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The Role of Learning Management Systems in School and Classroom Development: An Exploratory Mixed-Methods-Study Among German School Teachers

Abstract

As basic infrastructure of a school, digital learning management systems (LMS) have been used in universities and schools since around the turn of the millennium. However, their usage in schools has rapidly increased in the course of the COVID-19-pandemic, opening the desideratum on the role that these platforms can play in school and classroom development. This study aims at investigating the role of LMS for school and classroom development in information and communication technologies (ICT)-related school contexts from the perspective of German school teachers. The study follows a mixed-methods approach consisting of an exploratory interview study (study 1) and a questionnaire-based survey (study 2). For the qualitative approach we analyzed three rounds of interviews with Berlin teachers (N = 44), using the results to design a questionnaire for the quantitative study (N = 223) on LMS' potentials and challenges. While the qualitative data suggest a broad variety of possible means for school and classroom development, the preliminary quantitative results do not confirm these findings. Still, they point at teachers using LMS for individual and cooperative development among students and teachers and a possible starting point for digital transformation through LMS, while keeping a critical perspective on the topic.

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Keywords
Learning Management Systems (LMS), School and Classroom Development, Mixed Methods, Digital Transformation

Zur Rolle von Lernmanagementsystemen in der Schul- und Unterrichtsentwicklung: Eine explorative Mixed-Methods-Studie unter Lehrkräften in Deutschland

Zusammenfassung
*Digitale Lernmanagementsysteme (LMS) werden etwa seit der Jahrtausendwende an Universitäten und Schulen eingesetzt und gelten als grundlegende technische Infrastruktur. Im Zuge der COVID-19-Pandemie hat die Nutzung von LMS an Schulen rasant zugenommen, was die Frage aufwirft, welche Rolle diese Plattformen für die Schul- und Unterrichtsentwicklung spielen können. Ziel dieses Beitrags ist es daher, diese Frage im Kontext der informationstechnologisch geprägten Schul- und Unterrichtsentwicklung auf Basis von Lehrkräfteperspektiven zu bearbeiten. Die Studie folgt einem Mixed-Methods-Ansatz, bestehend aus einer explorativen Interviewstudie (Studie 1) und einer quantitativen Befragung (Studie 2). Für den qualitativen Ansatz haben wir drei Interviewrunden mit Berliner Lehrkräften (N = 44) ausgewertet und die Ergebnisse zur Entwicklung eines Fragebogens für die quantitative Studie genutzt. Damit wurden Lehrkräfte in Deutschland (N = 223) zu Potenzialen und Herausforderungen von LMS befragt. Während die qualitativen Daten auf vielfältige Maßnahmen zur Schul- und Unterrichtsentwicklung verweisen, bestätigen die vorläufigen quantitativen Ergebnisse diese Erkenntnisse nicht. Sie weisen jedoch darauf hin, dass Lehrkräfte LMS zur individuellen und kooperativen Entwicklung von Schüler*innen und Lehrkräften nutzen und sie – unter Beibehaltung einer kritischen Perspektive – als einen möglichen Ausgangspunkt für schulische digitale Transformation betrachten.*

Schlagworte
Lernmanagementsysteme (LMS), Schul- und Unterrichtsentwicklung, Mixed-Methods, digitale Transformation

1. Introduction

According to the German Standing Conference of the Ministers of Education and Cultural Affairs (KMK), digital learning management systems (LMS) can be considered technical cornerstones for “education in the digital world” (KMK, 2016, p. 40). Due to their significant expansion in recent years (Döbeli Honegger, 2022) through

different providers, there are various forms and functions of LMS, making it harder to define their role in current education. In sum, LMS serve as digital communication platforms supporting processes of teaching and learning by providing and organizing learning material, offering direct and indirect forms of online communication, allowing for data-based diagnostics and assessment as well as personalized and cooperative learning (Brägger & Koch, 2021; Ifenthaler, 2012). Also, a "standard LMS supports an inclusive learning environment for academic progress with interceding structures that promote online collaborative-groupings, professional training, discussions, and communication among other LMS users" (Bradley, 2021, p. 68). While there is a growing interest in research on LMS from various perspectives, the field of school and classroom development remains noticeably underrepresented in these studies. Therefore, the aim of this study is to analyze the possible role of LMS in school and classroom development by presenting first results from an exploratory mixed-method-study in this field, consisting of two consecutive studies: a qualitative (study 1) and a quantitative one (study 2).

First, we will introduce current research on school and classroom development in digital settings, providing theoretical backgrounds and empirical results on the usage of LMS in school contexts. In the following empirical section of this paper, we will first present results from study 1, focusing on the usage of LMS among school teachers as drawn from interviews with teachers in Berlin ($N = 44$) in the years 2020–2022. The subsequent quantitative study 2 will then focus on the instrument developed on the basis of the interview findings as well as on preliminary descriptive results from the survey ($N = 223$). Finally, by relating the qualitative and quantitative data, we will discuss the implications of our results for school and classroom development as well as further research perspectives.

