Martin Burghardt

Design, Implementation, and Evaluation of Self-Directed Learning in Digital and Hybrid Lab-based Environments

Abstract

In order to find out how Self-Directed Learning can best be embedded in a hybrid engineering laboratory environment to make learning there more effective, this paper briefly presents the related workflow within a research project. The procedure is presented from the perspectives of a requirements analysis to an iterative didactic design, from implementation and a formative evaluation as part of a design-based research approach to a survey design, and the first insights into the results of a summative evaluation. In the last section, the experiences and results so far are summarized and evaluated before there is a short outlook on the follow-up tasks of the research plan.

Keywords

Self-Directed-Learning, Hybrid Learning Labs, Design-Based Research

1 Goals, Project Context & Research Question

This paper will demonstrate the main work steps, research questions, results, and findings from the conceptual work developed for self-directed learning in the context of an ongoing international research project. This is a joint project involving different universities. It addresses, among others, the question of the best way to didactically design teaching and learning environments using different types of media, tools, and didactical methods combined with various kinds of educational labs (digital/virtual, remote, hands-on, hybrid) in engineering sciences which are (partly) interconnected with each other to be able to use them more efficiently and more broadly by doing so. The main goal is to maximize the benefit for students working within these settings in terms of learning progress, learning motivation, and acceptance (dependent variables). Furthermore, this approach applies specifically to self-directed learning, which in the context of the project is understood as a method, especially for learners who predominantly work individually and, at least temporarily, digitally. The creation, implementation, and evaluation of the self-directed learning concept is the focus here. Thus, the core question is to what extent the use of this concept leads to an increase in the aforementioned dependent variables when tested in practice.

2 Self-Directed Learning in digital and hybrid Educational Labs in the field of Engineering Sciences: Theoretical Context

First of all, it should be clarified at this point how self-directed learning, learning labs, engineering sciences, and the project are interrelated. This serves an essential function in allowing us to understand why the use of this learning method is theoretically appropriate in the given context of application and why it was accordingly chosen to be researched in the project.

So, teaching-learning labs are important in the engineering sciences to provide students with initial practical experience, skills, and references that can be linked to the theoretically acquired knowledge from other learning units (e.g. seminars, lectures) (Tekkaya et al, 2016). Those laboratory-based learning environments are characterized by practical tasks and their closeness to reality. In most cases, this circumstance implies an active and constructive role for the learners, which is accompanied by self-direction (Stauche & Sachse, 2004). Furthermore, self-directed learning is also relevant in connection with a second important feature of this research project: hybridity. For example, in many cases, the various learning phases associated with laboratory scenarios (preparation, execution, follow-up, etc.) occur partly in face-to-face form, partly in online phases, partly synchronously, and partly asynchronously (Kerres, 2018). The phases in computer-based asynchronous online learning environments (using a learning management system) especially offer great potential for self-directed learning, since the learners can determine the outcome of important decisions such as learning time, learning pace, or learning location themselves and they have permanent access to important learning materials (Stauche & Sachse, 2004 ; Dreer, 2008). Hence, suitable framework conditions for the successful implementation of self-directed learning as a method arise here, and subsequently the opportunity to benefit from the advantages associated with its use for learning. Among other things, this includes increased motivation and more enjoyment of learning, which in turn can be followed by an improvement in learning success (Stauche & Sachse, 2004).

3 Requirement Analysis plus Creation, Implementation, and Formative Evaluation of the SDL-Concept

Thus, it makes sense to investigate to what extent self-directed learning can positively influence such laboratory-based hybrid learning environments with regard to the variables mentioned above. For this purpose, a didactic concept of self-directed learning was created in the research project. It is based on findings, framework conditions, and needs that were previously identified with a requirements analysis through scenario descriptions, guideline-based expert interviews, literature studies, and project objectives. In this way, eleven requirements were identified for self-directed learning, which had to be obligatorily adhered to for concept development and later for scenario creation. Therefore, attention had to be paid to the anticipated prerequisites of the learners and teachers in the project. On the learner side, for example, the focus was on their self-regulation abilities, and their prior knowledge of or interest in the specific subject matter (Ferdinand, 2007; Friedrich & Mandl, 1997). For instructors and tutors, on the other hand, it was about various skills in areas such as guidance/counseling, planning, or media (Faulstich, 2001). Since the learning environments were intended to foster self-directed learning to ensure meaningful and successful application of the method, it is not surprising that all the other nine requirements had a direct reference to this area. For instance, learning environments must ensure that social interactions are enabled during learning to evoke additional motivation in learners. They must also be designed to demand the use of self-regulated learning as a learning method so that its benefits can be realized (Ferdinand, 2007).

