How to increase the potential of digital learning in achieving both cognitive and non-cognitive learning outcomes?

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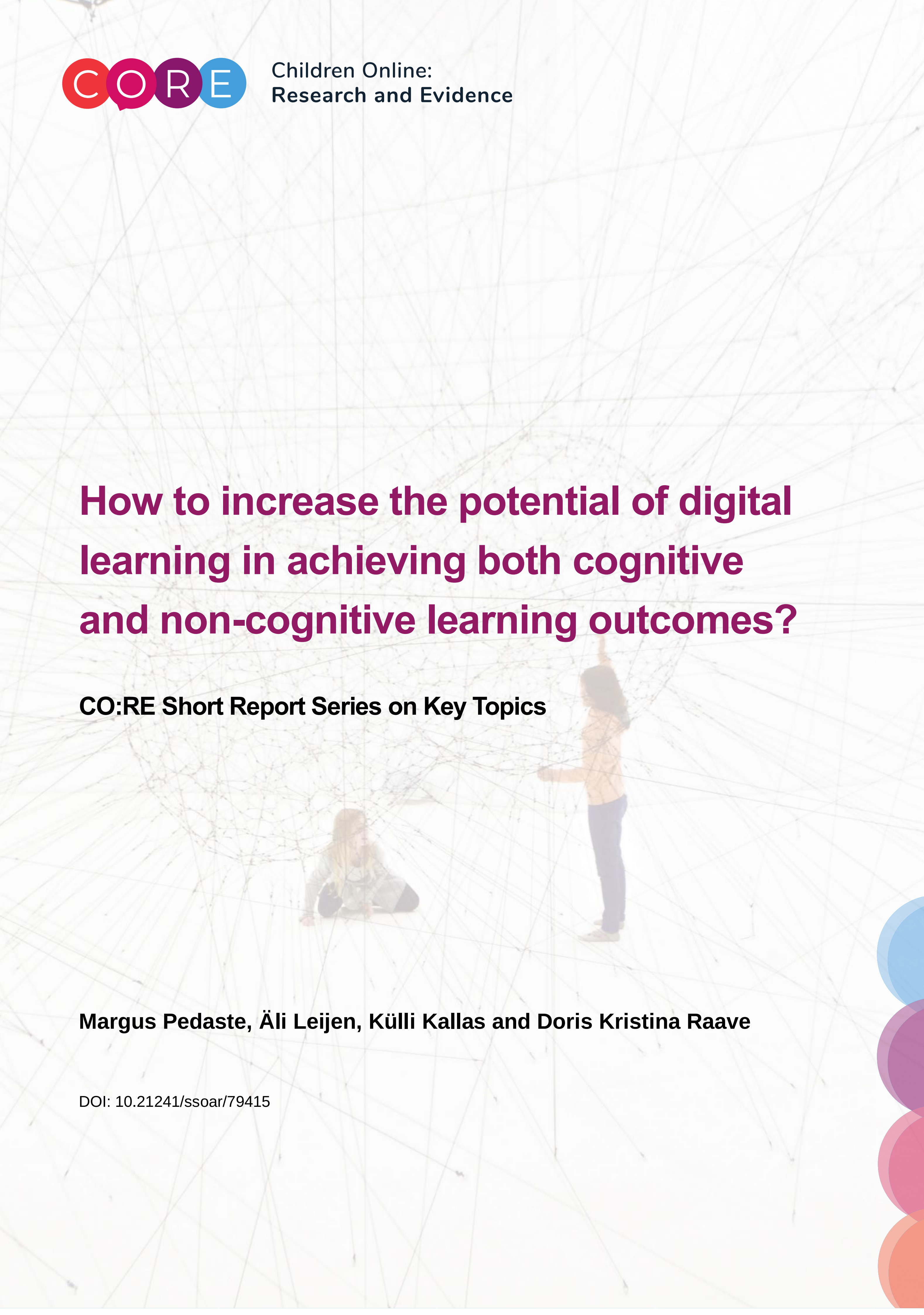
Erstveröffentlichung / Primary Publication
Kurzbericht / abridged report



Children Online: Research and Evidence

How to increase the potential of digital learning in achieving both cognitive and non-cognitive learning outcomes?

