Teaching with Technology: Evidence From an International Large-Scale Study on the Roles of Teacher and School Characteristics

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Abstract

Providing high-quality instruction while teaching with technology has become more important than ever before. However, the instructional practices and the degree to which key skills, such as digital literacy and computational thinking, are emphasized in classrooms vary considerably between teachers, schools, and countries. The present study aims at explaining this variation in the frequency of teaching practices involving technology and teachers' emphasis on developing students' computer and information literacy and computational thinking by key aspects of teacher motivation and expertise, school conditions and priorities, and countries' economy and innovation. Utilizing large-scale, representative data from the International Computer and Information Literacy Study (ICILS) 2018 (15,015 teachers in 1,195 schools in eight countries), we performed multilevel structural equation modeling and found that teacher motivation and collaboration were positively and consistently linked to teaching practices across countries. Besides, principals' expectations concerning the teaching with technology explained variation in Finnish and German schools. In three countries, teachers' professional development was related to their teaching practices. Finally, countries' economic development and innovation explained variation in the teacher-level effects. Our study sheds new light on the possible factors related to teaching with technology and advances the field by taking a multilevel perspective on these factors.

1. Introduction

Teaching norms can be attenuated by endogenous factors that arise in schools but also exogenous factors, namely the wider environment. A recent example of the latter comes from attempts to mitigate the effects of the pandemic which has meant the severe curtailment of normal school life, including global closures of schools. The near global shift to a fully remote format, provided the catalyst to educational systemsto explore how teaching in the classroom could be transferred to digital learning.

Acknowledging that students' ICT competences have gained substantial attention the last years, researchers investigate those factors that possibly influence teacher's integration of technology in their classrooms (Donnelly, McGarr, & O'Reilly, 2011; Fraillon et al. 2014).

At the same time, the use of digital technologies could enhance global equality, developmental opportunities, and economic growth (Kaarakainen & Saikkonen, 2020). The differences in the levels of economy and innovation across countries may explain the extent to which ICT has been integrated in their educational systems and shed light on the relationship between economic development, innovation, and teaching with technology (Blömeke et al., 2021; Scherer et al., 2021).

Thus, the present study examines the roles of teacher and school characteristics for the instructional use of technology in classrooms. Specifically, we extend the existing body of research by (a) adding a multilevel perspective to the factors that might explain teaching practices with technology; (b) utilizing international large-scale assessment data with representative and random samples of teachers from eight countries; (c) including not only frequency-based measures of technology use but also the emphasis on developing students' digital skills and computational thinking—a more fine-grained and skills-focused measure of teaching practice; (d) performing state-of-the-art analytic techniques to describe the relations (i.e., multilevel structural equation modeling and regression trees).

2. Theoretical Framework

Technology Acceptance research shows that teachers' integration of ICT into their teaching depends on their motivation and in particular the beliefs in their capabilities of using ICT (i.e., self-efficacy), but also on their beliefs in the usefulnessof ICT (i.e., positive views).

Except from teacher motivation, other elements are also important for the integration of ICT in teaching such as school conditions perceived by teachers. Teacher collaboration (Wong and Li, 2008), school's ICT equipment (e.g. Eickelmann, 2011) and professional development activities (Bingimlas, 2009) have been highlighted in ICT-supported teaching and learning processes.

School-level factors related to ICT resourcing and priorities are also known to influence both the way in which teachers use ICT for teaching and learning, and students' ICT-related learning (Fraillon et al. 2014; Gerick et al. 2017). Furthermore, collective teachers' self-efficacy of teaching staff with regard to ICT was identified as a very important supporting factor (Gerick et al., 2017).

Recently, the OECD (2010b; 2015) and the European Commission (2020) have claimed that digitalization has become a driving force in economic productivity. Consequently, countries worldwide develop the capacity to utilize technology and adapt to their educational needs supporting that technology can stimulate economic growth (Mihaela, 2014) and may facilitate innovation (Álvarez, 2016).

3. Method

The study used the International Computer and Information Literacy Study (ICILS) 2018 database. We utilized the teacher and principal data from the eight countries that participated in both the CIL and the CT assessments (Denmark, Finland, France, North-Rhine Westphalia in Germany, Republic of Korea, Luxembourg, Portugal, United States of America),

as the aim of the present study was to investigate the aforementioned teaching practices that give emphasis to students' digital literacy and coding skills.