Using these requirements as a starting point, the concept itself was then developed. This primarily had the goal of generating design ideas for the hybrid learning environments consisting of laboratories and learning management systems, by considering relevant specialist literature and deriving project-specific design recommendations from these. The latter were, if possible and reasonable, subsequently transferred to the teaching-learning scenarios available in the research project. They were implemented considering individual circumstances (learner prerequisites, organizational/institutional conditions, etc.), learning objectives, and the learning contents of the learning environments, which all were known through surveying important scenario-specific conditions using the requirement analysis. This procedure refers to Kerres' model of design-oriented media didactics, which served as a basis for all the didactic scenarios of the project and represents a kind of decision grid for the creation of learning scenarios (Kerres 2018). So, this whole sequence can be thought of as a kind of selection process in which appropriate design recommendations were adopted into scenarios.

Using a formative evaluation for each particular scenario, problems and ways of improving the implementation of the suggestions from the concept were then sought. To this end, semi-standardized guided interviews were conducted with experts from the fields of engineering and didactics as well as with the most important target groups of the learning environments (teachers and learners). The corresponding qualitative results (overall 33 interviews and 321 pages of transcriptions) were discussed within the research group and, subsequently, decisions were made on suitable optimization solutions. The innovations decided on were then embedded in the scenario. In the spirit of the design-based research cycle, this process was repeated as often as possible in each of the three scenarios.

The period of the surveys and refinements was mainly in the spring and summer of 2020. So, the concept itself has now been completed. In its final form, it contains a large number of design recommendations (more than 60), ranging from the use of certain tools and media, such as open badges, learning analytics, assistance systems, or guidelines on relevant topics, to the modularization of learning content or the choice of social form.

While in principle self-regulation elements were included in all the project scenarios—which means that they contain more self-regulation after revision than in their original state—by far the most were implemented in the measuring-chamber scenario. In this regard, the scenarios offered various entry points for the realization of the self-regulation recommendations, since they are hybrid laboratory exercises that alternate between individual and group learning phases and whose preparation and post-processing times take place primarily through working in a learning management system environment, created in the project. For communication and social interaction, which are important in self-directed learning, forums and feedback mechanisms have been built in (Ferdinand, 2007 ; Stauche & Sachse 2004). Furthermore, some of the exercises were divided into different sections with small intermediate targets, where choices were created in the tasks and voluntary extra tasks for practice were introduced. In this way, small learning paths with some intermediate goals were created in such scenarios, which were also made visually comprehensible by linking them to progress bars and Open Badges. Open Badges are digital awards in the form of small pictures that honor achievements and contain all relevant information about them—i.e. who did what, where and when with what goal, etc. They were applied in the project to support self-directed learning because, among other things, they can increase the motivation of learners (for example, through gamification and reward effects), but can also be helpful with regard to learning planning and learning assessment or reflection (Otto & Hickey, 2014 ; Cucchiara et al, 2014). All these aspects are considered essential for the successful use of the learning method in common self-direction models, such as Zimmermann's model (Zimmermann 2002). To encourage learners to discuss content and to engage with Open Badges, the latter were also awarded for meaningful communication within the forums.

Overall, all these measures are intended to communicate to learners that they have decision-making power in the learning process and to provide opportunities for them to plan and assess their learning better through the transparent presentation of learning objectives, content, and sequences. As a result, learners should perceive their learning as self-directed.

4 Summative Evaluation of the SDL-Concept and the related Scenarios

The self-directed learning concept is presently undergoing its final summative evaluation. Currently, the task is to find out how its concrete implementation in the various scenarios performs in comparison to the learning environments used before the start of the project. For this purpose, experimental groups (with treatment "SGL concept implementation") and control groups (without treatment "SGL concept implementation") were formed in each relevant scenario, enabling a direct comparison with regard to the above-mentioned dependent variables (learning progress, learning motivation, and acceptance). Pre- and post-measurements, and in some scenarios also intermediate measurements, were conducted in order to infer short-term and medium-term cause-effect relationships and to answer the related research questions, namely to what extent the use of self-directed learning can lead to an increase in the dependent variables. Roughly summarized, it is hypothesized that self-directed learning environments have a slight positive effect on motivation, acceptance of the learning scenarios, and ultimately on learning progress, in terms of knowledge and skill acquisition. These effects should be generally recognizable, but especially in comparison to the groups that did not receive self-direction treatment. These assumptions are justified by the basic suitability of the learning method for such learning spaces, which has already been discussed, and, among other things, by the expected increased satisfaction of the basic need for autonomy from the Self-Determination Theory, which can be expected from the design of the corresponding learning scenarios (Thomas & Müller, 2011; Deci & Ryan, 1993).

