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Teachers' participation in professional development concerning the implementation of new technologies in class: a latent class analysis of teachers and the relationship with the use of computers, ICT self-efficacy and emphasis on teaching ICT skills

Kerstin Drossel* and Birgit Eickelmann

*Correspondence:
kdrossel@mail.upb.de
Institute of Educational
Science, Paderborn
University, Warburger Straße
100, 33098 Paderborn,
Germany

Abstract

The increasing availability of new technologies in an ever more digitalized world has gained momentum in practically all spheres of life, making technology-related skills a key competence not only in professional settings. Thus, schools assume responsibility for imparting these skills to their students, and hence to future generations of professionals. In so doing, teachers play a key role with their competences in using new technologies constituting an essential prerequisite for the effective implementation of such skills. As models of school development and school effectiveness found teacher professionalization to be a key element with regards to student achievement as well as teachers' in-class use of new technology, the present research project conducts secondary analyses using data from the IEA International Computer and Information Literacy Study 2013 (ICILS 2013) regarding internal and external teacher professionalization. Particular emphasis is placed on the implementation of new technologies in class in a comparison between the education systems of Germany and the Czech Republic. A Latent Class Analysis serves the purpose of establishing a teacher typology with regards to technology-related professional development. This typology is subsequently used for further analyses of additional factors that show a correlation with the teachers' use of computers in class. These include the teachers' ICT self-efficacy and their emphasis on teaching ICT skills. The results show two different types of teachers across both countries. Teachers who participate in professional development use computers more frequently in class, put more emphasis on teaching ICT skills and have a stronger sense of ICT self-efficacy. When comparing teachers in Germany and the Czech Republic, teachers in Germany who participate in professional development consider themselves more ICT self-efficient, while teachers in the Czech Republic use computers more often and put more emphasis on teaching ICT skills compared with their colleagues in Germany.

Keywords: ICILS 2013, Professional development, New technologies, ICT skills, Teachers, Digital age

Introduction

New technologies have come to play a significant role in the individual's participation in society, providing access to information and hence knowledge in what is commonly referred to as the digital age (Fraillon et al. 2014, p. 3; cf. also Davis et al. 2013). The continuous creation and exchange of information in a globalized world have come to affect almost all spheres of an individual's life, making the related skills indispensable for contemporary education (Fraillon et al. 2014, p. 3). School systems, including its agents such as teachers, is now facing the challenge of imparting these skills to future generations of professionals—namely today's students. Naturally, the imparting of such skills requires a certain degree of competence on the part of the instructors, whose continuous professional development may ensure a dynamic and adaptable approach to providing learners with the competences necessary to effectively participate in society (cf. Voogt et al. 2013). As a lack of professional competences both at the didactic and methodological level has been found to constitute a hindering factor to the integration of new technologies in class (cf. Drossel et al. 2015; Eickelmann 2011), the professional development of teachers has the potential for taking countermeasures. A distinction is made between internal and external professional development: the former involves further training within the school setting whereas the latter comprises participation in external training activities. Morris et al. (2003) argue that while both forms are independent of each other, "linking the two doubles the power of each" (Morris et al. 2003, p. 767). Statistics show, however, that teachers in Germany have participated in external professional development activities significantly less frequently than the international average: the IEA (International Association for the Evaluation of Educational Achievement) International Computer and Information Literacy Study 2013 (ICILS) showed that a mere 18% of German teachers have participated in external training on the integration of new technologies into teaching and learning, while the international average is 43% (cf. Fraillon et al. 2014, p. 191). Participation by teachers in the Czech Republic lies at 36% and is therefore also significantly below the ICILS 2013 average, as are five out of the total of eleven items related to professional development participation (ibid.). In the domain of internal professional development, teachers in the Czech Republic indicate collaborating with their colleagues to develop ICT-based lessons in 36% of cases, while collaboration in this area among teachers in Germany amounts to a mere 12% (cf. Fraillon et al. 2014, p. 181).

These figures show a clear reference to the relationship of digital media with processes of teaching and learning. However, it is worth noting that other authors (e.g. Law and Chow 2008; Pelgrum 2008) have found advanced training options to focus more on technological aspects rather than on the didactic integration of ICT into relevant scenarios of teaching and learning. The unavailability of relevant options for professional development may thus also play a role here. The purpose of this paper is to investigate teachers' technology-related professional development in Germany and the Czech Republic using secondary analyses of ICILS 2013 teacher data. The research desideratum of establishing a typology of teachers regarding their participation in external and internal professional development both with regards to teacher characteristics and in the form of a comparison between the two selected education systems is pursued against the background of a theoretical framework. Following a review of relevant research literature, the methods of data analysis will be presented. The derived research gaps will then be filled with the

help of concise research questions. The respective results are expected to provide incentives for amending professional development activities in order to enhance outcomes against the background of school development and school effectiveness research.

