Technology and knowledge. In what way are knowledge and teachers' knowledge practices in subject areas crucial for the integration of technology in education?

Article *in* Nordic Journal of Digital Literacy · October 2022

DOI: 10.18261/njdl.17.3.2

Nordic Journal of Digital Literacy

Universitetsforlaget

RESEARCH PUBLICATION

Volume 17, No. 3-2022, p. 155–169
ISSN online: 1891-943X
DOI: https://doi.org/10.18261/njdl.17.3.2

Technology and knowledge. In what way are knowledge and teachers' knowledge practices in subject areas crucial for the integration of technology in education?

Erik Bratland
Professor, Nord University, Faculty of Education and Arts, Nesna
erik.bratland@nord.no

Mohamed El Ghami
Professor, Nord University, Faculty of Education and Arts, Nesna.

Morten Mediå
Senior Adviser, The Centre of Competence on Rural Development

Abstract
In recent decades, education has undergone a digital transformation. In Norway, the government's digitalization strategy for education includes ambitious goals and plans, with expectations of new forms of teaching and learning, better learning, and improved learning outcomes. Despite the increased availability of technology in Norwegian schools, there is still a significant gap between available technology in the classroom and teachers' use of this technology for educational purposes. This paper is based on Legitimation Code Theory (LCT) and explores teachers' understanding of subject-area knowledge practices. Drawing on an empirical survey of a number of schools in northern Norway, completed in 2018/19, this paper uses one dimension of LCT to explore and compare the organized principles underlying teachers' knowledge practices in the key subjects of mathematics and Norwegian. An analysis suggests a code 'clash' with mathematics and a code 'match' with Norwegian, which may help explain their different patterns of technology integration. This research provides new perspectives on the integration of technology in education and suggests that different forms of subject-area knowledge have varying effects on teachers' knowledge practices with the use of technology in schools. This insight, which reveals the importance of knowledge and knowledge practices, will have an impact on strategies for integrating technology in schools and on measures that can promote better learning in subjects using technology in education.

Keywords
Technology integration, Legitimation Code Theory, specialization knowledge practices, secondary schooling, subject areas

Introduction

In recent decades, Norwegian authorities have carried out a large-scale digitalization of schools. This digitalization of schools is expected to be extensive (Kunnskapsdepartementet, 2017). According to the government's curricula, students should develop skills and digital competence, and technology will be applied in all school subjects (Utdannings- og forskningsdepartementet, 2006; Kunnskapsdepartementet, 2019). Authorities' digitalization strategy is based on the idea that technology should contribute to significant changes in education (Bratland, 2018). Technology may enable students to participate in an increasingly digitalized society and work life, and digital competence should promote digital skills, collaborative skills, digital judgment, and in-depth learning (Kunnskapsdepartementet, 2017). Above all, such technology should stimulate better learning in schools, and it is expected that the technology will help improve pupils' learning outcomes. Although authorities in Norway, as in many other countries, have high expectations for the integration of technology in education, these expectations have only been met to a limited extent. Norwegian schools are at the forefront of technology density, but despite the increased availability of digital technology, there is still a significant gap between available technology in the classroom and teachers' use of this technology for educational purposes (Blikstad-Balas, 2015; Hatlevik, 2013; Egeberg, Hultin & Berge, 2016; Fjørtoft, Thun & Buvik, 2019; Madsen, Thorvalsen & Archard, 2018; Kopcha, 2012; Ludviksen & Rasmussen, 2006). The research also shows that the use of technology can vary considerably across subject areas in schools and that technology leads to little change in educational practice (Arnseth, 2007; Hatlevik & Kløvstad, 2009; Kløvstad, Søby, Kristiansen & Erstad, 2005; Selwyn, 2016; Webb & Cox, 2004). This problem of the lack of technology integration in education has led to extensive research into the use of ICT in schools, with the identification of factors that can contribute to a better integration of technology in the classroom (Archer, Savage, Sanghera-Sidhu, Wood, Gottardo & Chen, 2014; Howard, Chan & Caputi, 2015a; Krumsvik, Berrum & Jones, 2018; Tamim, Bernard, Borokhovski, Abrami & Schmid, 2011). Educational research has typically focused on factors such as teachers' digital competence, school cultural factors, access to resources and lack of ICT management (Erstad, 2010; Law, Pelgrum & Plomp, 2008). It has often been argued that there is a need to change all these factors, which is believed to lead to a better integration of technology in the classroom. In the Norwegian context, it is particularly the use of digital tools and teachers' lack of digital competence that have attracted attention (Krumsvik, 2016). Gradually, there has also been a stronger focus on the pedagogical use of ICT in certain subjects (Harris, Mishra & Koehler, 2009; Helleve & Almås, 2017; Otnes, 2009), where emphasis is placed on learning in subjects, with the use of specific subject didactic approaches. Although this research may provide new insights into the factors that have an impact on the use of ICT in the classroom, these approaches seem to overlook knowledge and knowledge practices in subject areas as key factors that seem to be of great importance for the integration of technology in education (Bratland, 2016; Howard & Maton, 2011; Maton, Hood & Shay, 2016). Similar to the government's strategy for the digitalization of education, much educational research is based on a generic idea of learning, where technology is supposed to be seamlessly integrated across different subject areas. This paper takes a different starting point, arguing that the integration of technology in classrooms will depend on subject-area knowledge and teachers' knowledge practices in subjects. As Bernstein (2000) explained, educational knowledge is not neutral knowledge but has different forms and structures, where the use of technology in school is shaped by teachers' knowledge practices and their perceptions of how students can best learn a subject (Howard & Maton, 2011; Maton & Chen, 2020). Based on Maton's LCT specialization (Maton, 2014; Maton, 2016), the paper presents new research that examines how the integration of technology in schools will depend on teachers' knowledge practices and different forms of subject-area knowledge. The differences between subject areas, as they are expressed in the curricula, provide different forms of technology integration in education (Howard & Maton, 2011; Howard et al., 2015a; Howard, Chan, Mozejko & Caputi, 2015b; Maton & Howard, 2016). It is of particular interest to investigate whether these insights can be transferred to the Norwegian context with a school structure characterized by relatively small schools, where teachers often teach several subjects (El Ghami, Bratland & Valstad, 2021). More specifically, and based on a survey of schools in northern Norway, an areae typically characterized by relatively small schools, this paper examines teachers' perceptions of technology integration in the subjects of Norwegian and mathematics, by addressing the following question: In what way are knowledge and teachers' knowledge practices in subject areas crucial for the integration of technology in education?

