Indicators for supporting personalised and adaptive learning environments in online further education: An interview study

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Abstract: Personalised and adaptive learning environments (PALE) are considered a promising invention for online further education, as they take the different prerequisites and backgrounds of learners into account. However, to what indicators (e.g., prior knowledge, interests) should PALE adapt? We conducted $N = 37$ interviews with German professionals to develop an empirical model of indicators for supporting PALE in online further education. Future research should build on the indicators identified in our interview study to design PALE for online further education.

Keywords: personalised and adaptive learning, online further education, learning context

1   Introduction

Current research focusing on educational technologies and artificial intelligence suggests that vast amounts of education-related data can provide useful insights into learning behaviour and offer benefits for implementing personalised and adaptive learning environments (PALE). PALE are digital learning systems that continuously analyse and leverage education-related data to tailor learning activities to the individual learner [PP20; Xi19]. PALE are considered a promising invention for online further education, as they take the different prerequisites and backgrounds of learners into account. However, learners differ in a wide range of indicators such as abilities, knowledge, interests, or learning strategies [PP20]. Hence, to what indicators should PALE adapt? Although researchers claim that this question requires empirical answers [Ga16; PP20], empirical approaches to identify indicators for PALE in online further education are scarce. Therefore, the aim of this interview study is to develop an empirical model of indicators for supporting PALE in online further education.

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2   Theoretical background

2.1   Personalised and adaptive learning environments in online further education

Further education refers to a broad range of learning activities aimed at developing or renewing knowledge, skills, or competencies after the completion of an initial phase of education (e.g., the completion of a university degree or apprenticeship) [De13, DB70]. While the initial approaches to further education were primarily classroom-based trainings, online and digitally-supported further education opportunities have become increasingly common in the last years [De13; If18]. Digital technologies enable the implementation of flexible and customised forms of further education such as PALE [DJI20; If18]. However, the identification of reliable indicators remains a major challenge in designing PALE for online further education. Indicators are variables (e.g., prior knowledge, interests) that are collected by the learning environment and processed by specific algorithms to personalise and adapt learning activities. Several research efforts have attempted to identify indicators for learning analytics in higher education. However, these research efforts have focused on data-driven analytics rather than pedagogical theories [Ga16; YI20]. Researchers claim that the search for indicators for PALE should be guided by pedagogical theories and rigorous findings from empirical studies, as these explain fundamental mechanisms of learning and help to design pedagogically meaningful interventions to support learning in online further education [Ga16; PP20]. According to [PP20], only variables that have a relevant impact on learning processes (i.e., on behaviour or motivational and emotional processes during learning) or outcomes (i.e., on subjective or objective learning success) should be considered as indicators for PALE.

2.2   Learning context

According to [WH98], learning processes and outcomes are inherently affected by the learning context. The learning context refers to a learner's resources and conditions, and can be divided into internal and external learning context. The internal learning context refers to personal and subjectively perceived variables (e.g., demographics, interests). It encompasses a learner's personal and emotional world as well as cognitive and motivational conditions. In contrast, the external learning context refers to objective and predefined variables (e.g., location, course characteristics) of a learner's environment [Ga16; Wi10]. According to [WH98], different characteristics of the learning context determine how learners engage in different learning tasks and construct new knowledge. For example, if learners are not interested in a specific task, they might engage in the task only superficially or even stop learning [Go19].

2.3 Research question

In a previously conducted systematic review, we identified several indicators of the learning context (e.g., age, interests, location) that have been associated with learning processes and outcomes of adult learners in various educational areas (e.g., higher education, massive open online courses, workplace learning) [HI22]. Our interview study aims to build on this systematic review and investigate which indicators of the learning context are especially relevant in online further education. Our interview study is guided by the following research question: *Which indicators of the learning context affect learning processes and outcomes in online further education and shall, therefore, be considered when designing PALE?*

3 Method

We conducted $N = 37$ semi-structured interviews with German professionals (23 female, 14 male) from different working areas (e.g., education and research, information technology). Participants were between 22 and 65 years old ($M = 39.9$, $SD = 12.3$) and had already participated in at least one online further education course. Participants were first asked to freely speak about their learning experiences in online further education. Then, each participant was presented a selection of five to six out of 26 different concepts related to the learning context (e.g., emotions, spatial context) that were derived from the above-mentioned systematic review [HI22]. Participants were asked to explain how these concepts affected their learning processes or outcomes by providing specific examples. Participants signed an informed consent form and all interviews were voice recorded, transcribed, and analysed using deductive and inductive content analysis [Ma15]. The identified indicators were clustered into dimensions.

4 Results and discussion

The indicators of the learning context identified in the interviews are presented in Table 1 and Table 2. Participants reported that these indicators had an impact on their learning processes (e.g., motivation, engagement) or outcomes (e.g., course completion, performance). For example, participants' *prior knowledge* had an impact on their motivation to learn: "If I already know everything, […] then that doesn't really motivate me" (interview 12).

The results of the interview study are similar to those of the systematic review [HI22], but the list of indicators identified in the interview study is shorter. Especially for the dimensions *educational history* and *values*, several indicators identified in the systematic review (e.g., previous grades, tradition) could not be replicated in the interview study. We conclude that these indicators are less relevant for online further education than for other educational areas focusing on adult learners that were considered in the systematic

review (e.g., higher education). However, in the interview study only indicators that the participants were aware of could be coded. Some indicators might affect learning processes and outcomes unconsciously. These indicators cannot be identified in an interview study, which might be another reason for the lower number of indicators identified in the interview study compared to the systematic review.