Theoretical framework

The Contextual Framework Model of ICILS 2013 provides the foundation for the conducted analyses (Fraillon et al. 2014, p. 37, see Fig. 1). This model aims to illustrate the interrelation of antecedent and process factors in achieving the outcome of student CIL. Thus, the factors can be located at different levels, including at the wider community, the school and classroom level, the individual student level and the students’ home environment. Fraillon et al. (2014) locate the extent to which teachers participate in ICT-related professional development at the school and classroom level of the antecedents. ICT-related professional development therefore has an effect on factors related to the process level, where amongst others the teacher’s use of new technologies in class is located.

Review of relevant literature

The current state of research, as represented in relevant research literature, incorporates multiple sub-dimensions. In a first step, a definition of the term “professional development” will be given, also addressing the differentiation between internal and external professional development. A further sub-dimension includes research findings on the extent of teacher participation in both internal and external professional development activities. Thirdly, the benefits of teacher professionalization will be examined more closely. Before pursuing this research desideratum, the factors that will be analyzed in the analysis related to types of teacher professionalization (teachers’ frequency of computer use, their ICT self-efficacy, and their emphasis on teaching ICT skills) will themselves be analyzed at a descriptive level.

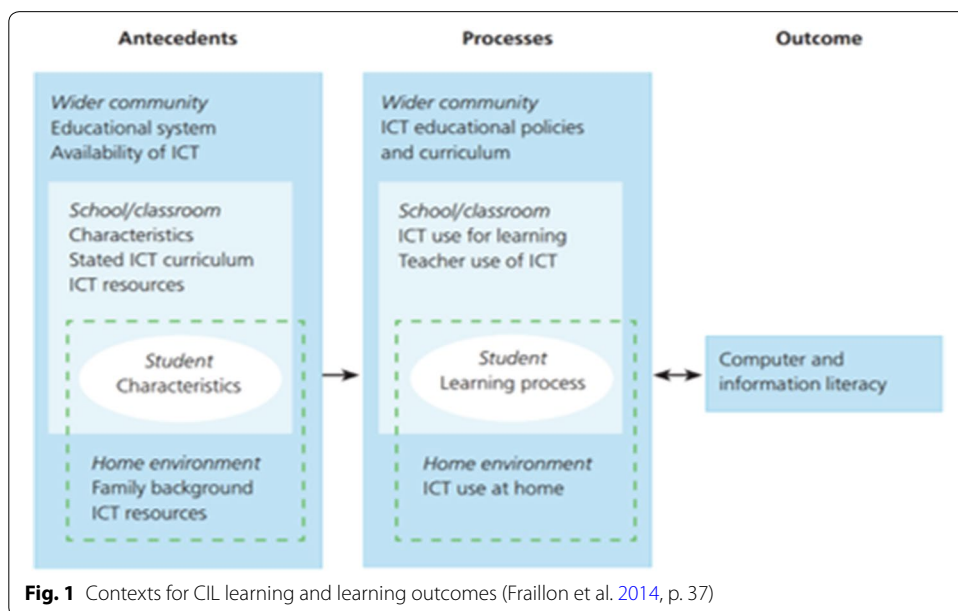


Fig. 1 Contexts for CIL learning and learning outcomes (Fraillon et al. 2014, p. 37)

The notion of professional development

While the professional development of teachers is commonly viewed within the realms of school development and school effectiveness, Hofman and Dijkstra (2010, p. 1031) summarize that “lifelong learning is at the base of professional development of people in general and this is particularly the case for teachers.” For the subsequent analyses, it can be deemed essential that a common understanding of the term is established. Describing a similar definition of professional development—also called continuous professional development (CPD) (cf. Cordingley et al. 2005; Geldenhuys and Oosthuizen 2015)—Coldwell (2017, p. 189) writes:

By professional development (PD) I mean formal and informal support and activities that are designed to help teachers develop as professionals. This includes taught courses and in-school training, as well as activities such as coaching, mentoring, self-study and action research.