CO:RE Short Report Series on Key Topics

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DOI: 10.21241/ssoar/79415

Please cite this report as:

Pedaste, M., Leijen, Ä., Kallas, K., & Raave, D. K. (2022). *How to increase the potential of digital learning in achieving both cognitive and non-cognitive learning outcomes?* (CO:RE Short Report Series on Key Topics). Hamburg: Leibniz-Institut für Medienforschung | Hans-Bredow-Institut (HBI); CO:RE – Children Online: Research and Evidence. https://doi.org/10.21241/ssoar/79415

Editors: Veronika Kalmus and Signe Opermann
Language editor: Michael Haagensen

The CO:RE Project is a Coordination and Support Action within the Horizon 2020 framework, which aims to build an international knowledge base on the impact of technological transformations on children and youth. Part of the knowledge base is a series of short reports on relevant topics that provide an overview of the state of research. This part is coordinated by Veronika Kalmus (University of Tartu, Estonia).

For all reports, updates, insights, as well as full details of all CO:RE consortium members and CO:RE national partners throughout Europe and beyond, please visit **core-evidence.eu**.

This project has received funding from the European Union’s Horizon 2020 EU.3.6.1.1 – The mechanisms to promote smart, sustainable and inclusive growth DT-TRANSFORMATIONS-07-2019 – The impact of technological transformations on children and youth. **Grant Agreement ID 871018.**

Acknowledgement:

The work described in this report is funded by the Estonian Ministry of Research and Education as part of the project DIGIVARA5 “The effect of using digital learning materials for learning and teaching in the context of Estonian basic school”.

Contents

Key insights

- Remote learning increases the need for excellent **digital competences** and **self-regulation skills**. Therefore, we need to better understand digital competences for learning, support student self-regulated learning and then also find how digital competences and self-regulation could help to better achieve various **cognitive and non-cognitive learning outcomes**.
- Digital competences in the context of learning need to be re-conceptualised to meet contemporary needs in schools. Current attempts have resulted in theoretical models that have not been confirmed empirically or only using rather simple empirically tested models that are not detailed enough to support learners and teachers in focusing on improving the different dimensions of digital competence.
- The Estonian **DigiEfekt project** re-conceptualises digital competence through **10 dimensions** and focuses on the question of how different approaches to applying digital devices, environments and content in learning will have an effect on digital competence and several other cognitive and non-cognitive learning outcomes.
- Preliminary findings of the DigiEfekt project show that students have rather **good digital competences** for **communication and collaboration**, **digital content creation**, and for **safe learning** while being **not so proficient at programming**, performing various technical operations or following the rules in digital learning environments. In addition, their attitudes are often not in favour of using digital solutions for learning although they have sufficient support from others and do not have much anxiety in using technologies.
- **Teachers are key stakeholders in supporting students** in acquiring appropriate digital competence for learning. Teachers need to guide learners towards meaningful self-regulated learning. Students should have sufficient autonomy but also receive support in the self-regulation of the learning process in four areas: cognitive, metacognitive, motivational, and emotional. Teachers need to consider the affordances of technology so that it is used not only for substitution and augmentation (functional improvement) of the learning process but also to support enacting modified and redefined learning processes and goals.
- The Covid-19 pandemic and the unstable situation in countries at war have significantly increased the **need to learn remotely** in various digital learning environments.

What is the problem?

The Covid-19 pandemic opened a new era in education by rapidly increasing the need for remote learning. Many schools, teachers, students and even parents struggled with new realities, where online learning was an everyday practice and learners had to self-regulate their learning with varying levels of guidance from teachers, parents, peers or siblings at home. Several studies have revealed the challenges in this new situation. For example, Gerard et al. (2022) demonstrated how teachers in supporting self-regulated learning using open educational resources creatively established new ways of using technology for transmitting information or increasing productivity. Lepp et al. (2021) showed how the first decisions of the teachers in this new context were mostly motivated by short-term goals, such as maintaining student social interaction and supporting student motivation. This means that the subject-specific, mostly cognitive, learning goals became less important than several non-cognitive learning goals. From their interviews with teachers, Rannastu-Avalos and Siiman (2020) found that they started to use video conferencing tools to engage in synchronous communication with students and continued to use the school's learning management systems to share information. In contrast, none of the teachers in their study felt that the remote learning situation was conducive to supporting collaborative learning. In the new situation, teachers often tried to regulate the learning process remotely or gave the students some autonomy in preparing their weekly study plans without specific guidance for the digital learning process or how to self-regulate. Therefore, challenges were revealed in relation to acquiring good digital competences for learning and self-regulated learning competences.

