots of data presented in the literature that could be statistically tested and therefore the results would be more reliable. Data collection and analysis related strengths and weaknesses of living lab process in education are discussed.

**Keywords:** Living laboratory, design-based research, literature review, education, data types.

## 1 Introduction

In the area of digitalization there is constant pursuit to develop better and better digital tools (games, apps, digital environments) for learning or teaching. In order to design those digital tools and test them in real life such participatory design process as living lab is often used. Living lab and design-based research are expressions that could be used as synonyms and we chose to use living lab throughout this article. Living lab methodology also seeks to increase the impact of education research into practice. It is accompanied by theory building and development of design principles. Living lab method dates back to the 1990s as Mitchell described it in the book about urban planning and living design [7]. Living lab is a process where all parties of interest such as the users, researchers and company workers developing the tool, are constantly co-operating.

The living lab is based on the theoretical approach that is user- or co-operation centred. The approach is different from manufacturer-centred approach [5]. The man-

manufacturer-centric model is based on the notion of the user who only has needs and the manufacturer identifies and fills those needs by designing and creating new products. In the model used in the living lab the user is in a great deal the product and service developer. The manufacturers and users work together to identify the needs of the learners in focus groups, create a design that takes into account scientific knowledge and the needs of the learners and test the tool in real learning environments. This open, distributed working process is difficult for manufacturers because it requires new business models that do not follow old models of the social division of labor. The living lab is a fine example of this paradigmatic shift. It is a process organized in iterative cycles until the co-operatively designed tool is ready for use.

### **1.1 The living lab process**

In the living lab data is collected during iterative cycles of consecutive phases of the process. A cycle usually begins with identification phase where the needs are identified asking questions in focus groups and distributing questionnaires. In the design phase the prototype is made and when prototype is ready, focus group feedback is collected. In the experiment phase data from each individual use of the tool is collected to be able to analyse the use of the tool. For example, how long the tool is in use every time it is initiated? How many times it is opened during a day, a week? What are the background activities that preceded or followed tool usage? What are the operations initiated when using the tool? Also, users are questioned about their emotions and thoughts and ideas about the tool. In the last, evaluation phase the data is analysed and conclusions are made whether to move on to begin new iterative cycle or proceed to finalizing the tool.

The researchers participating in the living lab are responsible for providing theoretical framework and for careful documentation of the time, commitment and contingencies that occur during creation and implementation of the intervention. Also, analysis of the data is a very important scientific aspect. These documented aspects should enable to replicate the intervention or modify it for even better results.

The living lab has a lot of potential in bringing the research and practice together. However, when compared to medical research, it can be seen that the potential has not been fully realized [2, 8] for various reasons. First, rigorous scientific research requires implementation of strict procedural protocol that cannot be followed in living lab that requires creativity, teamwork and enthusiasm. Second, the interests and dislikes of all stakeholders must be taken into account to enable smooth co-operation process. Therefore, it is often not possible to collect as much data as would be desirable for researchers and not all types of data as would be collected in lab experiments in order to take into account all possible influencing and confounding factors. Instead, certain types of data would be collected for practical purposes and research. On the other hand, as indicated in a review published about design-based research in educational field in previous decade (2000-2010) [1] and noticed by the authors of the current paper, when technology is tested, lots of data is collected during iterations and most of it remains unanalysed.

These characteristics of living lab point towards the necessity to review the documented interventions and methodologies in order to see better the weaknesses and strengths of user-centred approach and possibilities for development. The aims of the current review are to identify: 1) how popular was living lab in educational research during 2010-2020, 2) what type of technological interventions were undertaken in ICT living labs conducted in educational settings, 3) what types of data were most often collected in educational ICT living labs and 4) how the data was analysed or could be analysed. In order to achieve these aims we searched for peer reviewed academic journal papers and conference materials to get an overview.