Theoretical framework: LCT and specialization codes

This paper is based on a social and realistic framework (Maton & Moore, 2010), and informed by Karl Maton's Legitimation Code Theory (Maton, 2014; Maton, 2016). LCT includes several dimensions, where specialization and semantics are the most used, and focuses on the bases of achievement in an educational context. To show progress, individuals' practices and beliefs need to embody the dominant basis of achievement to be conceptualized as 'legitimate'. The LCT framework provides a multidimensional conceptual toolkit for analyzing knowledge practices. In this paper, we will focus on specialization (Maton 2016, p. 12-15), a dimension that provides an opportunity to explore the principles underlying teachers' practices with the use of ICT in different subjects in the school.

Specialization starts with the assumption that practices, viewpoints, or knowledge requirements are concerned with or oriented toward something or someone. Analytically, there is a distinction between epistemic relations (ER) between practices and their object or focus, and social relations (SR) between practices and their subject, author, or actor (carrying out practices). In the same way, knowledge claims are realized between epistemic relations (ER) and their object of study, and social relations (SR) between knowledge and its subjects or authors. These relations illuminate the question of what is legitimate, and can thus be described as knowledge and who can be a legitimate knower. Each of these relations can be either strong (+) or weak (-), thus creating four specialized and legitimizing codes: knowledge (ER+, SR-), knower (ER-, SR+), elite (ER+, SR+) and relativist (ER-, SR-). Figure 1 outlines four specialization codes, which can be defined as follows (Maton 2016, p. 13):

- *knowledge codes* (ER+, SR-), where possession of specialized knowledge, principles or procedures corning specific objects of study is emphasized at the basis of achievement, and attributes of actors are downplayed;
- *knower codes* (ER-, SR+) where specialized knowledge and objects are downplayed and the attributes of the actors are emphasized as measures of achievements, whether viewed as born (e.g. natural talent, cultivated (e.g. 'taste') or social (e.g. feminist standpoint theory);
- *elite code* (ER+, SR-), where legitimacy is based on both possessing specialist knowledge and being the right kind of knower; and
- *relativist codes (ER-, SR-),* where legitimacy is determined by neither specialist knowledge nor knower attributes – 'anything goes'.

These codes can be visualized with the following model.

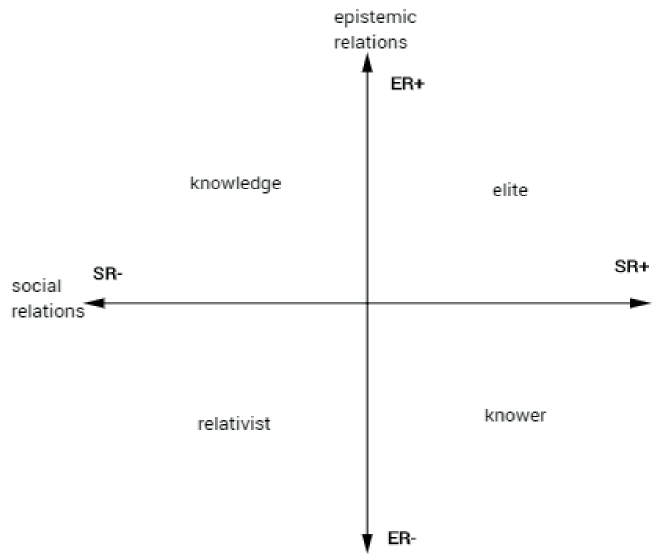

Figure 1
The specialization plane.