2. Research Overview and Objective

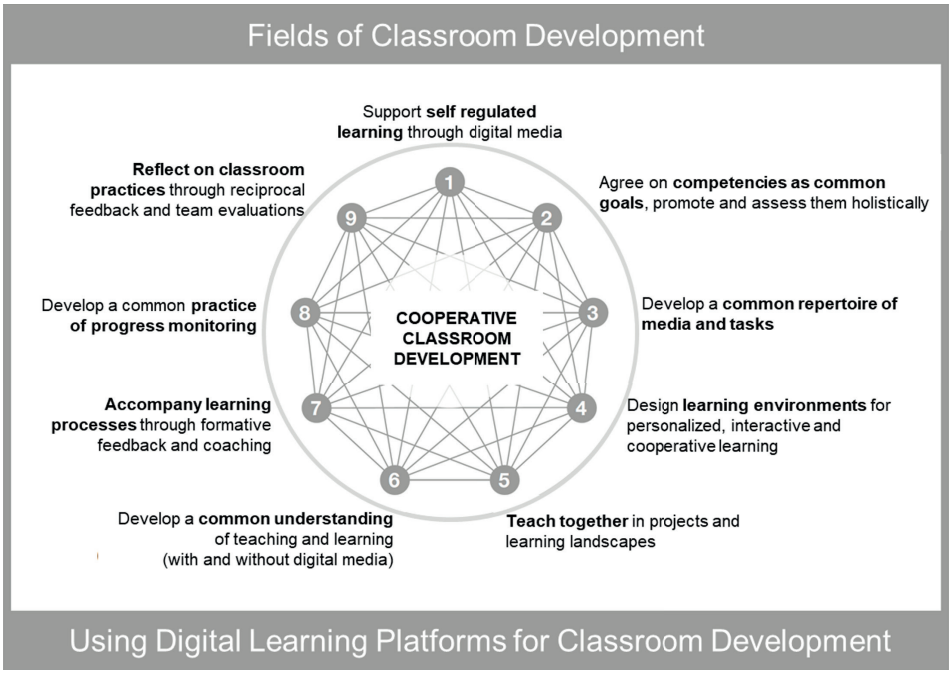
2.1 Theoretical Perspectives: School and Classroom Development in Digital Settings

School development as a major theme in educational research (i. e. Bryk et al., 2010; Fend, 2008) has recently turned towards the role of digitization and datafication (i. e. Gerick et al. 2023; Jarke & Breiter, 2019; Viertel et al., 2022). In discussing the transformational potential of digitization for institutional development, Wessel et al. (2021) created a Process Model of Transformation, dividing digital institutional development into *Digital Transformation* (DT) on the one hand, leading to a new organizational identity, and *IT-enabled Organizational Transformation* (ITOT) on the other hand, leading to a reinforced organizational identity (Wessel et al., 2021, p. 117). Taking this division as a starting point for their analysis of digitization as a permanent task in school development, Viertel et al. (2022) point out the relevance of learning, both of school-related actors as well as of the organization itself. They state that DT-oriented processes of change use digital technologies

to (re)define the fundamental objective and goals of a school, aiming, for example, at new forms of (hybrid) teaching or changed roles for teachers and learners. ITOT, on the other hand, is based on the use of digital technologies – such as whiteboards or tablets – to support existing forms, mostly consolidating the existing orientation and identity of the organization.

In trying to identify the role of LMS in these transformational processes, one important aspect concerns the variety of different platform providers, each stressing different individual features and aiming at different functions for school and classroom activities. As seen from Figure 1, Brägger and Koch (2021) highlight common features in order to illustrate possible areas of LMS use, focusing on cooperative classroom development as a central function of LMS from a theoretical perspective. By stating that LMS have – so far underutilized – great potential to promote teamwork in schools and to develop a transformation in learning culture, they name nine fields of cooperative classroom development through LMS:

Figure 1: *Fields of classroom development by using Digital Learning Platforms (according to Brägger & Koch 2021, translated by the authors).*



2.2 Empirical Research on LMS

There are different areas of interest in research on LMS, illustrating the growing influence on educational practice and research. In line with previous research on teachers' acceptance and intentions in using information and communication tech-