## 2 Method

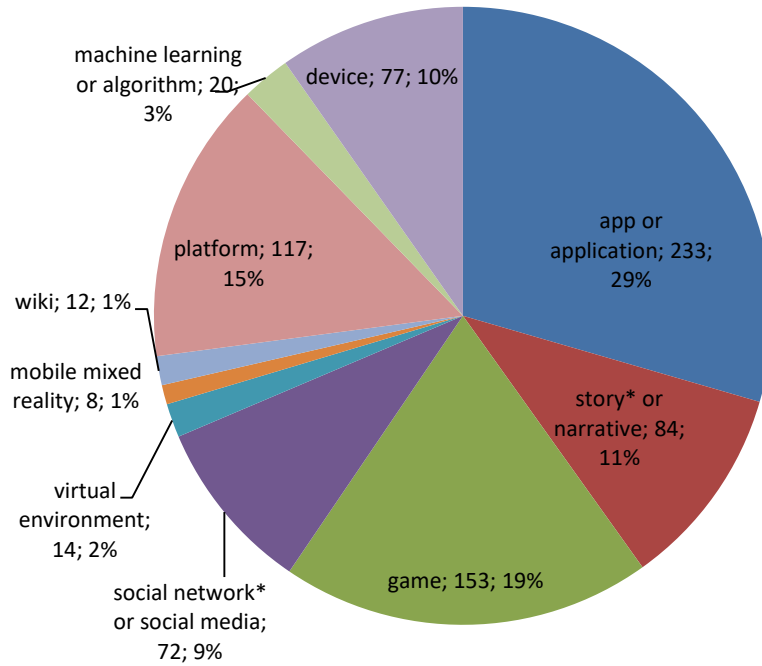
We aimed to conduct a systematic review of the papers where living lab or design-based research were mentioned in educational settings, more specifically, for developing digital tools or environments for human learning. EBSCO Discovery Service was used to search for records simultaneously from following databases: OpenAIRE; Academic Search Complete; Science Citation Index; MEDLINE; Complementary Index; Social Sciences Citation Index; Directory of Open Access Journals; APA PsycInfo; ScienceDirect; Health Source: Nursing/Academic Edition; Supplemental Index; MasterFILE Premier; ERIC; SciELO; Dentistry & Oral Sciences Source; Library, Information Science & Technology Abstracts; Teacher Reference Center; Health Source – Consumer Edition; SPORTDiscus; Communication & Mass Media Complete; Business Source Complete; Central & Eastern European Academic Source; JSTOR Journals; Scopus®; GreenFILE; British Library Document Supply Centre Inside Serials & Conference Proceedings; Digital Access to Scholarship at Harvard (DASH); APA PsycArticles; SAGE Research Methods; Arts & Humanities Citation Index; SAGE Knowledge; Emerald Insight; MLA International Bibliography; J-STAGE; IEEE Xplore Digital Library.

Time period used for search was 2010-2020, only peer reviewed full text academic journal papers and conference materials in English language were Boolean (phrase) searched. Firstly, we conducted a search with two components: first component was "design-based research" or "living lab\*" (TX All text) and second component was AND educat\* (abstract). In our search "educat\*" was searched from abstract in order to exclude papers where education was not the main topic but was mentioned in full text for comparative purposes or as a characteristic of a person eg. education level as collected data entry. The initial research resulted in 3126 items that were exported from search engine and imported bibliographical data together with abstracts of those items to bibliography program Mendeley Desktop (version 1.19.4). In Mendeley Desktop duplicates were removed and titles and abstracts were visually scanned for topic relevance. Irrelevant search items were removed. The final database for this study included 2244 items. The search continued within this data folder in Mendeley Desktop, where we searched from titles, keywords and abstracts for the third component, for example "questionnaire" or "survey" or "test".