Analyzing government plans for the digitalization of schools

After 2000, Norwegian authorities began to engage in the large-scale digitalization of primary and secondary schools. The Norwegian curriculum — Knowledge Promotion (Utdannings- og forskningsdepartementet, 2006, Kunnskapsdepartementet, 2019) — em phasizes the development of digital competence and digital skills in all school subjects. The official program for school digitalization was further developed in two central plans: the Program for Digital Competence 2004-2008 (Utdannings- og forskningsdepartementet, 2004) and Future, Innovation, and Digitalization – Digitalization Strategy for Primary and Secondary Education from 2017 to 2021 (Kunnskapsdepartementet, 2017). A common characteristic of these documents is that they treat knowledge as a neutral category, and assume that technology can be integrated into the classroom without any friction. An analysis of selected documents (Kunnskapsdepartementet, 2017; Utdannings- og forskningsdepartementet, 2004) shows that technology is regarded as a means of changing education at several levels, including better learning, better learning outcomes, and a change in pedagogical methods in education (Bratland, 2018). In his analysis, using LCT specialization, Bratland shows that social relations are important in both plans, and that they legitimize the use of technology in education with new needs following the growth of a new type of labor market, where digital skills, creativity, problem solving, and applied knowledge are central. This means that social relations (SR+) have a strong position in the official plans for the digitalization of schools, while epistemic relations (ER-) hold a weaker position. The aim of digitalization is not the need to learn specialized knowledge in school subjects but rather the need to enable students to participate in social life and in a new workplace environment. This form of legitimizing digital technology privileges practices in education that are characterized by a knower code (Bratland, 2018). Previous research suggests that this situation leads to code clashes, and to some degree to code matches, between the official strategy for the digitalization of school and forms of knowledge in subject areas and knowledge practices in the classroom (Howard & Maton, 2011; Howard et al., 2015a).

This paper is based on LCT specialization (Maton, 2014; Maton, 2016), and highlights subjects' forms of knowledge and the importance of this knowledge for the integration of technology in schools. Based on the Norwegian government's strategy for the digitalization of education, it is interesting to determine how much teachers use ICT and how important they think ICT is for pupils' learning. One key aim is to investigate how including the scope and form of the integration of technology in the classroom is dependent on various forms of knowledge as they exist in subjects and teachers' knowledge practices in schools. In this way, the project aims to increase the understanding of how the integration of technology in schools depends on subjects' knowledge forms.

Method and data sources

This section will give a more detailed discussion of methods and data sources. It starts with a description of the schools and participants, the questioners, and the statistical methods that are used in the paper.

Schools and participants

This paper is based on the collection of data through an empirical survey among a number of schools in northern Norway (Nordland, Troms and Finnmark), by distributing an online questionnaire, and exploring teachers' perceptions of subject-area knowledge practices and technology integration. A total of 144 female (72%) and 56 male (28%) participants took part in the study. The asymmetrical distribution between the sexes is not surprising because female teachers dominate Norwegian lower secondary schools. However, the relationship between gender and the use of technology is not a part of this study. Of these participants, 68% work at schools with more than 250 students. Approximately 63% of the respondents have been teaching in elementary and lower secondary schools from 11 to over 21 years, while 37% have 1 to 10 years of experience. Around 50% of the respondents have been teaching in their current school for more than 11 years. Participants were teachers of mathematics, Norwegian, English, science, and social science in grades five to ten.

Questioners

The current study compares the questionnaire responses of mathematics and Norwegian teachers, concerning what they believe in terms of the use of technology in teaching their main subject area. Given our illustrative focus, a total of 152 teachers of mathematics (N = 77) and Norwegian (N = 75) responded to the questionnaire in 2018-2019.

The internal reliability of the instrument was measured by Cronbach's α. Overall, the teacher questionnaire proved to have sufficient internal reliability ($\alpha > 0.73$). The analysis presented draws on a subset of 13 items from the teacher questionnaire. The independent variables in this analysis were the subject areas of mathematics and Norwegian. The instrument consisted of one scale for ICT integration in teaching, and three scales for beliefs about the importance of technology use in teaching, with items measured on a four-point rating scale from 1 (*Strongly disagree*) to 4 (*Strongly agree*). There were four scales for focus groups in their main subject area, with items measured on a five-point rating scale from 1 (*Never*) to 5 (*Always*). This scale was used in a previous study (Howard et al. 2015a; Maton & Howard, 2016).

The four variables that are used to measure the LCT concept as defined in previous research (Maton & Howard, 2016) are illustrated in Figure 2. This form was used in a larger study from Australia (Howard & Mozejko, 2013), in which 2,373 teachers participated. Each item was measured on a four-point rating scale from 1 (*Not at all*) to 4 (*Very*).

How important are the following things to do well in the subject you primarily teach?

a. Having natural talent in your subject area.

(1) ❑ *(2)* ❑ *(3)* ❑ *(4)* ❑

b. Learning knowledge in you subject area.

(1) ❑ *(2)* ❑ *(3)* ❑ *(4)* ❑

c. Learning skills and procedures in your subject area.

(1) ❑ *(2)* ❑ *(3)* ❑ *(4)* ❑

d. Developing a 'feel for' in your subject area through experience.

(1) ❑ *(2)* ❑ *(3)* ❑ *(4)* ❑

Figure 2
Specialization items from the teacher questionnaire.

Statistical methods

A confirmatory factor analysis of the four variables that are used to measure LCT (see Figure 2) indicated that the items loaded as two components: $\chi 2(6, N = 152) = 160{,}98$, $p < .001$. Factor loadings and squared multiple correlations were examined (see Table 1). The outcomes of this analysis show how much each item contributes to these factors. Completely overlapping factors will result in a score of 1 or -1, whereas those having nothing in common with the factor will obtain a score of 0. The factor analysis created two different factors, one relating to epistemic relations (ER) and the other to social relations (SR). The items of the two factors contribute over 0.5 to the factors, which are within the ranges recommended for social science research (>.32) (Costello & Osbourne, 2005). Squared multiple correlations (R^2) for individual items show that the model is adequately represented by the observed measures, and between 59% and 88% of the variance in individual items is accounted for by their assigned factors. The factor loadings and squared multiple correlations support the factor structure of the LCT scale.