Self-regulated learning has been systematically described by Panadero (2017) in a review of various frameworks of self-regulated learning. According to him, it is important to pay attention to three learning phases and in each of them to four areas that should be regulated. The learning phases include a preparatory phase, a performance phase, and an appraisal phase. The first is necessary for identifying and setting learning goals. Clear learning goals also need to be set in remote learning settings using digital devices, learning environments and content. In addition, in the preparatory phase activities should be planned for the digital learning process. Therefore, an awareness of the affordances of digital devices and learning environments is necessary (see Otchie et al., 2021). In the performance phase the focus is on cognitive processing of the content by applying different learning strategies and monitoring the learning process to improve performance. The appraisal phase is for looking back so as to evaluate the student's progress and reflect on it. The four areas that should be regulated in all learning phases are cognition (thinking processes), metacognition (regulation process), motivation, and emotions.

In other words, it is clear that self-regulation is important in remote learning using digital devices, learning environments and content. However, several studies show that there has not been enough attention paid to using educational technologies to support all phases and areas of self-regulation. For example, Pedaste and Leijen (2018) found in their analysis of research on 11 existing advanced educational technologies that these are mainly designed to improve subject knowledge and skills or to support collaboration and to some extent self-regulation. However, less attention has been given to learning skills and especially subjective well-being. It could be understood that motivation and emotional regulation have been supported less. Another review by Hooshyar et al. (2020) focused on studying open learner models in supporting self-regulated learning. The analysis of 64 articles revealed that in the preparation phase the focus was most often on metacognition but never on emotions. In the performance and appraisal phases, the main focus was on cognition and less on metacognition and motivations, and the least on emotions. Edisherashvili et al. (2022) reviewed 38 studies supporting self-regulated learning in distance education environments at the higher education level. The findings showed that metacognition regulation and self-regulation support in the performance phase has been extensively studied while emotion regulation and preparatory and appraisal phases remain understudied. Therefore, support for emotional regulation might be much more needed in online learning settings (e.g., allowing learners to express their emotions using emoticons or enabling expression or emotions through video- and audio-based tools). In conclusion, self-regulation in online learning settings seems to be understudied because previous research has not paid enough attention to all phases of the learning process and areas that need to be supported. Therefore, the scientific knowledge gained from earlier studies seems to be insufficient for transferring the knowledge to remote learning settings.

Consequently, it is evident that for remote learning in the context of Covid-19, the need for digital competences for learning and self-regulation skills increased, but in addition, we also need to pay attention to other expected learning outcomes. This means that digital competence and self-regulation are needed to achieve a range of other cognitive and non-cognitive learning outcomes (e.g., science competence, maths competence, communication competence, skills for using digital devices, environments and content for learning, attitudes towards learning with technologies). Therefore, the first challenge is to better understand digital competence for learning, the second challenge is to support student self-regulated learning, and the third challenge is to identify how digital competence and self-regulation could help to better achieve various cognitive and non-cognitive learning outcomes.

What is digital competence?

In the European context, digital competence has mostly been defined through the DigComp framework. DigComp 2.2 (see Vuorikari et al., 2022), the latest version of the framework, was launched in March 2022. According to the definition in this document, digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It means that the focus of this framework is broader than just the learning context. Similar to earlier versions, this framework specifies that digital competence entails more specific competences in five competence areas (see Figure 1).

It is possible to elaborate how all five competence areas specified in the DigComp framework could be implemented in the learning context. However, there are three issues with this model. First, according to our best knowledge there are no

Information and data literacy	1.1. Browsing, searching and filtering data, information and digital content 1.2. Evaluating data, information and digital content 1.3. Managing data, information and digital content
Communication and collaboration	2.1. Interacting through digital technologies 2.2. Sharing information and content through digital technologies 2.3. Engaging in citizenship through digital technologies 2.4. Collaboration through digital technologies 2.5. Netiquette 2.6. Managing digital identity
Digital content creation	3.1. Developing digital content 3.2. Integrating and re-elaborating digital content 3.3. Copyright and licences 3.4. Programming
Safety	4.1. Protecting devices 4.2. Protecting personal data and privacy 4.3. Protecting health and well-being 4.4. Protecting environment
Problem solving	5.1. Solving technical problems 5.2. Identifying needs and technological responses 5.3. Creatively using digital technologies 5.4. Identifying digital competence gaps

Figure 1: The DigComp conceptual framework (based on Vuorikari et al., 2022: 4)

studies showing that these competence areas could be distinguished in empirical studies.

