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Digital Maturity in Education

The Implementation of Digital Tablets

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Abstract
As educational institutions navigate the complexities of digital transformation, understanding the factors that drive successful technology integration is essential. The implementation of digital tablets in schools is becoming increasingly common. Through the application of the digital maturity framework, a Structural Equation Modeling (SEM) analysis was conducted to construct a digital maturity model for the implementation of digital tablets. The results identified how different factors (i.e. technical support, competence, leadership, and organizational conditions) influence digital learning resources and goal facilitation. The study also considered demographic variables, such as age and gender, revealing nuanced technology adoption and use patterns. The analysis highlighted the significance of factors such as competence and organizational conditions. Furthermore, an interesting finding was that leadership did not have a significant effect on the implementation of tablets. These findings challenge preconceived notions about the centrality of leadership in digital integration, and suggest the need for a reevaluation of the roles and support mechanisms that facilitate the advancement of digital learning environments.

Keywords
implementation, digital tablets, digital maturity, education

Background

The increased digitalization of society has had a profound effect, even on the educational system (Otterborn et al., 2019; OECD, 2021). As a result, schools emphasize technology in learning contexts (Javorský & Horváth, 2014). Accordingly, the availability of technology, such as digital tablets (e.g., Apple iPad, Amazon Fire, OnePlus, Samsung Galaxy Tab, etc.), in schools has increased substantially (Otterborn et al., 2019. These devices have become a prominent part of pedagogical practice in schools, which has both benefited and challenged teachers and students (McEwen & Dube, 2015; Otterborn et al., 2019). However, the availability of digital tools does not guarantee good learning outcomes (Spiezia, 2010; Swedish National Agency for Education, 2015). Indeed, there are several factors involved in successful implementation of innovations, rather than merely giving someone access (Damschroder et al., 2009; Fixsen et al., 2013; Rogers, 2002). Consequently, implementation of science in education has accumulated increased attention over the last 10-15 years (Hooley et al., 2019).

The development of frameworks focusing on implementation has increased with the growing emphasis on implementation science. Thus, to date, there are several implementation frameworks (i.e., the Active Implementation Framework [AIF: Fixsen et al., 2005; Fixsen & Blase, 2007], the Consolidated Framework for Implementation Research [CFIR: Damschroder et al., 2009], and the Leadership and Organizational Change for Implementation [LOCI: Aarons et al., 2015]). Most frameworks aim to describe and/or guide the process of translating research into practice, explain what influences implementation outcomes, and evaluate implementation (Nilsen, 2015). Moreover, due to the rapid and extensive digitalization in society, implementation scientists have started directing their interest towards theories, models, and frameworks aimed at facilitating the implementation of technology, specifically. For example, the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), the Technology Acceptance Model (Davis, 1986), and the Technology-Organization Environment Framework (Tornatzky & Fleischer, 1990).

Digital maturity

Since the 1997 Norwegian Curriculum Reform (L-97), there has been considerable emphasis on teachers' digital skills (Fernández-Batanero et al., 2022) and commitment to technology in education (Det kongelige kirke- utdannings- og forskningsdepartementet [UFD], 1997). However, despite the individual capabilities developed over time, a broader organizational context also needs to be considered. As Kane et al. (2016) indicated, organizational conditions, particularly an organization's stance on risk-taking, can be a decisive factor in the successful implementation of digital initiatives. Thus, while teachers may be well prepared to navigate digital challenges, the institutional framework and cultural climate must also support and sustain digital maturity (Egeberg et al., 2016). Hence, digital maturity has received increased attention (Egeberg et al., 2016; Kane et al., 2017). Digital maturity can be described as "how organizations systematically prepare to adapt consistently to ongoing digital change" (Kane et al., 2017, p. 5). This is in line with the psychological definition of maturity, which encompasses the capacity of an individual or entity to adeptly adjust and respond appropriately to its environment (Kane et al., 2017). Thus, digital maturity could be better conceptualized as a dynamic process rather than a static attainment (Bennett & Blome, 2013).