Table 1 R^2 factor loadings and Cronbach's α values for the 4-item LCT measure.

	R^2	ER	SR
b) Learning knowledge in your subject area	.88	.89	
c) Learning skills and procedures in your subject area	.86	.87	
a) Having natural talent in your subject area	.75		.79
d) Developing a 'feel for' your subject area through experience	.59		.51
Cronbach's α		.87	.44

Note. R^2 = Squared multiple correlations, ER=Epistemic relations, SR=Social relations.

For each factor, Cronbach's α was calculated based on the items that contributed over 0.5 to the factors (see Table 1). The values calculated for Cronbach's α are acceptable (0.44-0.87) in general. Some of the items had lower SR values, which was mainly due to the small number of items that contributed to the factors. The Spearman-Brown prediction formula shows that for these factors, slightly increasing the number of items will lead to acceptable Cronbach's α values. Due to this lower value, we presented the outcomes of factor analyses, as suggested by Taber (Taber, 2018), to support our measurement instrument (see Table 1).

As previously mentioned, questionnaire responses were numerically coded from 1 for '*Not at all*' to 4 for '*Very*'. The combined means of the second and third options on the item were used to calculate the epistemic relations, $ER = \sum \frac{b+c}{2}$, while the combined means of the first and fourth options were used to calculate the social relation, $SR = \sum \frac{a+d}{2}$. Mean scores were calculated for each of the two subject areas (mathematics and Norwegian). A total mean, averaging the two subject areas, was then calculated for the x-axis (SR) and y-axis (ER).

The analysis focuses on differences between the uses by and beliefs of mathematics and Norwegian teachers about technology integration. The analysis of teachers' responses gives us a picture of their perceptions of the kind of knowledge emphasized in their subject area. The strength of epistemic and social relations provides information on which of these capabilities is more important for students to be successful in a subject area.

Results

The questionnaire responses of mathematics and Norwegian teachers showed significant differences in how often they used computers in their teaching. These differences are presented in Figure 3, which indicates that Norwegian teachers in northern Norway reported (see Table 2) a greater use of technology in classroom practices (M=1.86, SD= .84) than did mathematics teachers (M = 1.35, SD = 0.64; p <0.001).

Table 2 Teachers' use of computers in northern Norway

	Subject	N	Mean	Std. Deviation
How often do you use a computer at school?	Mathematics	77	1.350***	.644
	Norwegian	75	1,866***	.843

Note. 5-point Likert scale, 0 = 'Never'; 1 = '1-2 times a week'; 2 = '3-4 times a week'; 3 = '5-6 times a week'; and 4 = '7+ times a week'.
*** The mean difference is significant at the 0.001 level (p < 0.001).

The findings show that mathematics teachers' computer use in northern Norway is significantly lower than that of Norwegian teachers.

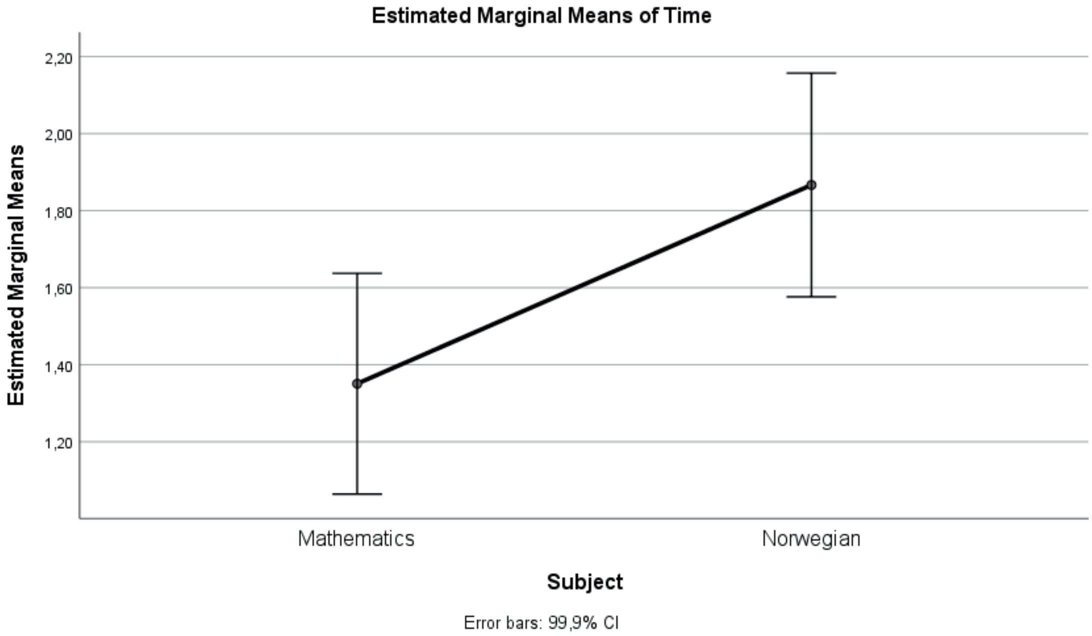

Figure 3
Computer use in northern Norway in mathematics and Norwegian.