The framework has been developed by experts and it is possible to explain how digital competence could be developed in these five areas or how one can assess his/her own competence systematically using the DigComp framework. In this way DigComp has been extensively used in many countries, including Estonia, where it is integrated into the national curriculum. Therefore, DigComp is suitable for describing digital competence, and setting goals for improving competence and self-assessment; however, there are missing assessment instruments that enable us to test digital competence so that these five areas could be distinguished. This might be seen as a limitation because research shows that self-evaluation and competence tests tend to correlate poorly. For example, Hofmann et al. (2005) found in their meta-analysis that the correlation between the Implicit Association Test and explicit self-report measures is only .24. Therefore, it might be questioned whether this framework reflects the competence areas that could be assessed and promoted in the learning context to support students in remote learning settings.

One more aspect of the DigComp framework is that it does not put much emphasis on attitudes for behaving according to the knowledge and skills one has. At the same time, attitudes are considered an integral part of a competence and attitudes often predict the development of knowledge and skills (in the case of positive attitudes the learner focuses more on improving knowledge and skills and the learning outcomes are better). The final limitation of the DigComp framework is that it is not contextualised. However, this is a key goal in remote learning settings.

The contextualisation of digital competence has been an important characteristic of several other frameworks. For example, Martin (2009) presented DigComp-specific competence areas as only the first level of digital literacy – a term that is used mostly as a synonym of digital competence. At the second and third level, Martin posits digital usage and digital transformation (see Figure 2). Digital usage refers to the skills, concepts, approaches and attitudes being applied in professional contexts. For learners it means that digital competence should be contextualised in the learning process.

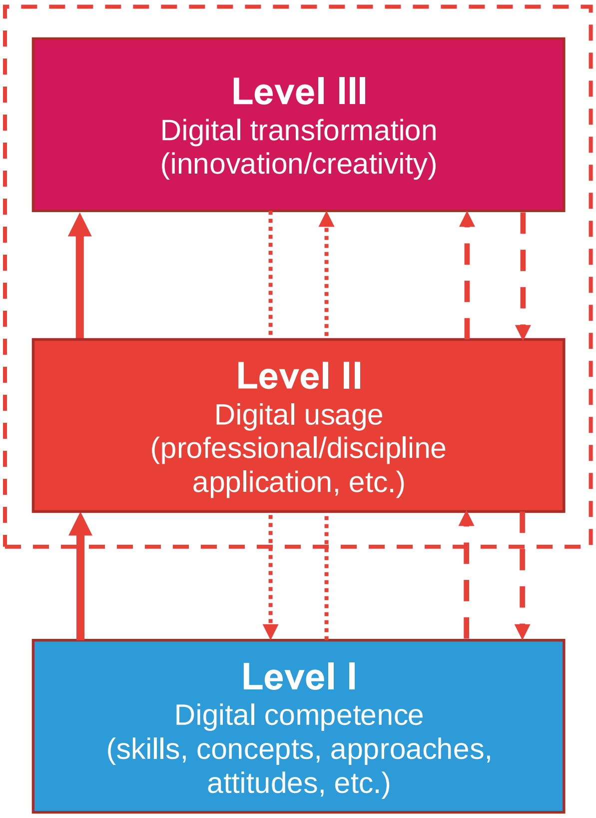

Figure 2: Levels of Digital literacy (based on Martin, 2009: 8)

This is not the case under the DigComp framework. Martin (2009) adds that at the highest levels, digital competence should lead to creative innovation for digital transformation. In the learning context this entails finding creative ways to use technology. It is not only the teacher who should guide learners to use technology (often in a predefined way) but the students could develop new ways of benefitting from the use of digital technologies.

Synthesising the ideas introduced in the DigComp framework with the levels of digital literacy (Martin, 2009), we can see that in the context of learning, students need to know how their digital competence could be contextualised depending on the digital devices they are using, their digital learning environments, as well as the digital content provided for them in the learning situation at hand. However, in addition, teachers should give them enough space to regulate their own learning process. To some extent students should have the autonomy to choose the digital tools (i.e., devices, environments, content) they use for learning. This could be seen as a prerequisite for digital transformation – the process through which students innovate the learning process by inventing new ways of learning. When the students reach the digital transformation level, they should be ready to use technology meaningfully and effectively in any new situation, such as, for example, in the remote learning settings they were suddenly faced with due to the Covid-19 pandemic. The students (and also teachers) who were capable of digital transformation smoothly found creative innovative solutions to achieve their learning goals in the changed situation.