The concept of digital maturity has become more significant within the modern educational system due to the cumulative importance of technology. In educational settings, digital maturity serves as a premise for the strategic use of information and communication technologies (ICT) to improve educational outcomes (Sergis & Sampson, 2014). Improving e-readiness among schools is crucial to successfully implementing ICT. This entails preparing the schools to effectively utilize digital and technological tools and devices (Egeberg et al., 2016). Major barriers to e-readiness include poor infrastructure, unreliable connectivity, lack of leadership and visionary direction of school administrators, insufficient ICT skills among educators, and limited access to ICTs (Ottestad, 2013). However, digitally mature schools operate in a supportive environment with adequate resources (i.e., financial provisions, technical support, and ICT equipment). Due to the complex dynamic processes involved in achieving and maintaining digital maturity, a growing number of models and frameworks have been developed that specifically focus on the operationalization of this process when implementing technology, such as the Self-Review Framework (SFR: The National Association for Education Technology [NAACE], 2014).

The SFR was developed to measure digital maturity and included six core elements: 1) leadership and management, 2) use of ICT in the curriculum, 3) teaching and learning, 4) assessment of digital capability, 5) professional development, and 6) resources (NAACE, 2014). The aim was to facilitate school improvement by promoting reflective practices. It enabled schools to assess and enhance their provisions based on a thoroughly researched and supported set of standards. Furthermore, it aimed to ensure that students gained digital literacy skills, enabling them to effectively utilize and express their thoughts while developing ideas through ICT (NAACE, 2014).

The national survey of the digital state of affairs in Norway, Monitor(Egeberg et al., 2016), confirmed a revised digital maturity model based on the SFR using Structural Equation Modelling (SEM). This resulted in a five-factor model that included: 1) the school leaders work with digital competence, 2) priorities and quality related to equipment, 3) organizational conditions, 4) management, and 5) planning. There were clear differences in digital maturity among schools, and schools with high maturity scores were generally better equipped to successfully implement technology (Ekeberg et al., 2016).

Implementation of Digital Tablets in Norway

Digital tablets were implemented in primary and secondary schools in three municipalities in collaboration with the University of South-Eastern Norway. The municipalities started their implementation process in Kongsberg, (2014), Larvik, (2016), and Notodden, (2018), respectively (the 1:1 iPad-Project: Wølner et al., 2019; Egeberg et al., 2020; Egeberg et al., 2021). Their goal was to increase pupils' digital competence and general learning outcomes. Furthermore, as put forward in this article, when implementing digital tools, it is important to evaluate the level of digital maturity. Thus, the aim of this study was to investigate the effects of digital maturity on the implementation of digital tablets.

Methods

All teachers (K1-K10) from the 1:1 iPad-Project within the three municipalities were invited to complete a 119-item survey about the implementation of tablets, in this case iPads, in classrooms (Wølner et al., 2019; Egeberg et al., 2020; Egeberg et al., 2021). The survey was developed by an expert panel of researchers within the field of professional digital literacy. The aim was to investigate teachers' attitudes toward digital technologies, and even their experiences with technological driven changes. After thorough discussions based on theoretical insights and practical knowledge a survey covering 10 topics was developed: 1) background variables, 2) self-efficacy, 3) deep learning, 4) adaptive learning, 5) digital learning resources (DLR), 6) classroom management, 7) school leadership and strategies, 8) school ownership, 9) digital classroom practices, and 10) technological support. For the present study the 40 items relevant to digital maturity were included in the analysis.

Data collection was conducted in September 2018, 2019, and 2020. The data used in this study were taken from the 2020 survey, where 46 schools and 805 teachers (female = 78.3%) participated. Missing data for all items were very low (maximum 3.2%), and thus inconsequential to the analysis. Most variables were measured on a 5-point or 7-point Likert scale, except for six items (i.e., items measuring the use of tablets as DLR), which were measured on a 3-point Likert scale.

Analysis

The analysis was built upon three constructs: digital maturity (27 items), goal facilitation (7 items), and tablets as DLR (6 items). However, digital maturity was considered the main construct. Leadership included items measuring strategic leadership, planning and leadership support as perceived by the teachers, whether the organization fostered innovation and development, and whether there was a cooperative climate at the school.

Two outcome constructs were included, both of which covered teachers' classroom practices. The first construct measured teachers' use of tablets in goal facilitation and measured teachers' self-reported use of tablets to help pupils reach goals by, for example, giving criteria for goal achievement and facilitating productive feedback. The second construct measures teachers' use of tablets as DLR, covering how teachers used tablets to enhance pupils' recollection, understanding, and performance, to achieve adaptive teaching.

SEM analyses were conducted using Mplus v. 7.4 for Mac. The model estimator was robust maximum likelihood (MLR). Base models were tested using confirmatory factor analysis (CFA). As a preliminary step each construct was independently tested to assess model fit before being analyzed with complex models that involved multiple constructs and effects. This approach was useful because it allowed for model re-specification in cases where model fit was not acceptable, which is in line with Marsh et al. (2004), who suggested investigating different models before drawing conclusions. Thus, if the suggested model's structure was not supported by the data, alternative theoretical models were tested.