While Coldwell (2017) hence focuses on the professional development of active teachers, it is worth noting that Fraillon et al. (2014, p. 39) make a distinction between pre-service and in-service professional development. In the context of this paper, the focus will be on in-service professional development. Focusing more on the character of professional development activities, a distinction between internal and external development has resulted in a lack of agreement among researchers as to which is more effective. Boone (2010) and Westheimer (2008) argue that teachers are capable of compiling relevant learning material themselves and do not require external assistance, whereas Morris et al. (2003) consider a combination of both external and internal professional development to be most effective. This distinction constitutes the key research interest of this paper in that they are used to evaluate the teachers’ participation practices.

Teachers’ professional development practices by international comparison

In terms of their participation in ICT-related external professional development activities, teachers responded to the categories of *An ICT-Mediated Discussion or Forum on Teaching and Learning*, *Course on Subject-Specific Digital Resources*, and *Course on Integrating ICT into Teaching and Learning*. The results in ICILS 2013 show that only 8% of teachers in Germany had participated in ICT-mediated discussions or forums on teaching and learning, while Czech teachers reported doing so in 21% of cases (Fraillon et al. 2014, p. 191). With regards to the course on subject-specific digital resources, 10% of German teachers gave a positive answer compared with 18% of their Czech colleagues (cf. *ibid.*). Turning to the third item, 18% of German teachers and 36% of Czech teachers indicated having participated in a course on integrating ICT into teaching and learning (cf. *ibid.*). All of these results were below the ICILS 2013 average.

Concerning the items used for internal professional development, the categories of *I observe how other teachers use ICT in teaching*, *I systematically collaborate with colleagues to develop ICT-based lessons based on the curriculum*, and *I work together with other teachers on improving the use of ICT in classroom teaching* were drawn upon. The teachers’ responses show that 41% of German teachers observe other teachers using ICT; the same is true for 45% of their Czech colleagues (Fraillon et al. 2014, p. 181). 36% of Czech teachers systematically collaborate with colleagues to develop ICT-based

lessons, while only 12% of German teachers report doing so (*ibid.*), and 30% of German teachers as opposed to 69% of their Czech colleagues work together with other teachers on improving the use of ICT in classroom teaching (*ibid.*).

Benefits of professional development

While Grosemans et al. (2015) recently postulated that on-going developments in society make a continuous learning process indispensable for teachers, Riley et al. (1997) already understand professional development as an overarching requirement for all professions, with a particular relevance for teaching in terms of fostering “the continuing engagement, enthusiasm, effectiveness, and retention of teachers” (Riley et al. 1997, p. 6).

Day and Gu (2007) likewise use teachers’ needs and professional commitment as points of reference for professional development (cf. Day and Gu 2007, p. 439), much like Coldwell (2017, p. 190) (cf. also Ross and Bruce 2007; Lakshmanan et al. 2011); other researchers, however, suggest student achievement and progress as units of measurement. Avalos (2011, p. 10), for instance, indicates that the professional development of teachers involves “teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students’ growth” (cf. also Anthony et al. 2014). Empirical evidence supports this claim as Desimone (2009) links the professional development of teachers (more specifically a content focus, active learning opportunities and a coherence with teachers’ beliefs and system policies etc.) with student outcomes—a finding that is also supported by Meissel et al. (2016, pp. 170–171). Cordingley et al. (2005, p. 1) further elaborate on the outcomes of professional development, distinguishing between outcomes for teachers (such as greater confidence, enhanced knowledge and practice) and outcomes for students (such as enhancement of motivation or improvements in performance, i.e. ultimately achievement).

Numerous studies focus on either internal or external professional development. While Colmer et al. (2015), for instance, see an important advantage in external professional development with reference to the catering for different development needs of employees, Nuttall (2013) finds that external professionalization in its individualized form occurs only sporadically, hence lacking continuity. In conclusion, the current state of research does not show a clear tendency in the findings on either external or internal professional development. Morris et al. (2003), however, link external with internal professional development, finding that the “two emerging approaches to professional development, when systematically linked, can provide the transformative power to alter professional development and teacher learning in profound and sustainable ways” (p. 764). This dual approach will also be adopted in this research paper, assessing both internal and external teacher professionalization.

