How Learning Outcomes are Measured in Digital Learning Environments in Higher Education

Elke Kümmel, Leibniz-Institut für Wissensmedien, e.kuemmel@iwm-tuebingen.de
Gabriele Irle, Leibniz-Institut für Wissensmedien, g.irle@iwm-tuebingen.de
Johannes Moskaliuk, Leibniz-Institut für Wissensmedien, j.moskaliuk@iwm-tuebingen.de
Joachim Kimmerle, Leibniz-Institut für Wissensmedien, j.kimmerle@iwm-tuebingen.de
Ulrike Cress, Leibniz-Institut für Wissensmedien, u.cress@iwm-tuebingen.de

Abstract: We investigated how learning outcomes are typically measured in empirical studies of digital learning environments in higher education. A database search of articles published in peer-reviewed journals between January 2000 and May 2017 resulted in n = 356 articles whose abstracts we screened for different types of dependent variables. We identified seven categories of learning outcomes: Self-reports, observable behavior, learning skills, elaboration depth, personal initiative, digital activity, and social interaction. We discuss opportunities for future research on the basis of these categories.

Keywords: learning outcomes, digital learning environments, higher education, database search

Digital learning environments

Even though several factors have been identified as being relevant for successful learning in digital learning environments (e.g., Tham & Werner, 2005), it remains largely unclear how digital learning environments improve learning success (Al Zahrani & Laxman, 2016). At least in part, this lack of clarity may be due to the heterogeneous definitions of learning with digital media and the great variety of different measures of learning success. Based on this assumption, we aimed to conduct a detailed review of prototypical approaches that are used for operationalizing learning outcomes in existing research on digital learning environments. Moore, Dickson-Deane, and Galyen (2011) analyzed existing literature to identify how current research defines digital learning environments. Although the authors encountered a lack of consistency in the terminology, they found four core characteristics of digital learning environments: (1) the provision of learning materials independent of time and space, (2) the broad access to learning materials, and (3) the support of educational opportunities (4) even for non-traditional learners. These characteristics are also highly relevant in higher education, resulting in increasing importance of digital learning environments for higher education contexts (e.g., Bientzle, Griewatz, Kimmerle, Küppers, Cress, & Lammerding-Koeppel, 2015). Currently, it is evident that the approaches to measuring learning outcomes in digital learning environments are quite manifold, making it very difficult to recognize potential success factors of digital learning. We therefore set out to identify how previous empirical research studies have measured learning outcomes in digital learning environments in higher education.

Methods

The aim of our study was to describe how previous research has measured learning outcomes in the context of digital media in higher education. We followed the procedure proposed by Cooper (2016) and identified four relevant thematic threads for our search in peer-reviewed journals: (1) digital learning environment, (2) instructional design, (3) higher education, and (4) performance criteria. The first thread of thought ensured that we would maintain a neutral perspective by finding as many studies as possible which dealt with operationalization of digital learning environments independently of theoretical traditions. The second thematic thread focused on the instructional perspective, since we were interested in cognitive processes and properties of digital learning environments that might support learning and instruction. The two remaining threads restricted our search to higher education and learning outcomes in that context. Learning outcomes of students are often referred to as academic performance, so that the fourth thread aimed to identify performance criteria. We searched the database *Web of Science* and limited our results to English language articles of empirical studies published in peer-reviewed journals with a publication date from January 2000 to May 2017. We further limited the results to the top three *Web of Science* research areas (*Education & Educational Research*, *Computer Science*, and *Psychology*) and the 25 most frequently represented journals. This procedure resulted in n = 1492 records. We ranked these journals with respect to their impact factor and included only journals with an impact factor equal to or larger than 0.8. The journal that was the most frequently represented was *Computers & Education*. Our next step was to conduct an abstract screen for the resulting n = 758 articles. We excluded qualitative studies that did not have precise operationalizations of learning outcomes as dependent variables.

Similarly, we excluded samples without students and studies without teacher instructions. We included data from the abstract screening of the remaining articles (n = 356). The features which were relevant to describing learning outcomes were the particular dependent variables of the respective studies.

Results

These data indicated seven categories with respect to digital learning environments. (1) *Self-reports* refer to accounts by learners of their own attitude, satisfaction, or motivation. To evaluate learning outcomes, it is important to know how individual learners assess their learning outcomes based on their experiences and perceptions. (2) *Observable behavior* is the learners' goal-orientated behavior, observed with the goal of evaluating learning outcomes in a more activity-oriented way, such as the evaluation of learners' intention to learn, choice of lectures, and persistence. (3) *Learning skills* refer to metacognition (e.g., time management, reflection, or self-regulation), writing, reading or listening skills, as well as awareness of group processes, workspaces or persons, and even usage of technologies, software or tools. This list of skills is not exhaustive but represents variables of skills in higher education. (4) *Elaboration depth* refers to the amount of mental effort invested, understanding, and comprehension, and cognitive load. This category represents cognitive information processing. (5) *Personal initiative* as a core property of interacting with digital media represents the commitment necessary for learning and learners' impact on social interaction (e.g., participation, attendance, access, and amount of contributions to a discussion). (6) *Digital activity* represents active and adapted use of digital tools (e.g., searching and sourcing). (7) *Social interaction* refers to the influence of the involved learning community on learners' outcomes, for example by providing feedback, and through co-operation or collaboration in group specific tasks (Jeong, Cress, Moskaliuk, & Kimmerle, 2017).

Discussion

Previous research has shown that a broad variety of variables are involved in learning with digital media in higher education. The results of our analysis indicate that the definition of learning outcomes in existing research is correspondingly multifaceted and versatile. Even within the limited context of students in higher education, the terminology for learning outcomes in empirical studies is multifarious and diverse. The data gathered for this research synthesis are preliminary results from screening abstracts. Some abstracts did not provide sufficient information about sample, design, variables, or effects. It would therefore be important to carry out a full-text screening of the empirical studies. This, in turn, could provide detailed descriptions of context, designs of the studies, methods, and statistical analyses to provide a reliable evaluation of learning outcomes with digital media in higher education. We have made a first step by describing measurements of learning outcomes, but no overall conclusion concerning the relationship of these learning outcomes with particular features of digital learning environments could be made and would definitely be required for future research. The process of identifying independent variables that are associated with these learning outcomes would also be a future significant step. Gathering and structuring these data would empower practitioners and scientists to be able to rely on the huge amount of results already in existence.

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