The models were assessed by inspecting descriptive statistics and model fit indices. Brown (2015) advised for caution when assessing fit indices, as several factors influence model fit (e.g., sample size, distribution, model type and specification, and choice of estimator). Thus, Brown (2015) suggested that the chi-square test for absolute fit should be non-significant and the $\chi 2$ -value equal to or below its critical value. A non-significant $\chi 2$ -value indicated a perfect fit of the model to the covariance matrix. However, the assumption of $S = \Sigma$ is a stringent demand, and there are several reasons why the chi-square test can fail. Therefore, models could be interpretable, even if the chi-square test is significant (Brown, 2015). For this study, the following indices were used with their guiding cut-offs: SRMR <= .08, RMSEA <= .06, TLI => .95, and CFI => .95. Standardized indicator loadings should be substantial, preferably over .4 (Brown, 2015). In models comprising multiple latent factors, multicollinearity might be an issue for large inter-factor correlations, and in such cases, further investigations of the model should be made.

Model modification indices (M.I.) were used to improve the model fit. Each model was revised and tested to see if there was a high M.I. value for an indicator to load on an alternative factor, or if the M.I. value indicates shared error variance. Alternative models must be logically reasonable and consistent with the theoretical assumptions guiding the model (Brown, 2015). Furthermore, if error terms are correlated for a pair of indicators, for instance, due to similar wording, then error terms of similar indicators should also be correlated. All parameters were given at the .05 significance level.

Results

Table 1 gives descriptive statistics and reliability estimates (coefficient alpha) for items measuring the two outcome constructs: tablets as DLR and goal facilitation. Furthermore, it provides descriptive statistics for the four factors measuring digital maturity: organization, leadership, technical support, and teacher competence.

Table 1 Descriptive Statistics and Reliability

Construct	Ind.	N	Min	Max	Mean	Std. Dev.	α
Tablets as DLR	6	799	0	15	12.42	2.16	.75
Goal facilitation	7	799	0	28	21.12	3.75	.74
DM – Organization	8	799	0	52	33.50	7.02	.87
DM – Leadership	11	801	0	70	39.34	12.80	.94
DM – Support	3	798	0	18	10.59	4.35	.80
DM – Competence	5	801	0	28	20.32	4.54	.85

Note. Overview of the constructs, including number of indicators, N, minimum and maximum values, mean score, standard deviation, and Cronbach's alpha. DM = digital maturity.

Table 1 shows teachers largely used tablets in various ways as learning resources (mean of 12.42 out of a maximum of 15), and they used tablets to facilitate goal achievement for pupils (mean of 21.12 out of a maximum of 28). Furthermore, the low standard deviation points to the fact that most teachers' responses were close to the mean. Table 1 presents the reliability estimates ranging from acceptable to excellent (α =.75–.94).

When inspecting the factors of digital maturity, it was interesting to note that the mean scores for three of the factors (i.e., organization, leadership, and support) were lower, and their standard deviation was generally larger. In particular, the factor measuring perceived technical support had a low score and a fairly high standard deviation, indicating a lower perception of technical support in general and considerable variation among teachers. The results from the SEM analyses are provided in Table 2.

Table 2 Model Fit of Latent Constructs

Model	χ^2 (df)	RMSEA		CFI	TLI	SRMR	Ind. load.	IFC
		RMSEA, [95% C.I.]	Prob. Cl. Fit (<.05)					
M1a	1745.24 (389), p<.01	.066 [.063-.067]	1.00	.89	.88	.077	.50-.87	.15-.93
M1b	960.23 (388), p<.01	.043 [.039-.046]	1.00	.95	.95	.047	.59-.96	.13-.64
M2	7.30 (6), p=.23	.02 [.00-.051]	.94	1.00	1.00	.014	.40-.77	
M3	31.47 (10), p<.01	.05 [.03-.07]	.41	.98	.95	.03	.26-.68	
M4	1694.539 (891), p<.01	.033 [.031-.036]	1.00	.95	.95	.05		

Note. SEM results of base models of digital maturity (M1a (5 factors) and M1b (4 factors)), iPad as DLR (M2), Goal facilitation (M3) and path model (M4).