Relevant background factors for teacher professionalization

Gerick et al. (2017, p. 1) have already pointed to the fact that “the relevance of school-level determinants for the use of ICT by teaching staff in schools differs between education systems”. Their analyses have found pedagogical support for IT, the teachers’ self-efficacy and their participation in professional development to be relevant for the students’ CIL in individual countries (*ibid.*). With regards to teacher professionalization

as one of these relevant factors, this study has selected teachers' frequency of computer use, their ICT self-efficacy and their emphasis on teaching relevant ICT skills as potential background determinants.

The frequency of computer use by teachers in the Czech Republic shows that 65.6% use computers at least once a week (Fraillon et al. 2014), while their German colleagues report using computers on a weekly basis in only 34.4% of all cases (ibid.). Germany ranks last in the overall comparison, whereas the Czech Republic is mid-table, yet above the average values for the EU and the OECD as well as the international average (ibid.).

The teachers' ICT self-efficacy for different tasks ranges from 29% (*Collaborating with others using shared resources*) to 97% (*Producing a letter using a word processing program; Finding useful teaching resources on the internet*) in the Czech Republic (Fraillon et al. 2014, pp. 208–209). German teachers show confidence in *producing a letter using a word processing program* (99%), but lack this confidence particularly in *collaborating with others using shared resources* (24%; ibid.). It can hence be concluded that German and Czech teachers' self-reported strengths and weaknesses are comparable.

The teachers' emphasis on developing students' CIL during their lessons shows that teachers in the Czech Republic attach greater importance to their students' ICT-based capabilities (percentages between 26 for providing digital feedback and 64 for accessing information efficiently, Fraillon et al. 2014, p. 216). Germany's values are at least 16 points below those of their Czech colleagues for each category (cf. ibid.).

Research questions

The current state of research reveals a lack of analyses in the comparison of external and internal teacher professionalization with a focus on teachers as school agents. In view of this research gap, this paper will pursue the following research questions empirically:

1. Can a teacher typology with regard to their participation in internal and external professional development be identified for the selected education systems?
2. What is the relationship of potential teacher types with the frequency of computer use during lessons?
3. What is the relationship of potential teacher types with further important predictors connected with the in-class use of new technologies such as the teachers' ICT self-efficacy and the emphasis on teaching ICT skills?
4. What differences between external and internal professional development can be found with regards to Germany and the Czech Republic?

Methods

In order to answer the aforementioned research questions, a secondary analysis of teacher data from the International Computer and Information Literacy Study 2013 (ICILS 2013) will be conducted (Fraillon et al. 2014). The selection of the education systems for the secondary analyses primarily relies on their performance in the context of the ICILS 2013 study, with the Czech Republic as a top performer and Germany as a participant demonstrating medium performance when it comes to the students' levels of computer and information literacy (CIL) (Fraillon et al. 2014, p. 96). Additionally, Germany is the authors' country of origin, while the Czech Republic is acting as a host of

the International Research Conference (IRC) in 2017. While the samples of the Czech Republic meet the ICILS 2013 requirements, Germany's samples do not consistently comply with these (Fraillon et al. 2015, p. 99). However, as the sampling requirements used in ICILS 2013 are very high, the results obtained for Germany can still be considered representative. The first research question will be addressed by a Latent Class Analysis (LCA) (Hagenaars and McCutcheon 2002) in order to come up with a teacher typology concerning technology-related external and internal professional development. The LCA draws on the teachers' response patterns in the teacher questionnaire for the purpose of allocating them to latent groups or classes, which share a number of characteristics in their responses. The emerging latent classes can then be named according to these responses and shall constitute the basis for further statistical analyses, as represented by the second and third research questions in this paper. The relevant items selected from the ICILS 2013 teacher questionnaire can be subdivided into external and internal professionalization. These categories of external and internal professionalization will be operationalized by three characteristic items each that yield information on teachers' professional development activities and provide information on teachers' principles with regard to learning to use ICT respectively, over the preceding 2 years. Thus, external professionalization consists of *Course on integrating ICT into teaching and learning*, *Course on subject-specific digital resources* and *An ICT-mediated discussion or forum*; internal professionalization comprises the items *I work together with other teachers*, *I systematically collaborate with colleagues to develop ICT based lessons* and *I observe how other teachers use ICT in teaching*. In order to deal with the complex structure of the teacher data, the analysis type 'Type = mixture complex' was used (Muthén and Satorra 1995). Additionally, the teacher weight for the calculation of an LCA was included (cf. Jung and Carstens 2015). Missing values across all six items were excluded from the analyses, which results in sample sizes of $n = 1377$ for Germany and $n = 2126$ for the Czech Republic.