The quantitative data collection through written surveys (questionnaires with open and closed questions) has now been completed. In two different learning scenarios, a total of four modes were fully tested with two student groups each, cumulatively 130 people. However, most of the analysis of these quantitative data and thus the answers to the research questions are still pending and are expected in March 2022. Unfortunately, only descriptive statistics of the progress of learner motivation in the four scenario groups in the measuring-chamber scenario are currently available. This is not yet sufficient to answer the research questions and related hypotheses, especially since there are a lot of other variables to consider in identifying causal relationships between the treatment and the dependent variables, which also cannot currently be included. Nevertheless, the given information shall be utilized here in order to get a first insight into the trends within the study:

In a comparison of mean values, an increase of 9.9% between the first and third (last) measurement time points was recorded with regard to their intrinsic motivation among all participating subjects (n=33). With values of 3.03 (first measurement), 3.15 (second measurement), and 3.33 (third measurement), intrinsic motivation (minimum 1.00; maximum 4.00) is at a relatively high level overall. The development of the groups with self-regulation treatment (plus 9.69%; n=19) and those without (plus 11.6%; n=14) is very similar in this respect and does not show any major differences. This already indicates that the hypotheses can probably not be confirmed and that the self-regulation groups were not able to gain any greater intrinsic motivational advantages from their learning environments. However, it is noticeable that the self-regulation groups were able to make increases in this area above all after completion of the laboratory work phases (time of the second survey) in the post-processing and report preparation phase (plus 0.22 points/ 7.46% vs. plus 0.16 points/ 4.71% (Group without treatment)), while the groups without self-regulation treatment made greater gains during the preparation and laboratory phases (with treatment +2.08%, without treatment +6.58%). Of course, these are minimal differences that are likely to have limited significance due to the general survey situation and the resulting analysis options. They also clearly originate exclusively from the hands-on lab groups and not from those who used remote access.

A second interesting variable was surveyed in terms of amotivation, which declined by a total of 16.75%. It is noticeable that the decrease occurred mainly between the first and second measurements (-20.69%), i.e. during the preparatory tasks and during the various laboratory phases (depending on the study group). Afterward, it increased slightly again with a plus of 4.97% (follow-up work, joint report writing). In relation to the minimum (1.00) and maximum (4.00), its values (2.03 (I), 1.61 (II) and 1.69 (III)) are at a rather low level. The self-control groups were able to benefit more here, recording a decrease in amotivation of 19.91%. In contrast, the other groups show "only" 14.74% less amotivation.

The differences between the various phases described above can be found in both groups (but to a much greater extent in the control group) and also in all scenario variations. Thus, for this variable, there are at least slight indications that the corresponding motivation hypothesis could be correct. Further and more detailed calculations must follow, though, in order for us to be able to make serious statements here, because this is not yet possible with the present calculations.

5 Conclusion & Outlook

In conclusion, it should be noted that the creation of the didactic concept based on the requirements analysis and its continuous improvement through the inclusion of further literature and the formative evaluation results worked as previously planned. Accordingly, it was possible to pass on project-specific design recommendations for implementation to the scenarios.

For various reasons, the implementation of the scenarios could not be completed, and thus many recommendations and also many suggestions for improvement that were obtained from the iterative data surveys could not be considered. Among other things, this was due to a lack of time and human resources, but also because the scenarios did not have the structure (time duration, etc.), framework (learning content, learning objectives, etc.), and extent that it would have taken to implement all the ideas. However, it was probably not realistic to expect this, which is why this work step was nevertheless successful in summa summarum in view of the challenges.

Far more problematic were the multi-factorial developments before and during the data collection phase, which will, unfortunately, have the consequence that the results yet to be calculated will, in all probability, have an overall low significance. The first factor to be mentioned here is the small number of probands in some scenarios. This fundamental problem was intensified by the coronavirus pandemic. In general, the pandemic was extremely disadvantageous in terms of test person recruitment and survey planning. This was compounded by the large number of forms of treatment and variables to be considered in the research project, all of which had to be accounted for. In combination with mostly small numbers of probands, it was not possible to plan the survey designs in such a way that the forms of treatment could be cleanly separated from each other. This will have to be considered in the analysis. Here, it will also be exciting to calculate how strongly self-directed the learners perceived the opportunities in each scenario to be because this perception is considered crucial for the positive effects of the learning method investigated (Ferdinand 2007). Accordingly, in the preliminary stages of the study, it is expected that groups with a higher perception of self-control will perform better on the dependent variables than those with a low perception.