Table 3 Teachers' beliefs about the importance of technology use in northern Norway in 2019.

	Subjects	N	Mean	Std. Deviation
It is important for me to work with a computer.	Mathematics	77	3.649	.601
	Norwegian	75	3.773	.452
It is important for students to work with a computer.	Mathematics	77	3.740	.523
	Norwegian	75	3.800	.402
I think working with computers should be a fun part of student learning.	Mathematics	77	3.493	.700
	Norwegian	75	3.653	.532

Note. 4-point Likert scale, 1 = 'Strongly disagree' to 4 = 'Strongly agree'.

Table 3 shows the differences in mathematics and Norwegian teachers' beliefs about the importance of technology in student learning and their own teaching. Even though these differences are not significant, they suggest that technology integration is valued less in mathematics than in Norwegian. The results from the specialization questionnaire item provide a way to understand the possible differences between the two subject areas. Figure 4 shows teachers' responses to the specialization item (see Figure 2) when they were asked to indicate the base of achievement in their subject area.

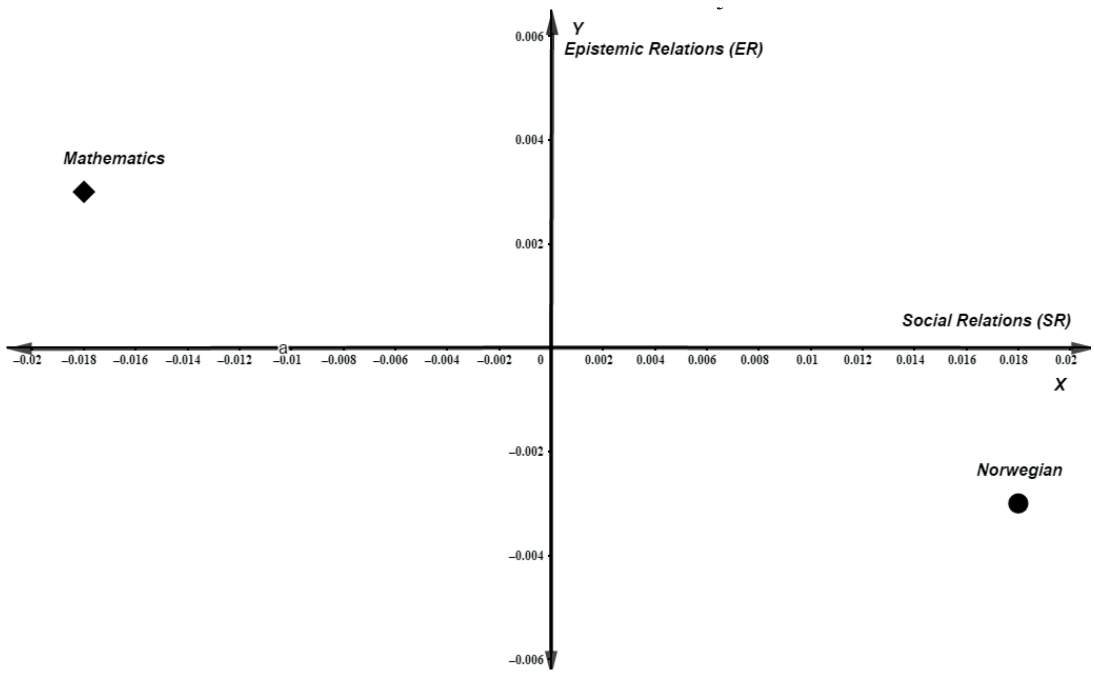

Figure 4
Teachers' perceptions of the bases of achievement in mathematics and Norwegian, 2019.

The results from the data collection, expressed in Figure 4, illustrate teachers' perceptions of the subject areas of mathematics and Norwegian. For each subject area, X and Y plots were determined by subtracting individual subject area ER and SR means from the total mean. The X and Y plots for each subject area identify their location on the specialization plane. Norwegian exhibits a *knower code* (SR+, ER-), and mathematics realizes a *knowledge code* (SR-, ER+). The results show that these subject areas include various forms of knowledge, with social and epistemic relations of different strengths, which determines teachers' perceptions of the subject area and what it takes to be successful in the subject. Norwegian is dominated by a knower code, where specialized knowledge is toned down and where the qualities of the knowing actors are stressed, particularly the acquisition of relevant experiences. In mathematics, the situation is the opposite. The subject area is marked by a knowledge code, where the epistemic relations are stronger than the social relations. In the subject, the possession of specialized knowledge and procedures is emphasized as the basis of achievement, and the attributes of the knowers are downplayed. These subject areas are not homogeneous but include different forms of knowledge, which is expressed in teachers' responses regarding the use of ICT in teaching and learning mathematics and Norwegian.

Table 4 Teacher focus groups in each subject area.

	Subject	N	Mean	St. Deviation
Write a first draft (e.g., writing in Word rather than on paper first)	Mathematics	77	2.311***	1.227
	Norwegian	75	3.640***	1.098
Create products with digital content (e.g., creating a product that includes images or graphics found online)	Mathematics	77	2.519***	.968
	Norwegian	75	3.306***	.853
My lessons are more student-centered when I plan to use computers in my teaching	Mathematics	77	2.727*	.754
	Norwegian	75	3.053*	.751
Using spreadsheets to create tables or graphs (e.g., create a bar graph in Excel or GeoGebra)	Mathematics	77	2.974***	1.038
	Norwegian	75	1.733***	1.031

Note. Five-point Likert scale, 1 = 'Never' 5 = 'Always. *** The mean difference is significant at the 0.001 level ($p < 0.001$). * The mean difference is significant at the 0.05 level ($p < 0.05$).