The analyses conducted for the remaining research questions rely on descriptive statistics. With reference to the teachers' frequency of computer use during lessons, the response patterns were dichotomized in order to distinguish teachers reporting frequent (i.e. at least weekly) use of computers from their colleagues that do not use computers in class on a regular basis.

The teachers' reported ICT self-efficacy is illustrated by means of an international index consisting of 14 items (e.g. *How well can you do these tasks: Monitoring students' progress*). The index was generated using the Rasch partial credit model (Masters 1982) and transformed to a mean of 50 points and to a standard deviation of 10 points. Internationally, the index shows satisfactory reliability with a Cronbach's $\alpha = .87$ (Germany: .87; Czech Republic: .87; cf. Fraillon et al. 2015, p. 199).

The emphasis on teaching ICT skills comprises 12 items, including multiple ICT-related activities in class (e.g. *Accessing Information Efficiently*, *Evaluating the Credibility of Digital Information*, *Providing References for Digital Information Sources* etc.). The index's Cronbach's $\alpha = .97$ (Germany: .96; Czech Republic: .97; cf. Fraillon et al. 2015, p. 205) is highly satisfactory for both selected countries and indicates the extent to which teachers promote students' ICT-related competencies in class.

Table 1 Information criteria for the LCA conducted for the Czech and the German ICILS 2013 sample

	Czech Republic		Germany	
	AIC	BIC	AIC	BIC
2-Group-solution	14300.510	14374.085	7055.450	7123.419
3-Group-solution	14190.395	14303.588	7025.069	7129.637
4-Group-solution	14115.260	14268.070	6993.540	7134.706
5-Group-solution	14113.107	14305.535	6986.468	7164.234

Results

In this chapter, the results of the secondary analyses will be presented individually for each research question. The following chapter will summarize and discuss these findings.

Research question 1

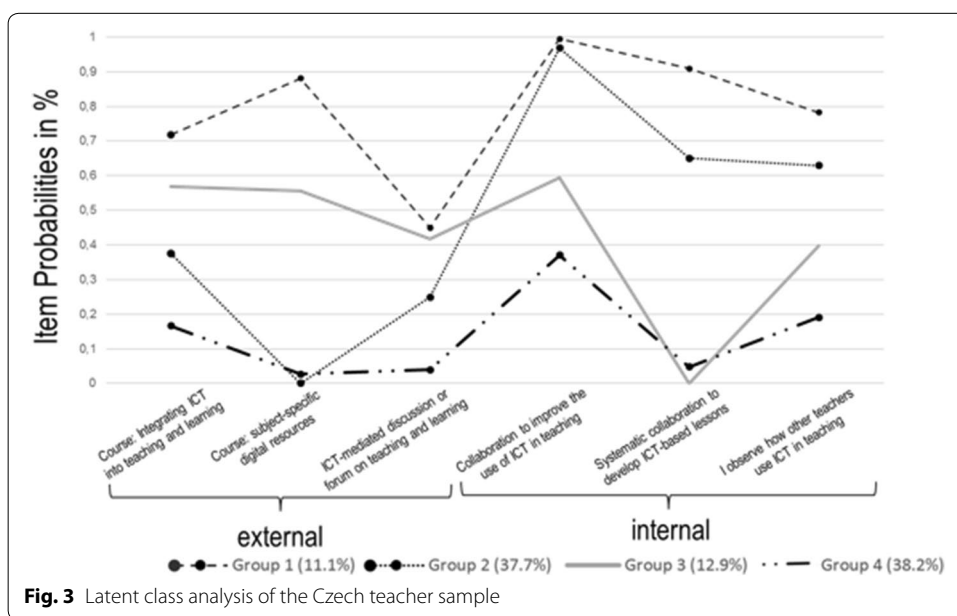
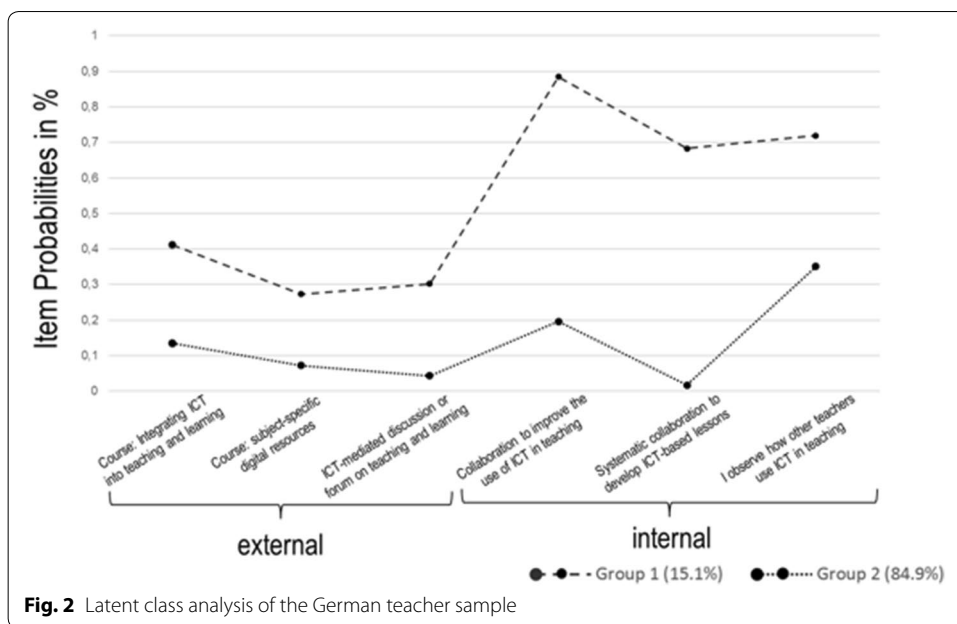
The results of the LCA were assessed using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The optimal solution that best fits the data can be deduced from the smallest values of both AIC and BIC (cf. Nylund et al. 2007). In the case of Germany, a two-group model is the optimal solution according to the results of the LCA—as shown in Table 1.