nology (ICT) (for an overview see Scherer & Teo, 2019), Utami et al. (2023) focus on the acceptance toward moodle-based LMS among teachers, finding a satisfying score on teachers' affirmative perspectives concerning the implementation of LMS, especially in facilitating distance learning. Also, in the context of ICT-acceptance, Alturki and Aldraiweesh (2021) focus on university students' perspectives on the application of LMS during the COVID-19-pandemic, finding mostly positive perceptions among the target group. As a third group of actors involved in LMS practices, Bradley (2020) explores parents' beliefs regarding LMS use, focusing on possible benefits in mathematical learning. Findings reveal parents' hopes for their children to become (more) autonomous learners through using LMS, especially highlighting parents' interests in LMS as a means to monitor their children's progress (Bradley, 2021). When examining teachers' perspectives, the 2018 International Computer and Information Literacy Study (ICILS) reveals that, compared to other European countries, German teachers lag far behind in the use of LMS (Drossel et al., 2019). Although this gap was slightly reduced during the COVID-19-pandemic, more than half of surveyed teachers reported never using LMS in their lessons in 2021 (Hardwig & Mußmann, 2021). Thus, it appears necessary that teachers are not only provided with technical resources, but also with support in order to increase their pedagogical use of LMS (Lomos et al., 2023). In terms of processes of (inclusive) school development, Frohn and Bengel (2022) examine teachers' usage of LMS for cooperative purposes, finding that LMS support the exchange of data among teachers, help in cooperatively dividing tasks among teachers and can influence co-constructive processes in school and classroom development. However, results also highlight teachers' concerns about a possible commercialization or recycling of teaching through LMS, potentially leading to even more shortages in schools' personnel as well as potential misuse in the monitoring of learners. Hence, the topic of data (mis)use as a current research field in ICT-related studies (i. e. Bock et al., 2023) also applies to LMS-research, more deeply investigated by Hangartner et al. (2022) on the theoretical basis of Foucault's Panopticon. According to their research, LMS can increase transparency within the team and towards parents, thus intensifying issues of control. By stating that LMS help integrating the previously institutionally demarcated school into an open ecosystem of both commercial and publicly funded education and support services, they identify a form of control through the use of LMS that is more decentered, less linear, more dissociated and more difficult to identify.

Hangartner et al. (2022) also point out that research on the use of learning platforms for classroom organization remains a desideratum. While there have been first empirical results on LMS as a tool for classroom organization (Rubach & Bonanati, 2022) and individualization (Hase et al., 2022), on concrete LMS and their potentials (Brandau, 2024), as well as research on general challenges in LMS-use (albeit mostly in the context of higher education, i. e. Rosário & Dias, 2022), studies on LMS still do not explicitly focus on their possible roles for school and classroom development in the K12-context.

2.3 Research Objective and Design

The main objective of this paper is to investigate the role of LMS for school and classroom development in ICT-related school contexts from the perspective of German school teachers. For this aim and due to the reported lack of current research in this field, we concretely address the following research questions, having formulated hypotheses on possible answers:

Q1: Which areas of school and classroom development can be addressed through the use of LMS from the perspective of German school teachers?

H1: Teachers identify a variety of means for school and classroom development through the use of LMS in accordance with the current theoretical discourse, such as cooperation, differentiation and flexibilization.

Q2: Which challenges and which transformative potential do German school teachers identify in the use of LMS for school and classroom development?

H2: Challenges might include technical difficulties and teachers' attitudes towards ICT use. The transformative potential lies within making school and classroom practices more flexible, pointing at Digital Transformation (DT) rather than IT-enabled Organizational Transformation (ITOT).

In order to test our hypotheses, a mixed-method study was conducted, consisting of two stages: First, we analyzed interviews with Berlin school teachers (study 1) and on this basis developed a questionnaire for a quantitative survey. Using this instrument, we conducted the quantitative study (study 2), also exploring the instruments' factor structure, internal consistency and preliminary results.

It is important to point out the exploratory character of the study, which, despite its limitations addressed below, seems necessary in this field of research: When rapid societal changes call for immediate action, as was the case when the COVID-19-pandemic burst into the field of education in spring 2020, schools need to react spontaneously to the new demands without acting upon scientifically validated recommendations, as there is limited knowledge about how to deal with such new challenges (Huber & Helm, 2020). As a result, new practices are constituted on the fly, since scientific evidence is not yet available while schools have to follow their responsibilities. Explorative designs can help collecting and systematizing these impulses in order to broaden research perspectives, taking practical developments in schools and classrooms as a starting point for further analytical exploration.

3. Study 1 – Qualitative Research Design

3.1 Method and Participants

The qualitative design is part of a longitudinal research project that initially investigated possible pandemic-related consequences on (growing) educational inequalities (Frohn, 2021), educational relationships (Piezunka & Frohn 2022), and questions of differentiated instruction under pandemic conditions (Letzel & Pozas, 2022). As seen from table 1, through the course of the first three years of the COVID-19-pandemic, three rounds of interviews were conducted with Berlin teachers (April 2020: $N = 16$, April–June 2021: $N = 14$, February–May 2022: $N = 14$). The majority of the interviewees work at integrated secondary schools with a high proportion of students from low-income households[2] (in the following L1–L13), the other interviewees teach at particularly high-performing schools with academic track (*Abitur* average better than 2.0, in the following L14–L17). The composition of the sample results from the initial focus on educational inequalities. When reaching out to schools, we asked for experts in teaching and learning as well as teachers participating in school management in order to create a wide perspective on our research objective. When analyzing the data, it quickly became apparent that the topic of LMS was increasingly important for the interviewed teachers. Hence, although questions on LMS were not originally discussed in the first interviews (T1), they were explicitly addressed in the following ones (T2, T3).