These differences in both the integration of ICTs and specialization codes for these subjects raise the possibility that the lower usage in mathematics (knowledge code) and the greater degree of integration in Norwegian (knower code) reflect their respective code clash and code match with the government's plans for digitalization of schools, respectively. To explore this further, we discuss the illustrative findings of teacher focus groups in each subject area. Norwegian teachers in northern Norway reported (see Table 4) more use of ICTs for writing in Word (M =3.64, SD = 1.09) than did mathematics teachers (M = 2.31, SD = 1.22; $p <$ 0.001), and for creating products with digital content (e.g., creating a product that includes images or graphics found online) (M =3.30, SD = 0.85) than did mathematics teachers (M = 2.51, SD = 0.96; $p < 0.001$). Similarly, when asked if they felt that their classroom practices were becoming 'more student-centered', mathematics teachers reported (M=2.727, SD=0.754) less agreement than Norwegian teachers (M=3.053, SD=0.751; p=0.008<0.05). Mathematics teachers often use ICTs to provide different ways for students to learn mathematical procedures and skills; for example, they reported (M=2.97, SD=1.03) a greater use of spreadsheet for creating tables or graphs (e.g., create a bar graph in Excel or GeoGebra) than did Norwegian teachers (M=1.73, SD=1.03; p<0.001). Teachers highlighted the knowledge needed for students to understand mathematics.

Discussion and conclusions

Authorities' ambitious plans to digitalize schools (Kunnskapsdepartementet, 2017) in Norway, as in other countries, have so far only been conditionally successful. There is a considerable gap between authorities' ambitions and realities in schools. This problem has triggered extensive research, highlighting several factors, such as a lack of digital competence, school cultural factors, available technological resources, and ICT management (Erstad, 2010; Law et al., 2008). Although these factors may contribute to technology integration in education, the role of knowledge is obscured in much of this research. This paper highlights teachers' knowledge practices in schools, arguing that subjects' forms of knowledge and the codes underlying teachers' knowledge practices play a crucial role in technology integration in education.

The analysis in this study reveals different patterns of technology integration, with varying degrees of 'code matches' and 'code clashes' inside the school subjects, but also between schools and official strategic plans. The connection between subject areas and the integration of technology in education has been emphasized in previous LCT studies (Howard & Maton, 2011; Howard et al, 2015a; Howard, et al., 2015b; Maton & Howard, 2016). This study shows that this claim, as well as the underlying principles that are uncovered, can be applied across different national education systems, and in a Norwegian school context, which has a structure characterized by relatively small schools, where teachers are obliged to teach in a number of different subjects. As this study illustrates, LCT is not locked into specific contexts but provides a means for exploring potential variations, where codes can take different forms depending on the strength of the social relations (SR) and epistemic relations (ER). The specialization codes reveal the principles underlying teachers' practices, and form a basis for legitimacy, which specifies how the technology should be used to support pupils' learning in the subject area. The paper draws on LCT specialization (Maton, 2014, Maton, 2016), and briefly discusses selected findings from a study of schools in northern Norway. The study focuses on teachers' perceptions and use of ICT in the key subjects of Norwegian and mathematics, and the analysis sheds light on the organizational principles underpinning the subject area and teachers' practices.

The analysis reveals that the subject areas of mathematics and Norwegian are based on different forms of knowledge, with different social and epistemic relations, which affect teachers' practices using technology in the classroom. These differences create degrees of code matches and code clashes between technology integration and subject areas (Maton, 2016). The Norwegian subject area is dominated by a k*nower code* (SR+, ER-), where social relations are strong. The subject area is characterized by a more extensive use of ICT. In teaching, teachers emphasize the development of students' skills, and technology is used to stimulate student writing with the development of digital forms of content production. These knower code practices are typically supported by student-centered and constructivist activities in classrooms. In the subject area of mathematics, which is characterized by a *knowledge code* (SR, ER+), we find a quite different form of technology integration. In mathematics, epistemic relations are stronger, while social relations are weaker, and specialized knowledge and skills are central, with the use of technology being guided by teachers' perceptions of how students can best learn the subject. The use of technology in mathematics is more limited, compared to Norwegian, with a more selective use technology, where the purpose is to learn specialized knowledge in the subject. In mathematics, students should learn procedures and skills, and teachers in the subject place more emphasis on using spreadsheets to create tables or graphs, and place less emphasis on meaning creation and digital content production. In mathematics, teachers, to a lesser extent, agree that student-centered classroom practices lead to the learning of knowledge and skills in the subject area.

The analysis of teachers' perceptions and use of technology in mathematics and Norwegian shows that the underlying organizational principles, expressed by the specialized codes of the subjects, play a crucial role in the integration of technology in these subject areas (Howard & Maton, 2011; Howard et al., 2015a; Howard, et al. 2015b; Maton & Howard, 2016). Different subject areas interact differently with digital technology, and this interaction determines the scope and form of integration in the classroom. Norwegian teachers describe a greater degree of integration of ICTs within their classrooms compared to mathematics teachers. Norwegian is dominated by a knower code, and there is a large degree of match between technological practices and knowledge practices in the subject. We find another pattern for mathematics. Mathematics is dominated by a knowledge code, with knowledge practices that emphasize epistemic relations. Here, technological practices come into use to the extent that they are considered valuable for knowledge practices in mathematics.