Teachers also have a major role in supporting learners to be proactive agents in their own remote learning process supported by digital tools. First, as already mentioned, they need to leave students sufficient space for autonomy and self-regulation. Second, they could also support learners in adapting, modifying and redefining the learning process. In this context the SAMR model is relevant, specifying four different levels of technology use in the education context – substitution, augmentation, modification and redefinition (Hamilton et al., 2016; see Figure 3). In the case of substitution, digital tools are used to substitute the learning process with no functional change in the learning process. For example, a regular schoolbook is replaced by its electronic version that does not have additional functionalities. Augmentation means that there is some functional improvement; for example, the e-book has hyperlinks to quickly reach other content in the same e-book or even in other sources through the internet. Substitution and augmentation are formats of technology use where technology enhances the learning process but does not transform it significantly. Transformation happens through modification and redefinition in the context of the SAMR model. In the case of modification, the task will be redesigned; for example, collaborative writing is possible in a cloud-based document. Redefinition specifies technology use that opens new opportunities for activities that were not even possible without technology; for example, learners can visit blood vessels and learn about oxygen transport by travelling on a blood cell in a virtual world using a head mounted device. In conclusion, digital competence in the context of learning is not limited to the skilful use of various digital technologies but also entails the ability to contextualise technology use and support the transformation of the learning process by aptly integrating the potential of digital technologies.

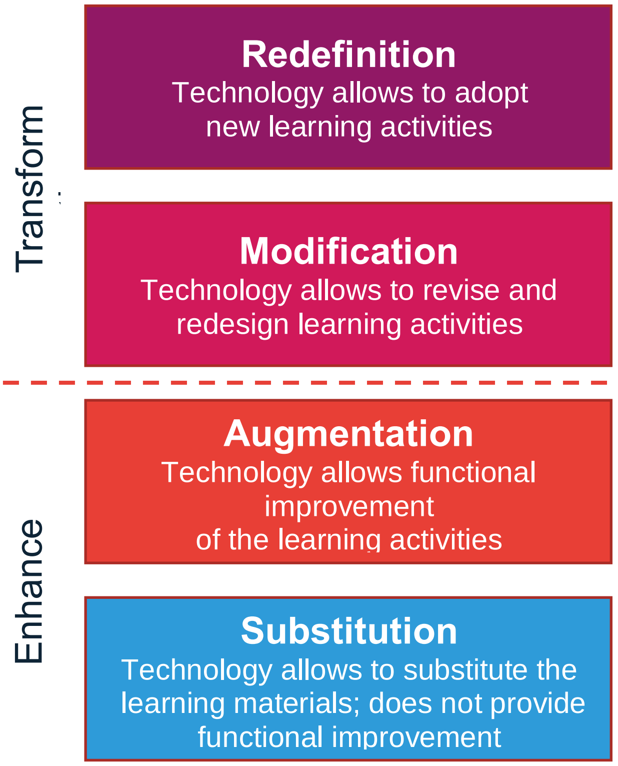

Figure 3: Puentedura's (2006) Substitution, Augmentation, Modification, and Redefinition (SAMR) model (based on www.hippasus.com/rrpweblog/)

In addition, digital competence includes a behavioural dimension; for example, expressing positive attitudes and employing technology meaningfully.

What are the educational challenges?

In the context of the Estonian DigiEfekt project, a new instrument was developed that allows re-conceptualising digital competence through ten dimensions (see also Pedaste et al., 2021 for an overview of the first phases of developing the instrument). In addition, classroom observations in the project have identified common practices in the use of technology in studying mathematics, science and mother tongue in primary and lower secondary schools. The next challenge is to find how different approaches to applying digital devices, environments and content in learning will have an effect on digital competence and several other cognitive and non-cognitive learning outcomes.