Table 1: *Overview of the participants in the qualitative study*

Time of interviews	Number of interviewees L1–L13	Number of interviewees L14–L17
T1: Interviews in April 2020 ($N = 16$)	12 teachers (L1–L12) at 9 schools	4 teachers (L14–L17) at 4 schools
T2: Interviews in April 2021–June 2021 ($N = 14$)	11 teachers (L1II–L13II; without L6, L8) at 8 schools	3 teachers (L14II, L15II, L17II) at 3 schools
T2: interviews in February 2022–May 2022 ($N = 14$)	10 teachers (L1III–L13III; without L6, L8, L9) at 8 schools	4 teachers (L14III–L17III) at 4 schools
total ($N = 44$)	33	11

The semi-structured interviews were conducted via video-call (average 47 minutes), recorded and transcribed anonymously according to Dresing and Pehl (2017). Using the program MAXQDA, the data were analyzed by means of qualitative content analysis according to Kuckartz (2018). Categories concerning the use of LMS were formed inductively due to the study's explorative character. Since the teachers' perspectives from the two groups (L1–13/L14–17) did not differ when speaking about

2 This was evidenced by learners' eligibility for the Berlin Pass "Education and Participation" for more than 75% of the students in these schools, funding students' meals, working materials and educational trips due to low income in families.

LMS, the material was coded as a whole without differentiating between the school tracks.

3.2 Qualitative Analyses: The Development of LMS Use 2020–2022

According to the interviewees, LMS were hardly used during the first survey period shortly after the first school closures in Germany.[3] In some interviews, they were not mentioned at all. When speaking about LMS, the teachers mostly reported a lack of competence when dealing with them: "I have NEVER worked with such a learning platform. And I guess we haven't really explored their potentials yet"[4] (L3, 30, cf. L4, L8, L16). Still, the use of LMS gradually increased, even if the management systems were initially often used among teachers only ("We use it but only among colleagues. And I also can't imagine that it can be handled any other way with our student body", L6, 29). Reasons for this included the lack of perceived user-friendliness (e.g. L4, L8, L4), unclear data security measures, and access difficulties ("The only problem was that it collapsed immediately in the first week", L10, 28).

The data of the second interview round suggest a significant increase in the use of LMS, both in terms of quantity and quality, which was discussed in almost all interviews. Additionally, the data point at an increasingly adept handling of digital LMS by school staff, both for organizational as well as teaching practices. Codes created inductively, for example, concerned "more flexibility in school processes", "simplified documentation", "feedback and support structures", or "cooperative lesson planning": "So I simply prepared something in the [LMS], an exercise, something else. Then the teacher went in, picked out one of my exercises, then imported them into their own [course], it was, of course, quicker that way" (L13II, 30). Also, competence development among students was reported, interpreting LMS as a "huge relief for the students" (L2II, 3) in spring 2021. These competencies concerned, among others, students' autonomy, dealing with digital infrastructures, subject-related learning, and motivation. While the above-mentioned negative aspects with regard to data protection issues or network stability went unchanged, the prospects for a sustainable use of LMS were also discussed in many cases, some of which suggest a fundamental change for schools and teaching: "It's something that we didn't use at all, or hardly at all, a year ago and now it's just the basis. Basically, the LMS has become our school building" (L11II, 27).

In the third interview round that focused more directly on LMS, some spoke of a decline in LMS use with re-entry into regular face-to-face teaching ("It currently feels like 2018 or before", L14III, 41, cf. L3III, L16III), which was attributed both to

3 For more detailed information on the qualitative study see Frohn, 2021.

4 The interview data used in this article was translated by the authors in a peer-translation process; parts of these teachers' statements and findings concerning the chronological development were also published in Frohn & Bengel, 2022.

still inadequate technical infrastructures and to declining motivation. In contrast, others pointed out LMS' potential for school and classroom transformation, mostly focusing on questions of making traditional classroom practices more flexible:

> As a school, we now have a [day of self-organized learning] once a month [...] – so that the pupils are given tasks to do at home, so to speak. [...] But they're not left completely alone, they have a check-in in the morning and a check-out at the end of the day, and in between the respective subject teachers, who have the lessons that day, also have checkpoints with them, so to speak, right? (L12III, 8)

In sum, there was a great variety of attitudes, uses and applications of LMS, which not only differed between the respective teachers but also among individual teachers over the years. This variety led to the development of a questionnaire.

4. Study 2 – Scale Development and Quantitative Research Design

In order to in investigate these first exploratory results further, the aim of study 2 was to create a scale for researching LMS' potential for school and classroom development and to conduct a quantitative survey among a broader sample.

