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Insights into Engineering Education Teaching Practice in Slovenian Primary Schools during the Covid-19 Pandemic: Distance Learning Model

Bernarda Urankar*[1] and Janez Jamšek[2]

When the Covid-19 pandemic started in March 2020, the educational process had to be redesigned to meet current needs. At the Faculty of Education of the University of Ljubljana, pre-service engineering and technology teachers (3rd and 4th years of undergraduate two-subject teachers' study programme) are obliged to complete a teaching practice in educational institutions and submit a teaching practice diary. Due to the closure of primary schools, the teaching practice was transformed to distance/online practice. This empirical study examines a recently developed intuitive model for distance learning, which took place during the teaching practice. Teaching practice diaries served as an instrument for gathering data. The sample size encompasses 56 lesson plan activities for the compulsory primary school Design and Technology subject for students aged 12–15 years at 15 primary schools in different parts of Slovenia carried out during online teaching practice by 11 pre-service technology teachers in the 2019/2020 and 2020/2021 academic years. The research methodology is focused on lesson-type determination and model elements analysis in lesson plan making and implementation activity. Distance learning model elements are evaluated with regard to online/offline learning tools from e-learning platforms to engineering education field-specific tools (e.g., technical drawings and electric circuits). Online teaching practice was as new for pre-service technology teachers and teacher-mentors as online learning was new for students. The advantages and disadvantages are highlighted. Furthermore, the distance learning model from the first Covid-19 wave teaching practice was adapted to challenge the second Covid-19 wave. The pandemic has enabled the rise of blended learning, which has been gaining focus in secondary and higher education levels in recent years; however, it encountered obstacles when entering the primary school domain. How to

1 *Corresponding Author. Faculty of Education, University of Ljubljana, Slovenia; bernarda.urankar@pef.uni-lj.si.
2 Faculty of Education, University of Ljubljana, Slovenia.

encompass blended learning into the evolved distance learning model will be shown.

Keywords: blended learning, distance learning model, engineering education, online learning tools, teaching practice, technology teacher

Vpogled v pedagoško prakso tehniškega izobraževanja v slovenskih osnovnih šolah med pandemijo covida-19: model učenja na daljavo

Bernarda Urankar in Janez Jamšek

Ko se je marca 2020 začela pandemija covida-19, je bilo treba izobraževalni proces preoblikovati, da bi ustrezal trenutnim potrebam. Na Pedagoški fakulteti Univerze v Ljubljani imajo bodoči učitelji tehnike v 3. in 4. letniku dodiplomskega dvopredmetnega študijskega programa obvezno opravljanje pedagoške prakse v izobraževalnih ustanovah. Zaradi zaprtja osnovnih šol se je učna praksa preoblikovala v prakso na daljavo/spletno prakso. Ta empirična študija preučuje pred kratkim razvit intuitivni model učenja na daljavo, ki se je izvajal med pedagoško prakso. Dnevniki pedagoške prakse so služili kot instrument za zbiranje podatkov. Velikost vzorca obsega 56 učnih priprav z dejavnostmi/aktivnostmi za osnovnošolski predmet tehnika in tehnologija za učence, stare od 12 do 15 let, na 15 osnovnih šolah v različnih krajih po Sloveniji, ki jih je med prakso na daljavo v študijskem letu 2019/20 in 2020/21 izvajalo 11 učiteljev tehnike. Raziskovalna metodologija je osredinjena na določanje tipa učne ure in analizo elementov učnega modela v učni pripravi z dejavnostmi/aktivnostmi izvedbe načrta. Elementi modela učenja na daljavo se ocenjujejo glede na uporabljena spletna učna orodja na platformah za e-učenje in spletna orodja za tehniško izobraževanje (npr. tehniške risbe in električna vezja). Pedagoška praksa, izvedena z modelom učenja na daljavo, je bila nova za študente – bodoče učitelje – in učitelje mentorje pa tudi za učence. Poudarjene so prednosti in slabosti spletnih učnih orodij. Poleg tega model učenja na daljavo iz učne prakse prvega vala covida-19 je bil prilagojen za izvajanje pedagoške prakse v terminu drugega vala covida-19. Pandemija je omogočila porast uporabe kombiniranega učenja, ki je osredinjeno na srednješolsko in visokošolsko izobraževanje, vendar je pri vstopu v osnovnošolsko domeno naletelo na ovire. Prikazano bo, kako kombinirano učenje vključiti v predlagani model učenja na daljavo.