### 3 Results

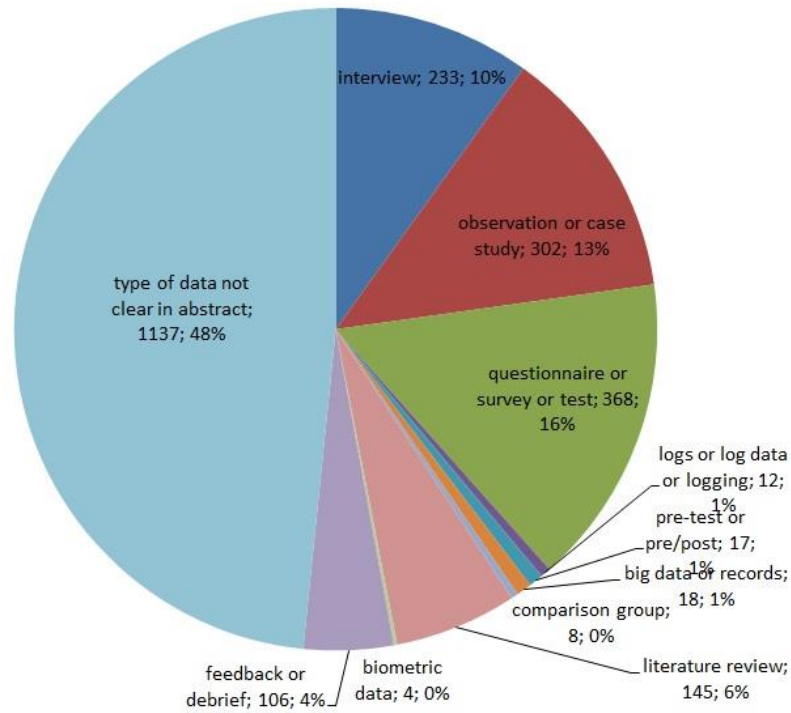
In order to get an estimate of the use of living lab in the last decade (2010-2020) we searched for the overall number of articles in English where living lab or design-based research was mentioned in the full text and “educat\*” was searched from abstract. Using selection criteria described in method section, we ended up with 2244 records. We have comparison data from a literature review about the previous decade (2000-2010) [1] where Google Scholar search led to 1940 academic journal articles that contained words design-based research and education in the same full text. We may conclude that the number of articles has somewhat increased in the 2010-2020 decade. However, our search is more focused (education was searched from abstract and EBSCO Discovery search engine was used) and therefore it is hard to determine how large exactly is the increase. We also searched for papers where any form of the word education “educat\*” was mentioned in abstract and found that 1412918 full text peer reviewed papers in English (1386343 in academic journals and 26575 in conference materials) were published during years 2010-2020. Therefore, the living lab/design-based research was used in 0.16 % of overall educational research papers published 2010-2020.

Only a portion of papers (35%) described some type of intervention, in other words type of a product. The rest of the papers were either more theoretical or methodological or described supporting activities of a larger educational programme etc. The types of technological interventions that were mentioned in those living labs/design-based research papers are seen in Figure 1. Each type of technological intervention on Figure 1 was searched from the data folder one at a time. It is possible that some papers had several searched terms. For example the words software and app could have been on the same database record and therefore this paper was taken into account twice, in the search where a platform was the search term and also in the search where app was the search term. Also, it is possible that both types of interventions were under study in the same living lab. The types we searched for come mainly from the published review [1] that was done for the period 2000-2010. It can be seen in Figure 1 that one third of the papers of this field mention apps in the educational field. Educational apps used in the research are for example ReFlex and TeamUp [6]. Games, platforms, devices or interventions based on stories and narratives were mentioned about 10-19%. The percentage of social network or media studies was the same (9%) as in 2000-2010 review. Social media and machine learning were next popular types under study (3-9%). When we compared these results with the results from previous decade [1] we can see that the most has increased interest in narratives, from 6% to 11%. However, these results have to be read with precaution because results of different intervention types are partly overlapping (platforms are partly overlapping with social media platforms and may involve other types of technology interventions, such as games).



**Fig. 1.** The figure depicts one portion of the searched papers (35% of the total number of items under study) that describe some technological interventions undertaken in living labs or design-based research studies in educational settings.

Our third aim was to see what types of data were most often collected in living labs in 2010-2020 (Fig. 2). It is important to note here that living labs are using mostly