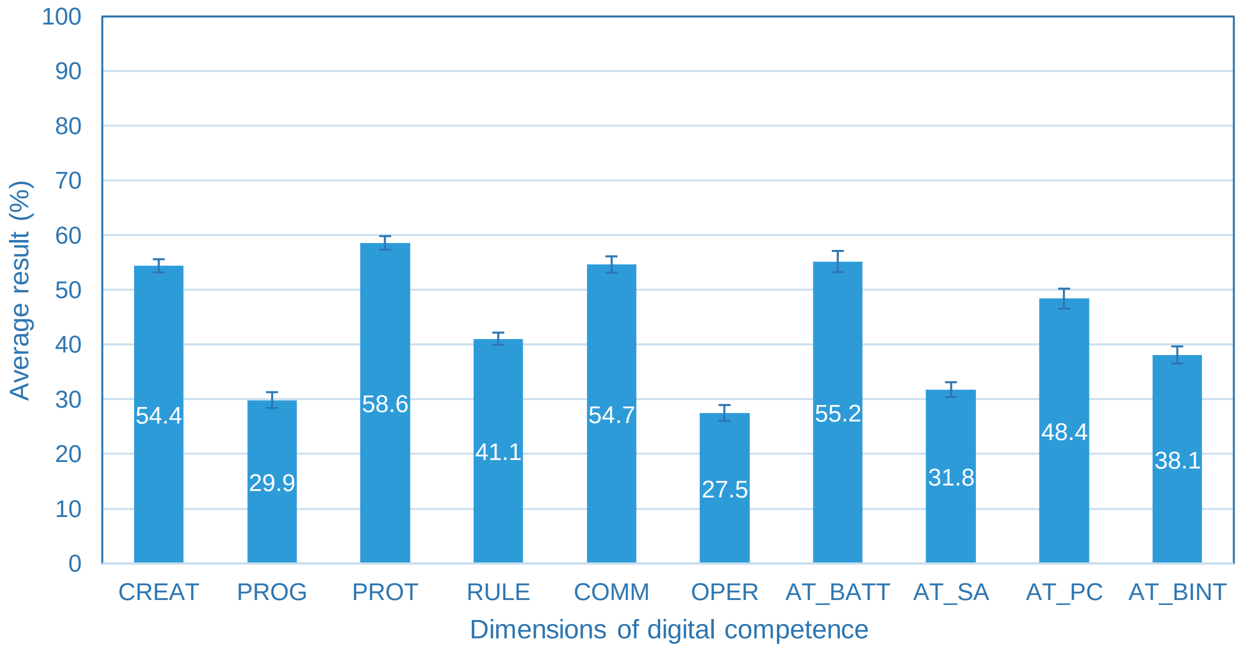

Figure 4: Student scores on ten dimensions of digital competence based on average values with standard error (%)

Note: Explanation of the abbreviations as in Figure 4. CREAT – creating digital materials, PROG – programming digital content, OPER – performing operations with digital tools, COMM – communicating in the digital world, RULE – following the rules in the digital world, PROT – protecting oneself and others in the digital world, AT_BATT – behavioural attitudes, AT_SA – social aspects, AT_PC – perceived control, AT_BINT – behavioural intention.

Preliminary findings of the DigiEfekt project in assessing the digital competence of 426 students can be seen in Figure 4. It appears that students have rather good digital competences for communication and collaboration, digital content creation (although it is not so easy to assess how good a webpage or video is for learning) and for protecting themselves and others in the digital world, while not performing so well in programming or in various technical operations in digital learning environments. In addition, it appeared that they often do not know how to follow different rules correctly in the digital learning context (e.g., licencing and authoring of content, age-dependent access to learning environments). It was also found that their attitudes are often not in favour of using digital solutions for learning (e.g., video vs face-to-face lessons, e-worksheet vs paper-worksheet, discussion in digital environment vs an oral discussion in the classroom), although they do not have much anxiety in using digital devices, learning environments and content. It seems that the students do not feel that teachers expect them to use digital technologies in the learning process. In conclusion, it seems that students' digital competences might vary remarkably on these different dimensions. Therefore, systematic assessment of digital competences for learning is needed to support more accurate planning of actions to improve competence levels.

Classroom observations showed that technology was used in one way or another in 82% of the 167 lessons observed so far in the DigiEfekt project. In these lessons, 269 activities were identified where digital technology was used. However, when used, it mainly happened in the form of substitution (61.1% of activities) or augmentation (33.5% of activities), but the technology was rarely used in a way that could be associated with the modification (2.2%) of learning activities or in a way that enables teachers to redefine the learning activities according to the affordances of digital technologies (3.3%); in other words, provide hybrid learning. This is well in line with the findings from one of our earlier studies that showed that Estonian student teachers and teachers felt they had good competences to use ICTs for supporting teaching and learning, but they had much poorer awareness of the purposes of ICT in planning teaching and learning (see Leijen et al., 2021). In 58.6% of cases, the technology is only used by teachers.