Compared to the government's digitalization strategy (Bratland, 2018, (Kunnskapsdepartementet, 2017, Utdannings- og forskningsdepartementet, 2006), which emphasizes knower-code-driven technological practices, this form of practice leads to code clashes with the goals set by authorities, with a lower integration of technology in the subject area. Because Norwegian authorities' initiative is characterized by a knower code, there seems to be a large degree of match between authorities' digitalization strategy and the technology practices that exist in subjects such as Norwegian. The goals formulated in authorities' digitalization plans seem to match rather well with teachers' knower code practices in Norwegian, where the teachers describe a greater degree of technology integration in classrooms. More generally, the LCT-driven analysis shows that the patterns of technology integration in classrooms are far more complex and composite than the ideas underlying the government's plans for the digitalization of education (Bratland, 2018, Howard & Maton, 2011; Howard et al., 2015a; Howard et. al, 2015b; Maton & Howard, 2016). Authorities' strategy assumes that technology integration can take place in a homogeneous way across different subject areas. However, the analysis in this study suggests a quite different approach. Technology integration does not take place in a homogeneous way, and education policy should take into account subjects' different forms of knowledge, where the relevant use of technology should match the underlying specialization codes in the subject areas.

The present study sheds light on how the subject area contributes to technology integration in Norwegian classrooms. However, more research is needed to fully understand the relationship between subject area and technology integration. Key issues will include teachers' pedagogical choices using technology in the subject area, how practices change as a result of technology integration, and how technology can support learning and contribute to better learning outcomes and student achievement. It should also be noted that the interpretations of the findings in this paper have limitations related to the voluntary nature of participation in the survey, the possibility of biased views, the number of teachers who participated, and weak competence in the subject area of individual teachers. Some of these limitations are associated with difficulties in collecting large amounts of data in Norwegian schools. As independent researchers, we encountered a system in which all data collection takes place via the school's principal. The system of distribution of questionnaires to teachers via the principal limited our opportunities to ensure a sufficiently good and purposeful distribution, which was reflected in our data material. These limitations have undoubtedly affected the results of our study. Future research should take these limitations into account.

In conclusion, knowledge matters in education, and the specialization codes underlying teachers' knowledge practices seem to explain the different degrees of technology integration in different subject areas, including the forms taken by the use of ICT in classrooms (Howard & Maton, 2011; Howard et al., 2015a). The use of technology is guided by knowledge practices in the subject area, and LCT-conducted research can help provide greater insights into how technology can best be integrated into education.

References

Archer, K., Savage, R., Sanghera-Sidhu, S., Wood, E., Gottardo, A., & Chen, V. (2014). Examining the effectiveness of technology use in classrooms: A tertiary meta-analysis. *Computers & Education, 78*(C), 140-149. https://doi.org/10.1016/j.compedu.2014.06.001

Arnseth, H. C. (2007). *Skolens digitale tilstand 2007* (Vol. 2007). Forsknings- og kompetansenettverk for IT i utdanning.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity: theory, research, critique.* Rowman & Littlefield.

Blikstad-Balas, M. (2015). Digital literacy in upper secondary school – what do students use their laptops for during teacher instruction? *Nordic Journal of Digital Literacy, 2015*(4), 122-137. https://doi.org/10.18261/ISSN1891-943X-2012-02-01

Bratland, E. (2016). The rules of the game: What role do specialized codes in the subjects play for the use of ICT in education? In D. Siemieniecka (Ed.), *Education and new technologies in culture, information and communication* (pp. 23-40). Adam Marszałek.

Bratland, E. (2018). Code clash and code match in education: why does the government's digitalization strategy clash with teachers' knowledge practices in school subjects? In D. Siemieniecka (Ed.), *Virtuality and Education – Future Prospects* (pp. 201-216). Adam Marszalek.

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research & evaluation, 10*(7), 1-9. https://doi.org/10.7275/jyj1-4868

Egeberg, G., Hultin, H., & Berge, O. (2016*). Monitor skole 2016. Skolens digitale tilstand.* Senter for IKT i utdanningen.

El Ghami, M., Bratland, E., & Valstad, I. L. (2021). Subject areas and teacher's integration of technology in education: What significance does the subject area have in a Norwegian school context?. In A. Strømmen-Bakhtiar, R. Helde, & E. Suzen (Eds.), *Supplemental Instruction. Digital Technologies* (Vol. 1, pp. 29-41). Waxmann.

Erstad, O. (2010). *Digital kompetanse i skolen.* Universitetsforl.

Fjørtoft, S. O., Thun, S., & Buvik, M. P. (2019). *Monitor 2019 – En deskriptiv kartlegging av digital tilstand i norske skoler og barnehager.* SINTEF.

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' Technological Pedagogical Content Knowledge and Learning Activity Types: Curriculum-based Technology Integration Reframed. *Journal of Research on Technology in Education, 41*(4), 393-416. https://doi.org/10.1080/15391523.2009.10782536

Hatlevik, O. E. (2013). *Om digital kompetanse og erfaringer med bruk av IKT i skolen* (Vol. 2013). Senter for IKT i utdanningen.