Here, the second teacher type regarding professional development accounts for more than four fifths of the entire sample (84.9%, cf. Fig. 2). This teacher type hardly participates in any professional development, be it external or internal. This group is therefore henceforth called “professionally undeveloped”. The first group, however, is characterized by the fact that the teachers have a strong tendency to participate primarily in internal professional development activities, but also in external development. This group accounts for 15.1% of the sample (cf. Fig. 2) and is henceforth called “inclined to professional development”.

The case of the Czech Republic shows that a four-group model best fits the data (cf. Table 1). The group showing the least commitment to professional development makes up 38.2% of the teacher sample (Group 4; cf. Fig. 3) and can be called “professional development opponents”. The greatest commitment to professional development is shown by teachers from Group 1 (11.1%; *ibid.*), called “professional development enthusiasts”. Teachers in this group exhibit strong tendencies to participate in both external and internal professional development activities. The remaining two groups can be split into the “internal professional developers” (Group 2; 37.7%) and the “external professional developers” (Group 3; 12.9%) (Fig. 3).

Research question 2

The results of the second research question show that the group of teachers who frequently participate in professional development activities (“inclined to professional development”) also use the computer significantly more often (70.7%) as opposed to their colleagues who do not regularly participate in such activities (“professionally undeveloped”) (29.2%). The same is generally true for the Czech teacher sample: while the difference between frequent and irregular participation in professional development is



even more pronounced in the enthusiast group (79.8% vs. 20.2%), the opponent group only shows a minor difference (53.3% vs. 46.7%).

Research question 3

With regards to the teaching of ICT skills, it can be postulated that teachers “inclined to professional development” in Germany emphasize these skills more than their “professionally undeveloped” colleagues (49.2% vs. 43.1%). The same ratio can be found in the Czech sample, where professional development enthusiasts show the strongest emphasis on the teaching of ICT skills (54.3%) as opposed to the “professional development

opponents” (46.2%). The “external professional developers” put more emphasis on the aforementioned skills (51.3%) than their “internal professional developer” colleagues (50.5%). With reference to the teachers’ ICT self-efficacy, the results show yet again that teachers “inclined to professional development” in Germany (55.2%) and “professional development enthusiasts” in the Czech Republic (52.2%) have a stronger sense of efficacy than their colleagues who are “professionally undeveloped” (in Germany; 48.2%) or “professional development opponents” (in the Czech Republic; 47.8%). Interestingly, however, in this case, the “internal professional developers” from the Czech Republic show a greater sense of ICT self-efficacy than their external colleagues (51.3% vs. 50.5%).