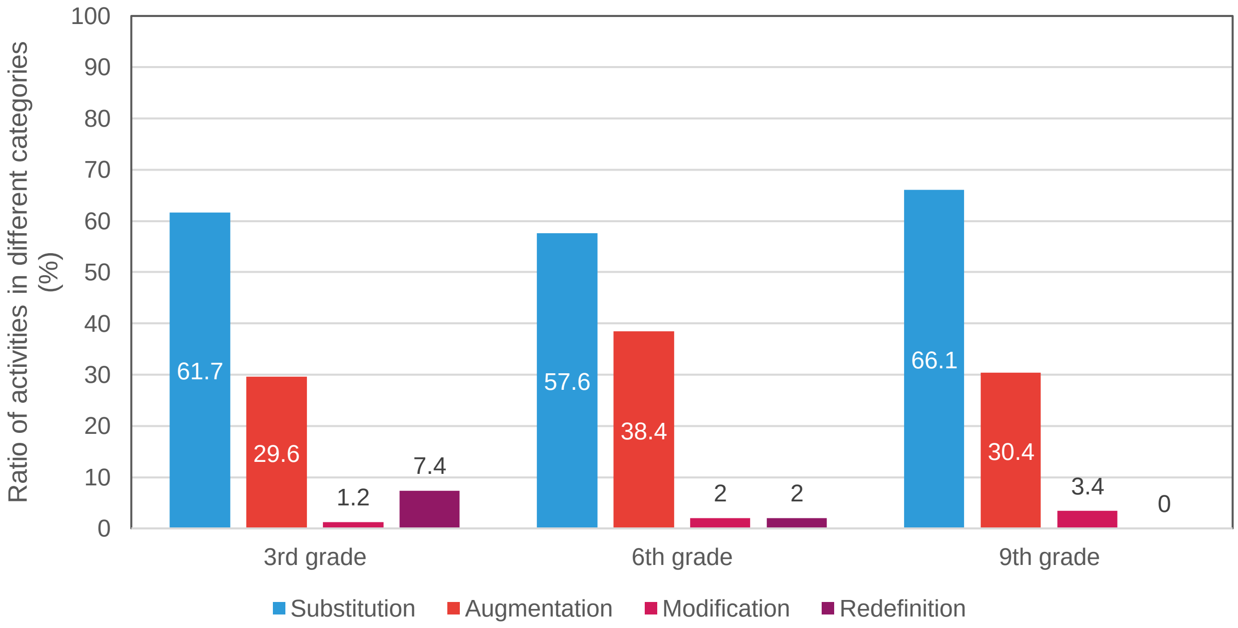

Figure 5: Technology-enhanced learning activities in Estonian mathematics, science and mother tongue classrooms in the 3rd, 6th and 9th grades according to the dimensions of the SAMR framework (%)

Some differences might be seen across grades – the older the students, the more activities are at the modification level (see Figure 5).

In conclusion, these are the following challenges in classrooms to applying the affordances of digital technologies meaningfully:

- More focus is needed on developing learners' programming skills, operational skills and knowledge about the rules in the digital world.
- Teachers need to guide students towards more meaningful uses of digital technologies by expressing their own interest in the purposeful and diverse implementation of the different affordances of technology; for example, to support the modification and redefinition of learning activities.
- Digital competences for learning should be systematically tested in order to make focused recommendations for improvement at the level of the class and the individual student.

Stakeholders' role in digital learning

- Researchers need to continue the development of evaluation instruments for assessing digital competences in both students and teachers, including attitudes, in order to provide feedback and recommendations from students and teachers for further improvement of digital competences.
- Teachers need to diversify their use of digital technologies to learn to better open up the potential of technology, especially through thinking about how to modify and redefine learning activities to better support achieving the set learning goals.
- Teachers need to guide learners towards meaningful self-regulated learning by offering sufficient autonomy and tasks that could be completed in a self-regulated learning process with sufficient support and scaffolding. In this context, the teachers need to pay attention to and reflect on four areas of regulation: cognitive, metacognitive, motivational, and emotional.
- Teachers need to systematically assess their digital competence and that of their students to make informed decisions when it comes to focusing on one or another dimension of digital competence.

Conclusion

The Covid-19 pandemic initiated a major change in education by increasing the need for remote learning. Given this new context, it became evident that existing conceptualisations about digital competence might be insufficient for describing student needs in improving their digital competence for learning. Even the DigComp framework might need to be re-conceptualised in the context of the remote learning process.

We developed a new framework for describing digital competence for learning through ten dimensions that could be differentiated empirically. The analysis of the initial results from the Estonian DigiEfekt project showed that in some dimensions student digital competence is rather good, while much improvement is needed in programming, performing technical operations, and in following the rules in the digital world.