The five-factor CFA model of digital maturity derived from Monitor (Egeberg et al., 2016) generally produces near-acceptable model fit statistics (M1a: Table 2). Thus, it could probably be modified to achieve acceptable results. However, there was a high and significant inter-factor correlation between "leadership" and "plans" (r = .93, p < .01), making multicollinearity a concern. Certain modelling alternatives can counter multicollinearity issues, for instance, using a two-level factor analysis (Brown, 2015). However, a two-level analysis would challenge the theoretical model. Furthermore, even when this approach was tested, the model did not improve substantially, and the interfactor correlation concern remained.

Therefore, the model was rejected. Next, the model was revised as a four-factor model, in which the factor measuring planning was combined with the leadership factor (M1b). The model fit was acceptable, solving the issue of multicollinearity, and was therefore used for further analyses. Model 2 was a one-factor model in which six indicators measured teachers' use of tablets as DLR. This model had a good fit and an acceptable χ^2-test. Model 3 was a one-factor model with seven indicators measuring teachers' use of technology to help students reach their goals. Despite a significant χ^2-test, other fit indices (e.g., RMSEA, CFI, TLI) indicated acceptable model fit. Model 4 was based on models M1b, M2, and M3. Here, M1b was regressed onto M2 and M3 to assess the impact of digital maturity on teachers' practices, specifically regarding their use of tablets as DLR and their use of technology for helping students reach their goals. The model produced an acceptable model fit; however, the χ^2-test failed. Some modifications were made to the models, which included correcting erroneous terms to improve fit.

Figure 1 shows the path model (M4) for the digital maturity construct and the two outcome constructs (tablet as DLR and goal facilitation) with standardized parameters. Furthermore, in M4, age, and gender were included. Only significant values ($p < 0.05$) were given. As was evident, the inter-factor correlation seemed sound, ranging from r = .14 to r = .61.

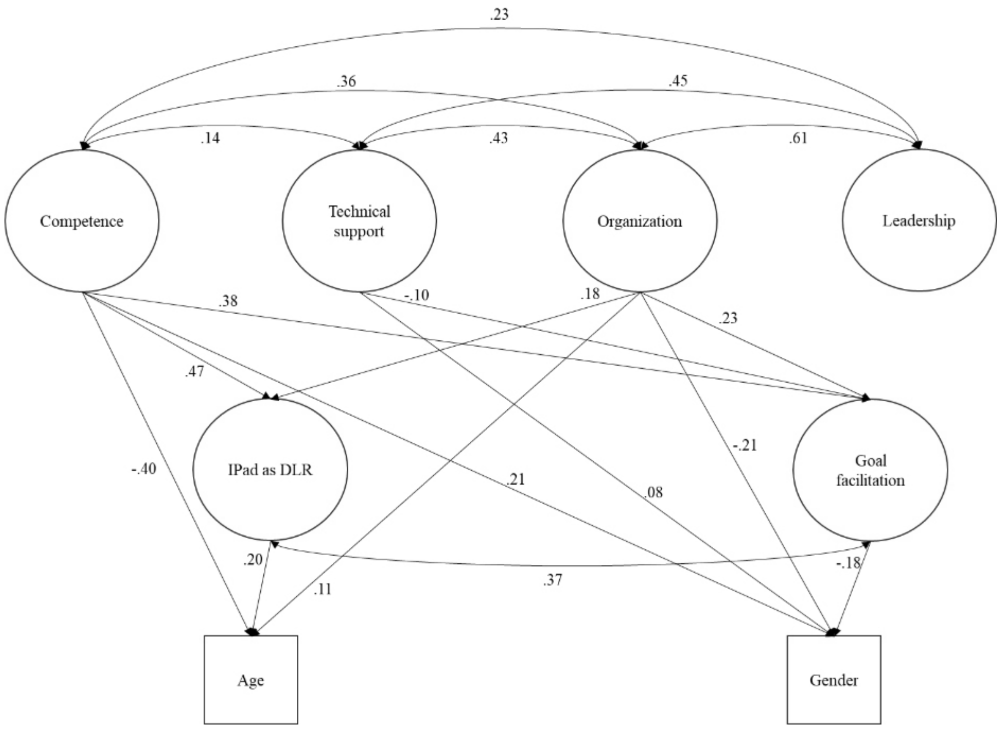

Figure 1 Digital Maturity in Implementation of Tablets

There were two observable variables included in the model: age and gender. Age seemed to predict the perception of organization (r =.11). Furthermore, age predicted tablet use as DLR (r =.20), albeit to a minor degree. However, age moderately predicted the reported level of competence (r = -.40). Younger teachers were more likely to report higher levels of competence than their older colleagues. Age was not significantly associated with any other factor. The gender variable (coded male= 0, female=1) produced four significant paths. Females were more likely to emphasize goal facilitation in their use of technology (r = -.18) and reported higher levels of perceived organizational maturity (r = -.21). Males, on the other hand, reported higher levels of competence (r =.21), while the perceived level of technical support produced a significant, but not substantial effect (r =.08). While the effect sizes were significant, gender seems to have little effect on the use of iPads as DLR, and the use of technology to facilitate goals as the effect sizes were low.