4.1 Scale Development

In developing the scale, we relied on the codebook created in the course of the qualitative content analysis of study 1 (for codebook creation see Miles et al., 2014). The codebook, initially "used as a guide to help analyze interview data" (DeCuir-Gunby et al., 2011, p. 138), included exemplary interview quotes illustrating themes, concepts, and patterns on school and classroom development that emerged from the data from study 1. These and other interview passages on the topic were successively collected and transformed into items (table 2), each item being formulated and double-checked among four independent researches[5]. The respective fields of investigation (school development, classroom development, student development) were then formed as main topics including the items.

A total of 36 items were identified and transformed into questionnaire items with a 4-point Likert scale (1 = *strongly disagree* to 4 = *strongly agree*).[6] Before piloting the questionnaire developed from the qualitative material, debriefing sessions among three researchers were initiated, allowing for final adjustments to the tool by discussing possible interpretations of the individual items (Ricci et al., 2018, p. 151).

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5 We want to thank Johanna Lau and Josefine Hundt for their contribution to this project.
6 A detailed overview of the raw items and the respective exemplary interview quotes in English and German will be provided upon request.

Table 2: *Exemplary interview data and item development*

Exemplary Interview Data	Item
School development	Using LMS ...
"We mostly used it when the kids were at home to document the correspondence – for us and also for our colleagues. [...]: Corona test obligation, for example. Corona test obligation means that you can't be absent without a certificate." (L11III,18)	*... enables processes of documentation.*
"Off the top of my head, I thought of something that doesn't have anything to do with the student body, but I think that you could organize a lot of conferences online, which you would otherwise have to do with your colleagues (laughs) at school. Um, that saves a lot of time and work." (L14II, 56)	*... can replace face-to-face events among the teaching staff.*
Classroom Development	Using LMS ...
"That students can choose for themselves how to implement this or that, like choosing an auditory approach or a haptic one, yes. That is certainly possible online or now via such learning management systems." (L16III, 39)	*... allows for a more extensive differentiation in the daily teaching routine.*
"Homework. I only have it handed in through there [the LMS]. I have a big list in the cloud, I can see right away who has it and who doesn't have it. That effectively saves me time in class, where I would otherwise be standing there looking at who has it and who doesn't have it." (L17II, 146)	*... increases the actual teaching time.*
Student Development (Note: The following quotes were directly related to LMS-use, although the actual mentioning of LMS took place at another time in the interview).	Using LMS can support student development ...
"But overall it is a lot easier than in the first lockdown because they know where to find their tasks, they know the structure [...] and I think they have also become a bit more independent in working on tasks." (L10II, 6)	*... in their autonomous learning.*
"Well, the pupils are a bit fitter, no, they have definitely become fitter when it comes to the use of digital media." (L3II, 6)	*... in dealing with digital media.*

4.2 Sample and Procedure

Using social media and contacting schools directly via e-mail, we invited teachers across Germany to participate in the study through a hyperlink to the questionnaire on LimeSurvey. A total of 223 teachers (62% female, 37% male and 1% diverse) working in different school tracks participated[7]: schools with an academic track (30%), comprehensive school (22%), schools with different courses of education without an academic track (SMB) (12%), general secondary school (2%), primary school (23%), special education school (5%), vocational training school (9%) and other (3%). The teachers were between 21 and 66 years old ($M = 47.46$, $SD = 9.97$) and had between 1 and 43 years of teaching experience ($M = 17.10$, $SD = 11.26$).

7 Teachers could select more than 1 school track.

4.3 Quantitative Analyses

The suitability of the data for an exploratory factor analysis (EFA) was revised by conducting the Kaiser-Meyer-Olkin (KMO) and the Bartlett's test of sphericity (Pallant, 2010). The decision on the number of factors to be extracted followed the Kaiser-Guttman rule, which determines that all factors with eigenvalues greater than 1.0 on visual inspection of the scree-plot can be retained (Osborne & Costello, 2009) and based on the interpretability and the fit of the scales into the theoretical framework. Tabachnick and Fidell (2007) argue that in practice, orthogonal and oblique rotation approaches often result in very similar results, so an orthogonal approach using varimax rotation was performed (Pallant, 2010). Lastly, factors with a minimum of three items and items with a sufficiently high loading of more than 0.30 were retained (Osborne & Costello, 2009).

4.4 Results

A total of 36 items qualitatively derived from the interviews in study 1 were subjected to an initial EFA using a varimax rotation. The KMO value was .73, exceeding the recommended 0.6 (Tabachnick & Fidell, 2007), and Bartlett's test of sphericity reached statistical significance ($\chi 2$ (630) = 1617.41, $p < .001$), indicating that there was sufficient communality in the manifest variables (Pallant, 2010). The scree-plot showed inflexions that would justify retaining three factors (Field, 2013). When exploring the communalities for the variables within the data, however, multiple items had very low correlations (< .30) and thus were selected for potential deletion from the tentative scale (Boateng et al., 2018). In successive steps of analysis, items with low correlations (< .30) and without a substantial primary loading (> .30) were excluded from the analysis.[8] This process ended with a final model of three factors with 27 items explaining 41% of variance. This model resulted in a methodically clean solution with a simpler factor structure (table 3). The factors were labelled accordingly: factor 1 as School and Classroom Development, factor 2 as Individual and Cooperative Development through LMS, and factor 3 as Challenges in using LMS. The internal consistency (McDonald's Omega) was good for the subscales of School and Classroom Development ($\omega = .84$) and Individual and Cooperative Development through LMS ($\omega = .82$), and – although lower than desired – acceptable for Challenges in using LMS ($\omega = .65$) (Dunn et al., 2014; Hayes & Coutts, 2020; McNeish, 2018). The convergent validity of the subscales was calculated using the average variance extracted (AVE) (Cheung et al., 2023). The AVEs for each