Hatlevik, O. E., & Kløvstad, V. (2009). *Skolens digitale tilstand 2009* (Vol. 2009). Forsknings- og kompetansenettverk for IT i utdanning.

Helleve, I., & Almås, A. G. (2017). Teachers' Experiences with Networked Classrooms in Norway. *Education research international, 2017*, 1-9. https://doi.org/10.1155/2017/8560171

Howard, S. K., Chan, A., & Caputi, P. (2015a). More than beliefs: Subject areas and teachers' integration of laptops in secondary teaching. *British Journal of Educational Technology, 46*(2), 360-369. https://doi.org/10.1111/bjet.12139

Howard, S. K., Chan, A., Mozejko, A., & Caputi, P. (2015b). Technology practices: Confirmatory factor analysis and exploration of teachers' technology integration in subject areas. *Computers and education, 90*, 24-35. https://doi.org/10.1016/j.compedu.2015.09.008

Howard, S. and Mozejko, A. (2013), "DER-NSW evaluation: Conclusions from the 2013 data collection". Faculty of Social Sciences – Papers. 5, https://ro.uow.edu.au/sspapers/543

Howard, S., & Maton, K. (2011). Theorising Knowledge Practices: A Missing Piece of the Educational Technology Puzzle. *Research in Learning Technology, 19*(3), 191-206. https://doi.org/10.1080/21567069.2011.624170

Kløvstad, V., Søby, M., Kristiansen, T., & Erstad, O. (2005). *På vei mot digital kompetanse i grunnopplæringen* (Vol. 2/2005). Forsknings- og kompetansenettverk for IT i utdanning.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education, 59*(4), 1109-1121. https://doi.org/10.1016/j.compedu.2012.05.014.

Krumsvik, R. J. (2016). *Digital læring i skole og lærerutdanning* (2. ed.). Universitetsforlaget.

Krumsvik, R. J., Berrum, E., & Jones, L. Ø. (2018). Everyday Digital Schooling – implementing tablets in Norwegian primary school. *Nordic Journal of Digital Literacy, 13*(3), 152-176. https://doi.org/10.18261/issn.1891-943x-2018-03-03

Kunnskapsdepartementet. (2017). *Framtid, fornyelse og digitalisering. Digitaliseringsstrategi for grunnopplæringen 2017-2021(FFD, 2017).* https://www.regjeringen.no/no/dokumenter/framtid-fornyelse-og-digitalisering/id2568347/

Kunnskapsdepartementet. (2019). *Læreplanverket for Kunnskapsløftet 2020 (LK20).*

Law, N., Pelgrum, W. J., & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world: findings from the IEA SITES 2006 Study* (Vol. 23). Comparative Education Research Centre, The University of Hong Kong and Springer.

Ludvigsen, S. R., & Rasmussen, I. (2006). Modeller på reise. *Nordic Journal of Digital Literacy*, *1*(3), 227–251. https://doi.org/10.18261/ISSN1891-943X-2006-03-05

Madsen, S. S., Thorvaldsen, S., & Archard, S. (2018). Teacher educators' perceptions of working with digital technologies. *Nordic Journal of Digital Literacy, 13*(3), 177-196. https://doi.org/10.18261/issn.1891-943x-2018-03-04

Maton, K. (2014). *Knowledge and knowers: towards a realist sociology of education*. Routledge.

Maton, K., Hood, S., & Shay, S. (2016). *Knowledge-building: educational studies in legitimation code theory*. Routledge.

Maton, K. (2016). Building knowledge about knowledge-building. In K. Maton, S. Hood, & S. Shay (Eds.), *Knowledge-building : educational studies in legitimation code theory* (pp. 1-23). Routledge.

Maton, K., & Howard, S. (2016). LCT in mixed- methods research: evolving an instrument for quantitative data In K. Maton, S. Hood, & S. Shay (Eds.), *Knowledge-building. Educational studies in Legitmation Code Theory* (pp. 67-89). Routledge.

Maton, K., & Chen, R. (2020). Specialization codes: Knowledge, knowers and student succes. In J. R. Martin, Y. J. Doran, & K. Maton (Eds.), *Accessing Academic Discourse : Systemic Functional Linguistics and Legitimation Code Theory.* Routledge.

Maton, K., & Moore, R. (2010). *Social realism, knowledge and the sociology of education: coalitions of the mind.* Continuum.

Otnes, H. (2009). *Å være digital i alle fag.* Universitetsforl.

Selwyn, N. (2016). *Education and technology: key issues and debates* (2. ed.). Bloomsbury.

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education, 48*(6), 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What Forty Years of Research Says about the Impact of Technology on Learning: A Second-Order Meta-Analysis and Validation Study. *Review of Educational Research, 81*(1), 4-28. https://doi.org/10.3102/0034654310393361

Utdannings- og forskningsdepartementet (2004). *Program for digital kompetanse 2004-2008* (PDK, 2004). Utdannings- og forskningsdepartementet.

Utdannings- og forskningsdepartementet (2006). *Kunnskapsløftet: læreplan for grunnskolen og videregående opplæring (LK06).* Utdannings- og forskningsdepartementet.

Webb, M., & Cox, M. (2004). A review of pedagogy related to information and communications technology. *Technology, Pedagogy and Education, 13*(3), 235-286. https://doi.org/10.1080/14759390400200183