When inspecting the effects of digital maturity on the two outcome factors, the most striking finding was the lack of any significant effect of leadership. Furthermore, technical support had only one significant effect (on goal facilitation), but the estimate was too low to be considered substantial. Organization predicted both tablets as DLR (r =.18) and goal facilitation (r =.23), but estimates were low. The most important factor in the model was competence, which moderately predicted both tablets as DLR (r =.47) and goal facilitation (r =.38). Lastly, the model produced a significant, moderate correlation between iPads as DLR and goal facilitation (r =.37).

Discussion

In this study, the previous five-factor model derived from Monitor (Egeland et al., 2016) was discarded in favor of a four-factor model (see Figure 1) that combined leadership and planning. This model was free of any multicollinearity issues. It was also more parsimonious, making it a superior model. Two background variables were included in the model: age and gender. Both models showed teacher competence had a significant effect on goal facilitation and the use of tablets as DLR. This suggests that teachers' self-reported levels of competence can be crucial for utilization of tablets as DLR and for goal facilitation. Technological competence may be the result of the long-established tradition of integrating technology into educational settings (UFD, 1997; Gilje, 2022). Furthermore, findings indicate that teachers have established routines that enhance their ability to address technical issues related to DLR independently.

Males reported higher perceived competence than females; however, females reported utilizing tablets to achieve their goals more often than males did. There was only a small significant difference in the frequency of tablet use to achieve goals between males and females.

Younger teachers reported greater competence with tablets than older teachers, yet it was surprising to find that older teachers used tablets more vigorously for goal facilitation than younger teachers. However, Siddiq and Scherer (2016) found that older teachers value the integration of digital skills more than their younger colleagues. Thus, despite potentially feeling less competent, older teachers may utilize tablets more frequently due to their personal value systems.

Technical support had no significant effect on tablets, as DLR. Neither did goal facilitation, which contradicted previous findings on technology implementation in education (e.g., Herro et al., 2013). However, educators' degree of technological competence might enable them to independently address and resolve technical challenges related to DLR. Alternatively, it could be the use of tablets, not technology in general, which makes technical support less necessary for effective implementation. Since tablets were designed to be intuitive and user-friendly (Neumann & Neumann, 2017), users might not need as much technical support as they would with other digital tools. However, previous research on the implementation of tablets in schools suggests teachers prefer older, more familiar technology, such as laptops, and that this has been a barrier to tablet use (Kalonde, 2018). Hence, teachers' preferences and competence regarding digital devices may differ.

With this in mind, the findings regarding organizational conditions are consistent with previous research (e.g., Kane et al., 2016), indicating that, aside from teachers' competence, the organization must also align to support and maintain the dynamic process of digital maturity (Bennett & Blome, 2013). The significant impact of organizational conditions on leadership in this sample could be attributed to the flat hierarchy structure of the Norwegian school system (Skaalvik & Skaalvik, 2014; Bjørgen, 2022). It may be within this flat hierarchical context that the potential for digital maturity can be fully realized or constrained. Age also had a small but significant correlation with organizational conditions. Indicating older teachers have a slight tendency to be more dependent on organizational conditions than their younger colleagues. In addition, gender was associated with a somewhat stronger correlation, which suggests that female teachers tend to rely more on organizational support than male teachers. Thus, these results imply that schools might benefit from customizing support by age and gender.

Within this context, previous research also emphasizes the importance of incorporating a well-defined educational framework, as well as explicit curriculum guidelines pertaining to tablet usage, to facilitate an implementation process (Otterborn et al., 2019). The absence of a comprehensive implementation plan for the integration of tablets within the Norwegian school system may contribute to the seemingly minor role that organization played in this process. Without a clear, system-wide strategy, the implementation of digital tools can become fragmented (e.g., Woiceshyn et al., 2017). The results indicate that teachers can comprehend and overcome this challenge. Their capacity to understand and respond to the complexities of technology integration can mitigate the absence of a unified implementation approach, leading to the observed trend. However, this reliance on individual initiative may also obscure the need for a more coordinated organizational effort to increase DLR and goal facilitation across the educational system.