8 The following items were deleted in the process: Using LMS ... "... is not important at our school", "... is positively received by the teaching staff", "... makes it easier for parents to gain insights into everyday classroom life", "... is difficult for colleagues to implement", "... increases the administrative effort", "... can replace face-to-face events among the teaching staff", "... requires extensive qualification measures", "... makes updating working materials and/or content impossible", "... allows for a more extensive differentiation in the daily teaching routine".

of the subscales are: a) School and Classroom Development .38, b) Individual and Cooperative Development .41 and c) Challenges in using LMS .31. The AVEs for all three subscales are lower than the rule of thumb of 0.50 to be acceptable (Hair et al., 2022), thus the subscales do not exhibit convergent validity. Table 4 shows the means and standard deviation for each of the three subscales.

Table 3: *EFA results and descriptive statistics for each item*

Item	*M*	*SD*	Item Loadings		
			F1	F2	F3
(F1) School and Classroom Development: "Using LMS ..."					
... provides support structures.	2.46	.93	**.74**		
... is an important tool for the development of hybrid formats.	2.34	.99	**.72**		
... can make teaching and learning more flexible.	2.46	.91	**.71**		
... allows for better coordination and control of processes in school and teaching.	2.34	1.00	**.67**	-.15	.11
... increases the sustainability of teaching materials.	2.41	1.00	**.65**	.14	.18
... leads to more flexibility in school processes.	2.38	.92	**.63**		.17
... is helpful due to automated tests and corrections in LMS.	1.98	.87	**.59**	.20	
... simplifies processes of documentation.	2.37	1.00	**.58**		.29
... can easily be implemented thanks to the technical equipment of our school.	2.30	.93	**.56**	.12	.21
... is the new basis of teaching and learning.	2.22	.88	**.41**	.22	.40
... makes communication with parents easier.	2.00	.99	**.39**		.23
(F2) Individual and Cooperative Development through LMS					
LMS can support students in structuring and organizing learning processes.	2.86	.74	.12	**.84**	
LMS can support students in self-regulated content learning.	2.89	.76		**.78**	.20
LMS can support students in developing autonomy.	2.94	.80		**.77**	.10
LMS can support students in dealing with digital infrastructure.	3.17	.68	.13	**.66**	
LMS can support students in their motivation to learn.	2.75	.80		**.62**	.14
LMS can support students in dealing with overwhelming situations.	2.23	.81		**.56**	

Item	*M*	*SD*	Item Loadings		
			F1	F2	F3
Using LMS is fun and motivating.[a]	3.16	.69		**-.52**	.16
Using LMS makes cooperative lesson preparation among several teachers easier.[a]	3.09	.72		**-.43**	.21
Using LMS makes the exchange between colleagues easier.[a]	3.48	.67		**-.37**	
(F3) Challenges in using LMS: „Using LMS …“					
… leads to an additional workload in lesson planning.	2.29	.85			**.67**
… requires a reorganization of teaching-learning environments in digital settings.	2.14	1.05	.22	-.12	**.64**
… has no added value for teaching without the integration of other digital teaching-learning environments (apps, …).	2.16	.79	.13		**.61**
… makes new social forms impossible.	2.08	.78	.16		**.55**
… requires close, joint planning and implementation.	2.17	.82	.16		**.51**
… is always school-specific, as the individual developments cannot be transferred to other schools.	2.27	.90	.28	.11	**.44**
… increases the actual teaching time.	2.99	.78		.22	**.41**

Note. [a]The items were recoded from an originally negative formulation. Grey item loadings refer to cross loadings.

Table 4: *Means and standard deviations*

Subscale	*M*	*SD*
(F1) School and Classroom Development	2.31	.58
(F2) Individual and Cooperative Development through LMS	2.99	.50
(F3) Challenges in using LMS	2.18	.51