Teaching practices refer to the classroom or teacher but can vary considerably across schools or countries (e.g., Klieme, 2020). To quantify the between-school variation and examine the teacher-level, school-level, and contextual effects (RQ1 & RQ2),

we performed multilevel structural equation modeling (MSEM) by extending it to a multi-group MSEM (RQ3), computed possible contextual effects and reported the effect size ES2 (Marsh et al., 2009).

4. Results

The study reports that most of the positive and significant effects have been observed at the teacher level supporting that in general, technology use in teaching depends mainly on teachers themselves and not so much on school-level policies (OECD, 2015).

Considering the results from the teacher level and the effects from the full sample and the country specific analyses, it was found that teacher characteristics such as their self-efficacy and their views on using ICT in their teaching practices are important elements for explaining variation in the use of ICT in their teaching practices which is in line with previous studies supporting this positive relationship (e.g., Bas, Kubiatko, & Murat, 2016; Rohatgi, Scherer, & Hatlevik, 2016; Scherer et al., 2015).

Regarding teacher expertise and teacher's experience in ICT use in particular was found to be an important indicator supporting previous research which claims that teachers' experience with computers for teaching purposes strongly predicted their future use of technology in teaching situations (Drossel et al., 2017). The contribution of professional development though was not consistent among countries and outcomes.

Considering the perceived school conditions, teacher collaboration was positively related to teaching practices consistently across countries with very few exceptions indicating

that collegial collaboration among teachers encourages the use of digital technologies in teaching practices (Hatlevik & Hatlevik, 2018; Gil-Flores et.al., 2016). ICT resources was not a significant predictor almost for all countries.

As far as the second research question, based on which we attempted to examine the effects of the collective teacher and school characteristics on the three outcomes, it was found that the variation in teachers' technology usage can be explained by a small proportion between schools (Kaarakainen & Saikkonen, 2020; OECD, 2015).

Overall, the study highlights two main findings coming from this level. Considering the full sample, the study reports that collective teacher motivation explained variation in some teaching practices. Moving to the country-specific results, the contextual effect of professional development was found in European countries of the sample.

At the country-level, only the relations among ICTPRAC, CODEMP, and ICTEMP were significant and positive; however, none of the correlations with log-GDP and the GII existed at the country level. Exploring further the relations among the teacher-level effects and the country characteristics, we found that countries' *log-GDP* and *GII* were substantially associated with some teacher-level effects.

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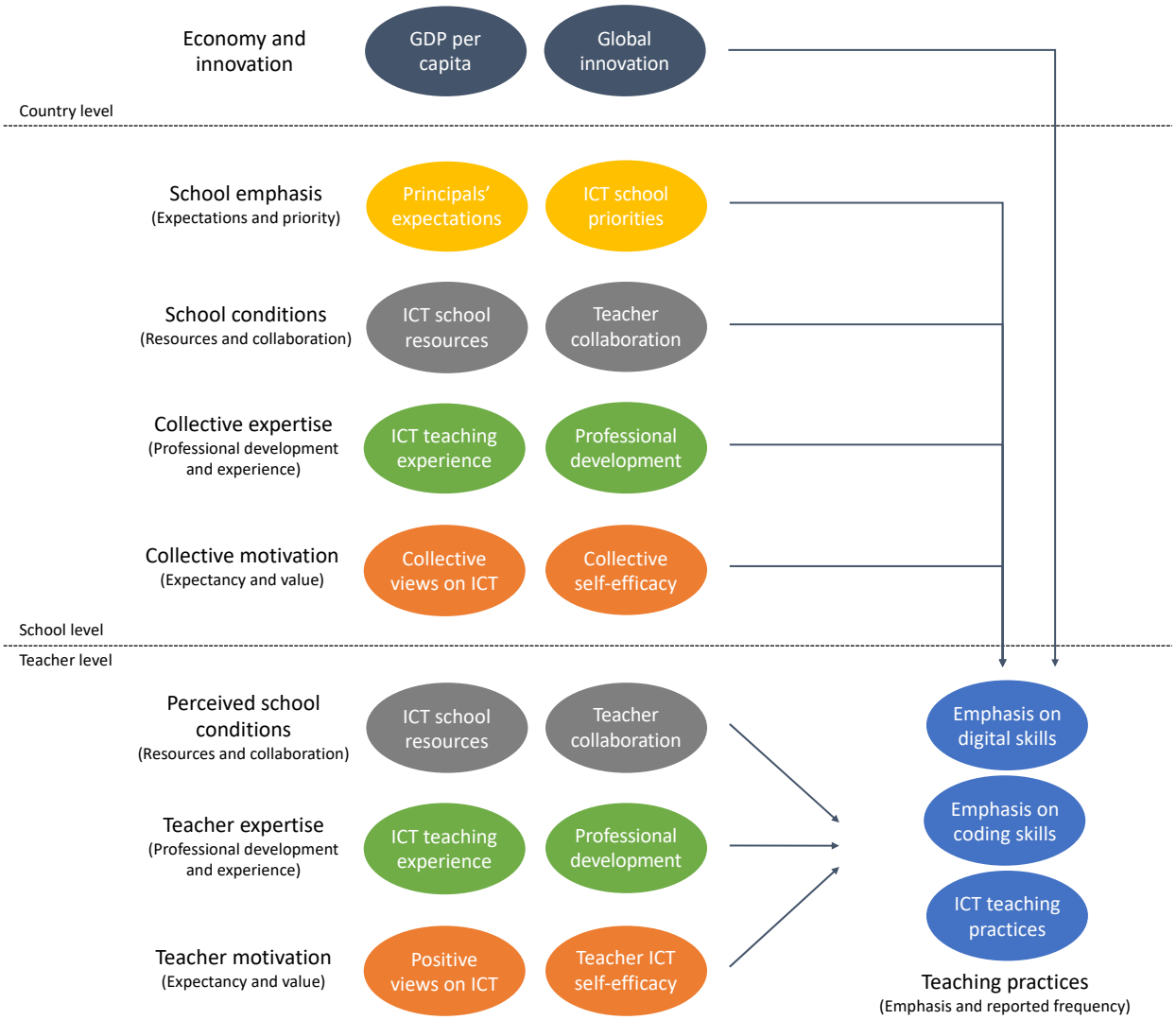
Appendix