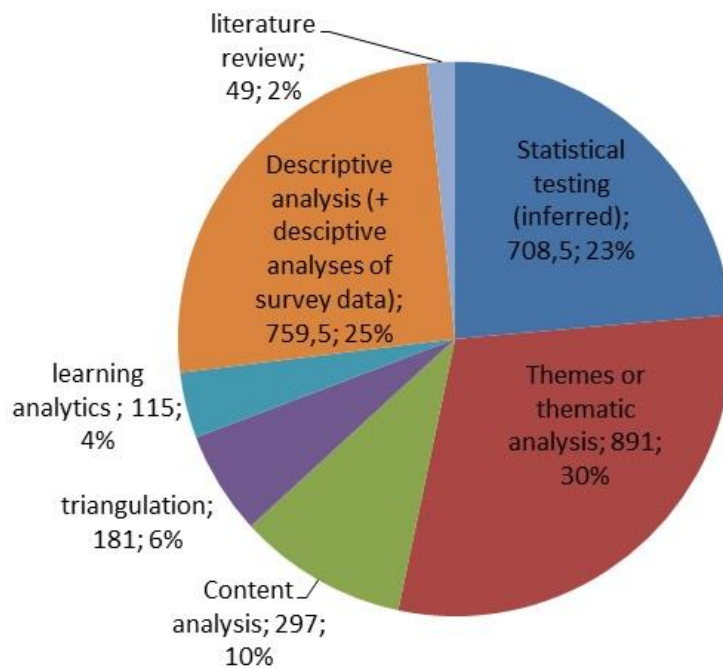


**Fig. 2.** Types of data collected in living labs or design-based research studies in educational settings.

mixed methods. Quite often a study includes for example descriptions or analyses of interviews, analyses of observations and maybe also results of the questionnaires. It is only natural that these categories were represented in almost equal amount. Log data, pre-test or pre/post-tests, comparison group data, and big data were least used. Log data refers to data records of logging in and out of the app or digital environment. Pre/post-tests refer to questionnaire and survey data that is collected before the intervention and after the intervention. Comparison group data refers to collecting data from comparative groups. For example, from a group that receives digital intervention and from the group that receives different kind of intervention. Big data or records refer to retrieving data from blog posts, social media posts etc. These results show that majority of studies result in rich descriptions of living lab settings, actions, created designs and user feedback. On the other hand, there is room for growth for comparative and quantitative analysis.

Forth aim of this study was to see what types of data analyses were conducted in the living lab or design-based research in previous decade (Figure 3). Since analysis methods are mostly not described in the abstract or keywords we searched for this

information directly from EBSCO Discovery database using every time one search term seen in Figure 3 as a third component (TX All Text) of the search. The most popular data analysis method in living labs is analysis of themes or categories derived from observation or interview transcripts. Also other types of descriptive analyses (including descriptions of survey data) are very often used. Statistical testing (eg. Chi-square test, Spearman rho or any other non-parametric test) was performed in a quarter of studies. We derived the frequency of statistical testing by reading 20 most relevant papers in our search where questionnaire or survey was the third component and counted papers where statistical testing was used. In 9 papers out of 20 statistical testing was used. We can say that probably 50% of survey data is statistically tested and we divided the total number of questionnaire/ survey papers by two to get the rough overall estimate of the use of statistical testing. The other half of survey papers referred to figures and tables of percentages and frequencies and descriptively compared the frequencies in the text. Triangulation for validation of the mixed data, learning analytics and literature review were least used analyses methods.



**Fig. 3.** Types of data analysis undertaken in living labs or design-based research in educational settings. The types were chosen from the abstracts of first 50 most relevant papers when third search term was: AND “data” (TX All text).

## 4 Discussion

Our descriptions of the 2010-2020 decade living lab papers showed that the number of education related living lab papers has increased compared to the 2000-2010 time period. Most of the data collected was descriptive and allowed descriptive analysis. Statistical testing could be used more in studies where questionnaire or survey results are collected. About one third of studies where data was mentioned used data types and analyses types that are truly quantitative. Learning analytics was used in 4% of studies that is somewhat surprising for the educational field.

Our literature review confirmed that the strength of the education related living labs are rich descriptions of users, their ideas and the environment that allow recreating the environment that lead to certain tool characteristics or development. The studies covered wide range of data types and analyses types but interview data, observation data and questionnaire/survey data prevailed. Stories and narratives were collected and analysed more than they were in 2010-2020. It all indicates that the subjective user data is documented.

The weaknesses related to the data in living labs are: statistical hypothesis controlling is not done in many studies, probably because the project is not finished (finishing the project can take many years) [1], statistical testing of the described data is often missing eg. [4] and truly quantitative data analyses is used in one third of studies.

The living lab can be very helpful for practical purposes (for companies) and it has a huge potential in science because the research is taking place out of traditional laboratory. However, the data analysis part can be developed further, there is lots of data that could be statistically tested and therefore the results would be more reliable. The weaknesses of living lab are related to limitations in time and statistical methods. Those limitations may partly result from business related restrictions imposed on researchers by the companies participating in the living lab. The restrictions could involve mentioning specific characteristics or principal design elements of the tool in order to not reveal them to competitor companies, limitations in time (research may take more time than the company is willing to spare for one iteration) and even limitations to what data and in what form can be collected and published. These weaknesses can be overcome by ensuring equality in management process of a living lab [3] and also by enhancing the quality and amount of statistical analyses that enable more certain conclusions. More literature reviews on different topics (for example, who have contributed more into educational living labs, students or educators) may provide ideas of what types of data could be analysed in which way and what types of data could be collected and analysed even more often (eg. learning analytics).

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