The superiority of the respecified four-factor model compared to Monitor (Egeland et al. 2016) could be because in the context of digital maturity, planning is a core aspect of leadership. Surprisingly, leadership had no significant effect on the two outcome factors, even though previous research stated that leadership was crucial to organizational dynamics, and it has consistently highlighted the critical role of leadership in the successful implementation of initiatives within organizations (e.g. O'Reilly et al., 2010; Ottestad, 2013; Bamburg & Andrews, 1991). Leadership is often highlighted as important in schools, and it was expected that leadership would impact how teachers use tablets in goal facilitation and as DLR. The lack of such effects might be related to the fact that Norwegian teachers have a large degree of autonomy in their teaching (Skaalvik & Skaalvik, 2014; Bjørgen, 2022). While leadership can create an environment conducive to innovation (Bjørgen, 2022; Bamburg & Andrews, 1991), translating these favorable conditions into specific teaching practices remains a complex process.

Practical Implication and Future Research

The findings of this study, particularly those regarding the insignificant effect of leadership in the model, can have practical implications for the implementation of tablets and other digital devices in schools. While other models suggest an intricate focus on several key implementation components (i.e., AIF, CFIR, and LOCI), these findings suggest that schools should focus on competence and organizational factors when implementing digital devices. Previous research has proposed that weaknesses within one component can be compensated for by strengths in other components (Fixsen et al., 2005). Thus, this study indicates that the strength of organizational and competence-related components may compensate for the weaknesses within *all* other implementation components suggested by previous models. Hence, the implementation of tablets may be less complex than previously assumed. Indeed, this study suggests that organizational and competence-related components should be the main focus when implementing digital devices in schools and, perhaps, organizations in general. However, these findings cannot say with any certainty whether the model can be applied within non-educational organizations or if they are relevant for schools with different organizational and hierarchical structures than those included in the study. Thus, it would be interesting to investigate whether the results can be replicated in school structures that are different from those in Norway.

The SEM analysis conducted in this paper provided a foundation for future research exploration about advancing the understanding of educational dynamics. While not directly related to pupils' learning outcomes, it is crucial to investigate the nuanced impact of tablets on pupils' learning experiences. Considering the insights of McEwen and Dube (2015), who highlighted tablets as effective learning tools for some pupils, it is imperative to delve deeper into the disparities that exist. Specifically, understanding why tablets may not be as beneficial for certain pupils, often those considered academically weaker, becomes paramount (McEwen & Dube, 2015). Future research should focus on unraveling the potential stratification of learning experiences within classrooms and offering insights into the diverse outcomes of tablet usage among pupils. Such inquiries are integral to the ongoing discourse on educational equity, guiding the formulation of policies that foster truly inclusive learning environments.

Limitations

The present study is based on self-reported data, which is known to be exposed to bias, for instance regarding social desirability, attitudes toward the survey and item wording.

The failing chi-square test indicate less than perfect model fit to the data, which can be considered a limitation. However, as Brown (2015) point out, the chi-square test is stringent, and thus other fit indices are often relied upon when assessing model fit.

Gender distribution might be considered as a possible source of bias, as the survey 78.3 % of the participants are female, but as this reflects the national teacher gender distribution in compulsory school (i.e. 74.4 % female teachers in 2022; Statistics Norway, 2024), bias is not considered likely.

Conclusion

This study examined the impact of digital maturity on the implementation of digital tablets in Norway, employing a four-factor model to assess the roles of leadership, organizational structures, teacher competence, and technical support. The model utilized a robust framework by examining and evaluating the fitness of several components from well-established theories and methodologies in the field. While leadership established the groundwork for technology adoption, it was the competence of teachers within the organizational framework that was essential in utilizing tablets for DLR and goal facilitation. The model revealed that technical support played a helpful yet non-decisive role in the successful implementation of tablets.

Teacher competence is a particularly strong factor, enabling educators to adeptly navigate the challenges associated with DLR, even in the absence of a standardized approach to tablet usage. However, the study also highlighted that technical support, competence, and organizational structures were integral to creating an environment conducive to technology adoption and goal facilitation. Therefore, it can be asserted that the quality of the digital maturity model remains central to the research methodology, contributing significantly to the depth and credibility of the findings.

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