5. Discussion

5.1 Areas of School and Classroom Development that can be Addressed Through the Use of LMS

In study 1, the analysis of three interview rounds with Berlin teachers in the years 2020–2022 introduced various fields of school and classroom development. Having formed the categories inductively and without prior knowledge of an existing theoretical frame, the generated codebook shows great correspondences to the theoretical framework introduced by Brägger and Koch (2021, fig. 1), although aspects

of developing a common understanding of teaching and learning with digital media were not mentioned by the interviewees.[9] Still, the qualitative data allows for insights into self-regulated learning as well as competence development, offering a more detailed examination of different fields of competence. The codebook also includes categories on commonly reflecting upon classroom activities (in this case focused on lesson preparation), creating flexible classroom formats, supporting learning processes, developing feedback practices and aiming at a sustainable repertoire of materials. Most importantly, the interview data contains lots of material on teacher cooperation, which – according to Brägger and Koch (2021) – is a central theme in fields of classroom development through LMS (see also Frohn & Bengel, 2022). Additionally, the qualitative data hints at lots of potential of LMS for individual and cooperative development for both students and teachers. In sum, study 1 produced results corresponding to our hypothesis that various fields of school and classroom development according to the current theoretical discourse, as illustrated in Fig. 1, as well as personal development, can be addressed through the use of LMS.

While study 1 introduced a variety of positive aspects possibly arising from using LMS for school and classroom development, study 2 has revealed – partially significantly – negative teacher perspectives on the developmental potential of LMS. Against our expectations, the mean values in the subscale "School and Classroom Development" (F1) all scored below the theoretical mean value of 2.5, with the comparatively low means in items concerning automated feedback and processes of documentation being especially surprising. However, the teachers also confirmed the potential on individual and cooperative development (F2) through LMS, highly agreeing on LMS supporting students in structuring and organizing learning processes, in self-regulated content learning, in developing autonomy and mostly in dealing with digital infrastructure. Additionally, the surveyed teachers recognize LMS as being fun and motivating. This could be one of the reasons why they attribute a high potential to LMS for cooperation among teachers, also with regard to cooperative lesson preparation. However, it is important to highlight the exploratory nature of the present study. Consequently, the issue of validity surrounding the instrument developed and implemented is still lacking and urgently needs to be explored. Considering that validity is a fundamental assessment aiming to ensure "*the soundness of inferences*" (LeBaron Wallace, 2011, p. 234), further analyses concerning the validity of the instrument are necessary and highly relevant.

9 Brägger and Koch's figure also includes "create personalized, interactive and cooperative learning environments"; this aim fits the item "(Using LMS ...) allows for a more extensive differentiation in the daily teaching routine", which was deleted due to forming a simpler factor structure.

5.2 Challenges and Transformative Potential in the Use of LMS for School and Classroom Development

As expected, the interview data from study 1 testifies to various technical difficulties in implementing LMS in daily classroom practices, concerning hardware, software, internet access and data volume. Interestingly, study 2 did not quite confirm the expected challenges when implementing LMS from teachers' perspectives, as they did not report on LMS as overly challenging (F3). Neither does using LMS seem to lead to an additional work load in lesson planning, nor does it appear to require close, joint planning and implementation.

In discussing the results concerning LMS' transformative potential with reference to the Process Model of Transformation by Wessel et al. (2021) introduced in the theoretical section of this paper, it seems that the interview data from study 1 point at potential for actual Digital Transformation (DT) in the use of LMS: Almost half of the interviewees reported on experimenting with old school structures by exploring hybrid formats for certain classes or on certain days of the school, opening possibilities for more flexible teaching and learning, also allowing for more differentiation in classroom practices and personalized learning – all on the basis of using LMS for school and classroom development. However, the results from study 2 again do not match our hypothesis, since the teachers did not seem to agree to potentials for transformability or flexibilization through LMS use. Instead, the quantitative data suggest LMS rather contributing to IT-enabled Organizational Transformation (ITOT) instead of DT. This echoes Rossiter's (2006) broad distinction of *networked organizations* (retaining their basic structures and modes of operation) and *organized networks* (forms of organization modelled and based on the affordances of technological media). In opposing to LMS as a means of school and classroom development, the surveyed teachers in study 2 underline the inertia of schools as an organization and mostly consolidate existing forms of teaching and learning by addressing LMS rather as an add-on to traditional formats.

5.3 Conclusions from the Comparison of the Two Studies

Reasons for the differing results in study 1 and 2 could lie within the comparatively small and special sample in study 1, in which experts in teaching and learning were directly addressed. Hence, these teachers could be more motivated and competent in using LMS, therefore also being more positive about possibilities of school and classroom development through LMS than the broader sample of German school teachers from study 2. By demonstrating a rather reluctant perspective on LMS' developmental possibilities, it seems that the surveyed teachers from study 2 do not quite share the currently rampant technological solutionism (Morozov, 2014). This could be explained through teachers' attitudes on ICT in general and LMS in particular or through an informed skepticism in the face of possible downsides – surveillance, incapacitation – of LMS use, hinting at a reflexive engagement with these

platforms, including an awareness of much-discussed consequences on the modulation and commercial exploitation of group behavior (Zuboff, 2019). Additionally, the platforms might just not be as potent for school and classroom development as current discourses promise them to be. However, both the data in study 1 and 2 suggest that teachers see potential of LMS for individual and cooperative development of school actors. Since Viertel at al. (2022) state the development of school actors as a central prerequisite for DT, this could also imply that teachers perceive a possible transformation of school and teaching as a successive process, taking the first step towards DT through individual and cooperative development while maintaining a necessarily critical perspective on an increased ICT-development and dependency. In this sense, the aspect of cooperative development, as emerged from study 1 as well as study 2, seems promising for a thorough DT in the context of school and classroom development – in particular, when not only taking place in individual schools but across schools. As Brandau (2024) shows, LMS can be implemented with features shared among schools in a whole state, allowing for cross-school expert exchanges while still critically reflecting which ideas on school and development a school might "import" by integrating existing LMS-structures into one's school.