Figure 1

Conceptual Model Underlying the Present Study



Note. GDP = Gross Domestic Product, ICT = Information and Communication Technology.

Table A1

Descriptive Statistics of the Teacher and Principal Variables and Scales

	Full sample		*Denmark*		*Finland*		*France*		*North-Rhine Westphalia*		*Republic of Korea*		*Luxembourg*		*Portugal*		*United States of America*	
Scale	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
ICTEMP	46.99	11.37	51.37	8.95	43.51	9.66	46.32	10.56	39.70	10.66	50.02	9.79	44.60	12.25	50.11	10.55	48.58	12.45
CODEMP	48.32	10.96	47.76	8.52	44.04	8.65	44.92	11.01	43.90	10.69	50.41	9.66	43.45	11.69	50.35	10.67	53.33	11.10
ICTPRAC	48.16	10.24	54.26	8.24	47.68	7.75	44.40	9.29	42.61	9.44	49.28	11.01	45.69	9.44	47.75	10.02	51.60	10.21
ICTEFF	50.48	10.02	53.28	8.29	51.02	9.38	44.62	9.01	44.96	8.40	50.42	10.27	46.86	8.97	52.70	9.27	54.38	10.03
VWPOS	47.71	10.01	48.11	8.85	45.46	8.32	43.73	9.67	43.47	9.85	49.28	9.21	43.91	8.66	51.31	9.50	50.19	10.53
EXLES	2.42	0.88	2.68	0.58	2.50	0.70	2.40	0.84	2.38	0.82	2.45	0.88	2.26	0.96	2.83	0.55	1.98	1.11
PROFSTR	49.38	9.94	49.23	9.09	49.47	8.05	49.15	9.09	44.26	7.54	48.99	9.77	49.89	8.82	46.68	8.73	55.60	11.11
RESRC	49.21	10.20	51.26	8.46	48.76	8.35	48.78	9.00	42.70	11.25	50.94	9.50	52.91	8.90	47.70	9.06	53.12	10.46
COLICT	47.90	10.10	49.53	9.01	48.51	9.21	47.13	10.07	43.62	10.48	47.63	9.44	47.44	9.83	48.96	9.10	49.71	10.91
EXPLRN	48.65	9.30	54.87	7.16	50.88	7.67	45.58	7.24	40.45	8.06	53.84	9.33	42.56	9.89	48.85	6.37	49.31	9.31
PRIORH	50.47	9.75	48.57	11.27	53.52	8.07	51.63	9.27	51.72	8.76	45.22	9.04	42.37	11.35	50.29	9.12	52.85	9.88
PRIORS	49.25	9.23	47.14	6.88	50.29	7.64	47.92	9.07	47.10	8.81	49.89	9.98	47.76	10.58	49.89	8.53	50.60	10.41