Internal learning context	
Dimension	Indicators
Demographics	Age, origin/nationality, marital status, socioeconomic status, parents' education
Educational history	Educational degrees, previous experiences with the course format
Learning approaches	Importance of education, attitudes towards digitalization and digital education, deep/surface approach, self-regulated learning strategies (cognitive and metacognitive strategies, resource management strategies)
Skills and abilities	Prior knowledge, language skills, digital literacy, intelligence
Values	Optimism, achievement
Personality	Openness to experience, conscientiousness, extraversion, agreeableness, neuroticism, resilience, grit
Needs	Autonomy, control, competence, relatedness
Emotions	Boredom, frustration, overburdening, satisfaction, excitement, curiosity, pride
Motivation	General motivation for the course, type/source of motivation, voluntariness of participation, self-efficacy, task value, learning goals
Mental and physical states	Attention, flow, fatigue, engagement/effort, stress, well-being, trust, mood
Perception of the course	Immersive experience, hedonic value, social value, difficulty, time pressure, sociability, learning climate, quality, teacher's presence/engagement, teacher's competence
Perceived social influence	Perceived social support, acquaintances and friends in the course, mimetic pressures
Duties outside the course	Professional duties, family duties, leisure activities
Perception of the job	Work experience, organizational culture (of learning), job satisfaction

Tab. 1: Indicators of the internal learning context identified in the interview study

External learning context

Dimension	Indicators
Job characteristics	Hours of work, working area, organizational requirements, organization size
Course characteristics	Course size, course length, course content, teacher-guided vs. student activating methods, collaborative learning, social media learning, regulatory teaching, examples, homework, media type, communication channel, nonlinear learning, tests, social comparison, gamification, course homogeneity, receipt of feedback, possibility to give feedback, type of feedback
Educational institution	Reputation, costs, institution size
Spatial and temporal context	Location, date, time saving for virtual classes, time available for learning, technical and material resources, disruptive factors, simultaneous activities

Tab. 2: Indicators of the external learning context identified in the interview study

Our interview study provides the first empirical model of indicators of the learning context for supporting PALE in online further education. It provides an overview of different indicators that might be considered when tailoring learning activities to the individual learner. We suggest that the indicators identified in our interview study offer several benefits for designing PALE for online further education. First, they might help to make accurate predictions about learning processes and outcomes, and to identify learners at risk who might need special support [YI20]. Second, a detailed analysis of certain indicators of our model might help to design adequate interventions to individually support learning in online further education. For example, if an individual's prior knowledge is analysed in detail, personalised learning paths can be created in which certain content is either skipped or specifically explained, depending on the individual's prior knowledge [RM21]. However, our model is based on qualitative data and cannot provide information on the strength of the influence of different indicators on learning processes and outcomes. An in-depth analysis of the effects of specific indicators on learning processes and outcomes is still necessary to design PALE for online further education.

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Bibliography

[DJI20]   de Laat, M.; Joksimovic, S.; Ifenthaler, D.: Artificial intelligence, real-time feedback and workplace learning analytics to support in situ complex problem-solving. A commentary. The International Journal of Information and Learning Technology 37/5, pp. 267-277, 2020.

[De13]   Demary, V. et al.: Berufliche Weiterbildung in Deutschland. Ein Vergleich von betrieblicher und individueller Perspektive. Institut der deutschen Wirtschaft, Köln, 2013.

[DB70]   Deutscher Bildungsrat: Strukturplan für das Bildungswesen. Klett, Stuttgart, 1970.

[Ga16]   Gašević, D. et al.: Learning analytics should not promote one size fits all. The effects of instructional conditions in predicting academic success. The Internet and Higher Education 28, pp. 68-84, 2016.

[Go19]   González-García, N. et al.: Attitude and learning approaches in the study of general didactics. A multivariate analysis. Revista de Psicodidáctica 24/2, pp. 154-162, 2019.

[HI22]   Hemmler, Y. M.; Ifenthaler, D.: Indicators of the learning context for supporting personalized and adaptive learning environments. In (Chang, M.; Chen, N.-S.; Dascalu, M.; Sampson, D. G.; Tlili, A.; Trausan-Matu, S., eds.): Proceedings of the International Conference on Advanced Learning Technologies. IEEE, Bucharest, 2022.

[If18]   Ifenthaler, D.: How we learn at the digital workplace. In (Ifenthaler, D., ed.): Digital workplace learning. Bridging formal and informal learning with digital technologies, Springer, Cham, pp. 3-8, 2018.

[Ma15]   Mayring, P.: Qualitative Inhaltsanalyse. Grundlagen und Techniken, 12th edition, Beltz, Weinheim, 2015.

[PP20]   Plass, J. L.; Pawar, S.: Toward a taxonomy of adaptivity for learning. Journal of Research on Technology in Education 52/3, pp. 275-300, 2020.

[RM21]   Rasch, J.; Middelbeck, D.: Knowledge state networks for effective skill assessment in atomic learning. arXiv, 2021.

[Wi10]   Winne, P. H.: Improving measurements of self-regulated learning. Educational Psychologist 45/4, pp. 267-276, 2010.

[WH98]   Winne, P. H.; Hadwin, A. E.: Studying as self-regulated learning. In (Hacker, D. J.; Dunlosky, J.; Graesser, A. C., eds.): Metacognition in educational theory and practice, LEA, Mahwah, pp. 227-304, 1998.

[YI20]   Yau, J. Y.-K.; Ifenthaler, D.: Reflections on different learning analytics indicators for supporting study success. International Journal of Learning Analytics and Artificial Intelligence for Education 2/2, pp. 4-23, 2020.

[Xi19]   Xie, H. et al.: Trends and development in technology-enhanced adaptive/personalized learning: A systematic review of journal publications from 2007 to 2017. Computers & Education 140/19, Article e103599, 2019.