Finally, teachers could benefit more from modifying (using functions that are not possible without technologies) and redefining (planning activities that are not possible without technology) learning process to expand the potential of digital technologies in the context of learning. Therefore, there is also a need for a more varied use of technologies in everyday teaching and learning practice to support achieving different learning goals. In this re-conceptualised learning process, teachers have to leave sufficient autonomy for the learners while at the same time also providing sufficient support and scaffolding so that they can learn how to self-regulate their learning process in cognitive, metacognitive, motivational and emotional areas in all phases of learning – preparatory, performance, and appraisal.

Researchers need to collaborate with teachers to support the optimal use of the affordances of digital technologies in teaching and learning processes. In summary, collaboration between teachers, students and researchers is the key to opening up the potential of digital learning in achieving both cognitive and non-cognitive learning outcomes.

References

Edisherashvili, N., Saks, K., Pedaste, M., & Leijen, Ä. (2022). Supporting self-regulated learning in distance learning contexts at higher education level: Systematic literature review. *Frontiers in Psychology*, 12: 792422. https://doi.org/10.3389/fpsyg.2021.792422

Gerard, L., Wiley, K., Debarger, A. H., Bichler, S., Bradford, A., & Linn, M. C. (2022). Self-directed science learning during COVID-19 and beyond. *Journal of Science Education and Technology*, *31*(2): 258−271. https://doi.org/10.1007/s10956-021-09953-w

Hamilton, E. R., Rosenberg, J. M., & Akcaoglu, M. (2016). The substitution augmentation modification redefinition (SAMR) model: A critical review and suggestions for its use. *TechTrends*, *60*(5): 433−441.

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., & Schmitt, M. (2005). A meta-analysis on the correlation between the Implicit Association Test and explicit self-report measures. *Personality and Social Psychology Bulletin*, *31*(10): 1369–1385.

Hooshyar, D., Pedaste, M., Saks, K., Leijen, Ä., Bardone, E., & Wang, M. (2020). Open learner models in supporting self-regulated learning in higher education: A systematic literature review. *Computers & Education*, *154*, 103878. https://doi.org/10.1016/j.compedu.2020.103878

Leijen, Ä., Pedaste, M., & Baucal, A. (2021). Assessing student teachers' agency and using it for predicting commitment to teaching. *European Journal of Teacher Education*, 1−17. https://doi.org/10.1080/02619768.2021.1889507

Lepp, L., Aaviku, T., Leijen, Ä., Pedaste, M., & Saks, K. (2021). Teaching during COVID-19: The decisions made in teaching. *Education Sciences*, *11*(2): 47. https://doi.org/10.3390/educsci11020047

Martin, A. (2009). Digital literacy for the third age: Sustaining identity in an uncertain world. *eLearning Papers*, *12*, 1–15.

Otchie, W. O., Pedaste, M., Bardone, E., & Chounta, I. A. (2021). Contextualizing social media ecology and its pedagogical affordances: The perspective of high school teachers. *Electronic Journal of e-Learning*, *19*(6): 471−489. https://doi.org/10.34190/ejel.19.6.2486

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, *8*: 422. https://doi.org/10.3389/fpsyg.2017.00422

Pedaste, M., Kalmus, V., & Vainonen, K. (2021). Dimensions of digital competence and its assessment in basic school. *Eesti Haridusteaduste Ajakiri = Estonian Journal of Education*, *9*(2): 212–243. https://doi.org/10.12697/eha.2021.9.2.09

Pedaste, M., & Leijen, Ä. (2018). How can advanced technologies support the contemporary learning approach? In *2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT)* (pp. 21–23). IEEE.

Puentedura, R. R. (2006). Transformation, technology, and education [Blog]. http://hippasus.com/resources/tte/

Rannastu-Avalos, M., & Siiman, L. A. (2020). Challenges for distance learning and online collaboration in the time of COVID-19: Interviews with science teachers. In Nolte, A., Alvarez, C., Hishiyama, R., Chounta, IA., Rodriguez-Triana, M., & Inoue, T. (Eds.), *Collaboration Technologies and Social Computing.* CollabTech 2020. Lecture Notes in Computer Science, 12324 (pp. 128−142). Springer, Cham. https://doi.org/10.1007/978-3-030-58157-2_9

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The digital competencefFramework for citizens*, EUR 31006 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-48882-8. https://doi.org/10.2760/115376

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