6. Limitations

Possible limitations in the qualitative study could arise from distortions due to the teachers' statuses as experts in teaching and learning as well as the comparatively low number of teachers interviewed. Hence, these insights might only represent the perspective of the participating teachers, which also applies to study 2. In this sense, external and internal validity of the instrument should be explored within other teacher samples. Furthermore, it is necessary to first validate the psychometric properties of the questionnaire by means of confirmatory factor analysis as well as explore differences across teacher groups (such as amongst the different school tracks and gender) by conducting measurement invariance analyses. Another limitation lies within the manifold connotation of LMS that were – aside from a brief introduction – neither specified in the interviews nor the questionnaire. Hence, participants might have had different understandings of LMS' forms and functions, possibly influencing the teachers' views on LMS' potentials.

Important to consider is that the study is built on teachers' self-reports; such responses can be sensitive to overestimation, underestimation, or social desirability. However, previous studies have found that teachers' self-reports of their teaching practices are highly correlated to classroom observations (Desimone et al., 2010) and have a pattern of correspondence with students and/or external observers (Tetzlaff et al., 2022). Nevertheless, future research should also seek to use students' self-reports and incorporate other forms of data collection procedure such as classroom observations. Lastly, the internal consistency (McDonald's Omega) of F3

Challenges in using LMS, although acceptable, was lower than the other two factors. A potential explanation to the lower McDonald's Omega could possibly be due to the fact that there are multiple different LMS platforms, each with varying individual characteristics that inherently have diverse functions for classroom activities. Thus, teachers could potentially experience (and interpret) contrasting challenges when using LMS, which could result in inconsistent responses. Additionally, the subscales did not exhibit convergent validity. Thus, in order to fully identify the probable reason for the resulting low internal consistency and lack of convergent validity, it is therefore necessary to conduct further research with other teacher samples not only focusing on a quantitative level (the instrument itself) but their own personal experiences with different LMS platforms.

7. Summary and Outlook

This study researched teachers' perspectives on the – possibly transformative – potentials of LMS for school and classroom development. The design included a qualitative (study 1) and a subsequent quantitative approach (study 2). In accordance with our hypotheses, the data from study 1 point at various fields of school and classroom development that can be addressed through the use of LMS, and also to a number of challenges and transformative potentials in school and classroom development. On the basis of the categories from study 1's codebook, a questionnaire on the topic consisting of three subscales was developed. The instrument shows acceptable to good internal consistencies and represents current research themes on LMS use for classroom development. While the descriptive results from study 2 do not mirror the findings from the exploratory qualitative analysis from study 1, they still point at the perceived potentials of LMS for individual and cooperative development for students and teachers.

For further research, we need to investigate more closely on individual reasons for diverging perspectives. Here, our current analysis of open items from the instrument ("I use LMS for the following activities", "The use of digital learning management systems fails at our school due to …", "Please give examples of open teaching formats through LMS use") might offer more detailed explanations for or against using LMS in class, also allowing for a more thorough analysis of LMS' potential role in the digital transformation of schools. This way, the underrepresented aspects of developing a common understanding of teaching and learning with digital media in the classroom could also be investigated further (see Frohn, Lau & Pozas, under review).

This seems especially promising with regard to inclusive teaching and learning, since teacher cooperation – as identified as a major field of LMS use through this study – is a distinctive characteristic of an inclusive classroom (Neumann, 2019). Hence, analyzing the items on differentiated instruction (Pozas & Schneider, 2019)

that the scale introduced in this study also includes, might shed light on inclusive classroom practices through LMS use.

Finally, there is an urgent need for deeper insights into LMS-related critical data studies (What happens to the data? What kind of assumptions determine how they are gathered, parsed and used? How do datafied mechanisms then reproduce and stabilize such assumptions?) as well as digital platform studies (Who owns the data? What is the business model behind these platforms?), in order to locate this study's findings within the critical discourse on the datafication of education (Bock et al., 2023). In addition, these questions must be addressed with regard to potentials and pitfalls of adding Artificial Intelligence (AI) to the recent state of LMS. As first studies show, functions such as chat bots, adaptive tasks or automated learning recommendations can increase LMS' functionalities for learning – while also sparking the fear of e-learning systems replacing face-to-face-teaching in the long run (Altun et al., 2022). Ongoing research in this field will help understanding these processes, leading to (more) informed decisions on why and how to use LMS for school and classroom development.

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