As mentioned above, the outstanding analyses on self-directed learning are expected to be available in March 2022. In the next steps, they will be interpreted in relation to the research questions and hypotheses. If possible, conclusions will be drawn from them.

References

Cucchiara, S., Giglio, A., Persico, D. & Raffaghelli, J. E. (2014). *Supporting Self-regulated Learning through Digital Badges: A Case Study.* In Cao, Y., Väliataga, T., Tang, J. K. T., Leung, H. & Laanpere, M. (eds.). New Horizons in Web-Based Learning – ICWL 2014 International Workshops – SpeL, PRASAE, IWMPL, OBIE, and KMEL, FET – Talinn, Estonia, August 14–17, 2014, Revised Selected Papers. Heidelberg, Germany/ New York, United States of America/ Dordrecht, Netherlands/ London, United Kingdom.

Deci, E. L. & Ryan, R. M. (1993). *Die Selbstbestimmungstheorie der Motivation und ihre Bedeutung für die Pädagogik*. Zeitschrift für Pädagogik, 39, pp. 223–228.

Dreer, S. (2008). *E-Learning als Möglichkeit zur Unterstützung des selbstgesteuerten Lernens an Berufsschulen*. In Zeitschrift für Theorie und Praxis der Medienbildung. ISSN 1423 – 3636.

Faulstich, P. (2001). *Förderung selbstgesteuerten Lernens*. In Dietrich, S. (ed.). *Selbstgesteuertes Lernen in der Weiterbildungspraxis. Ergebnisse und Erfahrungen aus dem Projekt SeGel/ DIE.* Bielefeld, Germany: Bertelsmann.

Ferdinand, P. (2007). *Selbstgesteuertes Lernen in den Naturwissenschaften. Eine Interventionsstudie zu den kognitiven und motivationalen Effekten eines Blended Learning Ansatzes.* Hamburg, Germany: Dr. Kovac.

Friedrich, H.F. & Mandl, H. (1997). Analyse und Förderung selbstgesteuerten Lernens. In Weinert, F. E. & Mandl, H. (eds.). Psychologie der Erwachsenenbildung. Enzyklopädie der Psychologie, D, Serie I, Pädagogische Psychologie, vol. 4: Erwachsenenbildung (pp. 237–293). Göttingen, Germany: Hogrefe.

Kerres, M. (2018). *Mediendidaktik: Konzeption und Entwicklung digitaler Lernangebote* (Fifth Edition). Boston, Massachusetts, United States of America: Walter de Gruyter GmbH.

Otto, N. & Hickey, D. T. (2014). *Design Principles for Digital Badges Systems – A Comparative Method for Uncovering Lessons in Ecosystem Design.* In Cao, Y., Väliataga, T., Tang, J. K. T., Leung, H. & Laanpere, M. (eds.). New Horizons in Web-Based Learning – ICWL 2014 International Workshops – SpeL, PRASAE, IWMPL, OBIE, and KMEL, FET – Tallinn, Estonia, August 14–17, 2014, Revised Selected Papers. Heidelberg, Germany/New York, United States of America/Dordrecht, Netherlands/ London, United Kingdom.

Stauche, H. & Sachse, I. (2004). *Selbstgesteuertes Lernen als mögliche Alternative zu traditionellen Bildungswegen? Dargestellt am Beispiel der Lehrveranstaltung „Arbeit mit SPSS" unter besonderer Berücksichtigung der virtuellen Lernform.* Universität Jena, Germany, 2014.

Tekkaya, A. E., Wilkesmann, U., Terkowsky, C., Pleul, C., Radtke, M. & Maevus, F. (eds.). (2016). *Acatech Studie: Das Labor in der ingenieurwissenschaftlichen Ausbildung: Zukunftsorientierte Ansätze aus dem Projekt IngLab: acatech Studie.* Munich, Germany: Herbert Utz Verlag GmbH.

Thomas, A. E. & Müller, F. H. (2011). Skalen zur motivationalen Regulation beim Lernen von Schülerinnen und Schülern – Skalen zur akademischen Selbstregulation von Schüler/innen SRQ-A [G] (überarbeitete Fassung). In Wissenschaftliche Beiträge aus dem Institut für Unterrichts- und Schulentwicklung (IUS), No. 5. Alpen-Adria-Universität Klagenfurt, Austria.

Zimmerman, B. J. (2002). *Becoming a self-regulated learner: An Overview.* Theory into Practice, 41, pp. 64–70.

Author

M.A. Martin Burghardt
University of Koblenz-Landau
Universitätsstraße 1
56070 Koblenz
https://www.uni-koblenz-landau.de/de/iwm
burghardt@uni-koblenz.de