Research question 4

Comparing the education systems in Germany and in the Czech Republic, the results regarding the frequency of computer use show that Czech teachers—on average—use computers significantly more often than their German colleagues. While the difference between teachers “inclined to professional development” (Germany) and “professional development enthusiasts” (Czech Republic) is noticeable (70.7% vs. 79.8%), the skeptical teacher types (professionally undeveloped in Germany and professional development opponents in the Czech Republic) show a significant difference of 29.2% vs. 53.3%. The average emphasis on teaching ICT skills is also higher in the Czech Republic, while teachers’ ICT self-efficacy is—on average—higher in Germany.

Discussion and conclusions

While the cross-sectional design of the study does not allow for the interpretation of causal relationships between professionalization and the selected indicators, the results show an overall clear tendency that teachers in Germany have more absolute approaches to professional development, given the fact that the German teacher sample is only subdivided into two groups. Teachers in the Czech Republic show more diversified approaches to professional development (on a scale between enthusiasts and opponents), whereas teachers in Germany can be allocated to groups that are either skeptical or have a tendency towards internal professional development. External professional development activities—or even both external and internal professional development activities—do not seem to play an important role in the German context. Such skeptical teachers account for almost 85% of teachers in Germany, whereas Czech teachers oppose professional development activities altogether in only 38.2% of cases. A closer examination of framework conditions, especially with regard to external professional development activities in Germany, could be the focus of further research. At this point, we can only speculate that resources such as time and money could be the underlying influencing factors. Teachers in Germany often have to bear part of the costs of professional development activities themselves as schools only have a limited budget available for such activities. In the case of the district government of Düsseldorf, the per capita budget for professional development amounts to only 45€ per teacher per school year (Düsseldorf 2016). In the case of the federal German state of Bavaria, the overall budget for teachers’ professional development was cut by 7.5% between 2003 and 2009 (Landtag 2010). In the Czech Republic, on the other hand, research indicates that teachers can use 12 days per school year of their paid working time as an incentive to participate

in professional development (European Commission 2010; cf. also Eurydice 2008). For schools in the Czech Republic, it is furthermore mandatory “to have a continuing professional development plan for their teachers as part of the school development plan” (European Commission 2010, p. 50). The extensive support measures in the Czech Republic may therefore have had an impact here; however, the reasons for different participation rates may be more diverse and need to be investigated further. The analyses in this contribution have shown that teachers who engage in professional development tend to use computers more often, put more emphasis on the teaching of ICT skills and have a stronger sense of ICT self-efficacy than their skeptical colleagues. These results can be concluded to lay a foundation for effective student learning, which, however, will be difficult to achieve with the aforementioned high proportion of skeptical teachers in Germany. Against the background of the Czech Republic’s top performance when it comes to students’ CIL, this finding may provide incentives to take a closer look at how the professional development of teachers impacts students’ achievement. While teacher and student data in the IEA-study of ICILS 2013 cannot be linked, further research may therefore seek to amalgamate longitudinal teacher and student data in order to investigate the causal relationship of the two constructs. This will ultimately contribute to a sounder understanding of the effects that teachers’ professional development has on student achievement, providing valuable insights for necessary reforms of the educational systems required to ensure students’ successful participation in today’s digital society. Furthermore, it could be helpful for policy making purposes to analyze how common the identified types of teacher professionalization are to the various school types which exist in both countries. For Germany, for example, it is possible using ICILS 2013 data to identify teachers working in a *Gymnasium* (upper secondary school) as opposed to teachers working in other types of school (lower secondary schools).

Authors’ contributions

All authors made a substantial contribution to the conception and design, as well as to the analysis and interpretation of results. They were jointly responsible for drafting and revising the article. Both authors read and approved the final manuscript.

Acknowledgements

Not applicable.

Competing interests

The authors declare that they have no financial or non-financial competing interests.

Availability of data and materials

The data as well as the instruments of ICILS 2013 are publicly available on the ACER website (<https://www.acer.org/aus-icils/data>).

Consent for publication

We provide our consent to publish this manuscript upon publication in the Springer open journal LSA.

Ethics approval and consent to participate

We rely on data from the ICILS 2013 study, which conforms to IEA ethical standards. The Australian Council for Educational Research (ACER) in Melbourne served as the international study center for ICILS, working in close cooperation with the IEA, and the national centers of participating countries.

Funding

There was no funding for our research.

Publisher’s Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 12 June 2017 Accepted: 31 October 2017

Published online: 27 November 2017

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