Ključne besede: kombinirano učenje, model učenja na daljavo, tehniško izobraževanje, spletna učna orodja, učna praksa, učitelj tehnike

Introduction and context

To avoid misconceptions about engineering education terms, we start by explaining them. The technology teacher study programme at the University of Ljubljana, after bachelor's or master's degrees, enables teachers to teach technical subjects at the primary school level (students aged 12–15 years) that are more commonly termed 'technology subjects'. Pre-service teachers in this field are 'pre-service technology teachers'. They can also teach technological subjects at the secondary level (students aged 15–19 years) that are more commonly termed 'engineering subjects'. Technology teacher programmes are not common around the world; in many countries, the general primary school teacher study programme does not even cover any technique/technology/engineering related subjects for students aged 6–14 years. For clarity in this study, we use the domain-related term 'engineering education' and address students of the technology teacher study programme as 'pre-service technology teachers' (PSTT).

Teaching/learning methods

The predominant teaching method in engineering education is the traditional teaching method: frontal, face-to-face lectures followed by practical work, regardless of the education level (from primary school to university). The term 'traditional teaching method', also known as 'face-to-face learning', is characterised by classroom implementation with time and space constraints, using traditional methods (lecturer-centred) and traditional resources, such as textbooks, discussions, chalkboards and others (Jansen, 2004).

Technological development induced a demand to exceed these time/space constraints. The beginning of distance learning is considered to be correspondence education at the beginning of the 20^{th} century (Kahiigi, 2008; Moore, 2013). With the accelerated development of radio, television technology, and the internet, teaching materials have moved online. The new way of learning was termed 'e-learning' (eL) and reached its peak in 1997–1999. Distance learning and eL overlap in some cases, but they are not the same (Bonk & Graham, 2005; Kahiigi, 2008; Moore, 2013). eL is any learning that involves technology as a learning aid. It can be done both in the classroom and with teacher and learners separated, which is not the case in distance learning (Kemeny & Kurtz, 1967).

Along with the rapid development of new technologies, eL has been developing in parallel from the first phenomenon of personal computer integration and thus computer-aided teaching (CAI) to current mass open online courses and their versions, such as MOOC, c-MOOC, x-MOOC and LOOC (Deimann & Friesen, 2013). As learning technology evolves, there is still no common agreement on definitions and terminologies (Lowenthal & Wilson, 2010). Interchanged terms are often without meaningful definitions. eL has many different names related to the technology used (e.g., online, virtual, network, distributed and web learning). However, Rodrigues et al. (2019) affirm that both these concepts share the common feature that 'they are a form of instruction that occurs between a learner and an instructor and are held at different times and/or places, using several forms of material' (p. 88). Lately, eL is alternatively called 'online learning', which is an umbrella term for any learning that takes place across a distance and not in a face-to-face platform (Anderson, 2016; Mpungose, 2020).

Furthermore, Choudhury and Pattnaik (2020) affirm that the definition of eL evolves with the evolution of the internet. It started with Web 1.0, which was a read-only site, internet-based learning from which a wide range of material could be accessed, and information sought and downloaded. This was the early development of what became known as browsers. Today, Web 4.0 is rising using artificial intelligence, which can directly interact in real-time with human beings (Choudhury & Pattnaik, 2020, p. 2). Online learning is defined as a learning experience in synchronous or asynchronous environments using different devices (e.g., mobile phones, laptops, etc.) with internet access. In these environments, students can be anywhere (locally independent) and learn and collaborate with instructors and other students (Singh & Thurman, 2019). Despite the initial success of the eL method, it subsequently emerged that the structured learning environment and targeted e-learning materials did not motivate participants sufficiently to persevere to complete their courses. More and more studies (Nikoubakht & Kiamanesh, 2019) argue that face-to-face is irreplaceable even if the current discourse and technological revolution demand the use of eL. An upgrade of eL is blended learning (Bonk & Graham, 2005), which combines online and face-to-face learning and enables students to use many ways of accessing course content based on their needs (strengths/limitations) (Anderson, 2016).

Blended learning is most rapidly implemented at the higher education level, where it is easiest to introduce (Rihtaršič & Jamšek, 2019). The lower we go along the educational ladder, the more sophisticated its implementation must be to ensure success. The trend of student learning motivation is declining mainly due to the well-established, traditional delivery of knowledge on stock that is widely available on the web, and students can access it almost anytime. All contemporary learning models are, therefore, based on learning on demand. The slow introduction of distance/flexible/online/blended learning on primary/ secondary school level (Dvorščak & Jamšek, 2017; Kosec et al., 2020; Lokar & Jamšek, 2017) was changed with pandemic declaration due to the Covid-19 (SAR-CoV-2) virus outbreak in China by the World Health Organisation on 11 March 2020. In response to the pandemic in many countries worldwide, schools were closed. This occurred suddenly, giving school communities limited time to prepare new learning models.

Schools were also locked down in Slovenia; teachers across the entire educational system (and everyone else) were forced to switch overnight from traditional teaching, face-to-face, to distance or online learning. While PSTT receive relevant competent knowledge at the postgraduate study level and are therefore trained for introducing and teaching students at primary/secondary school level using online/blended learning, PSTT at the undergraduate level still do not have this knowledge. During undergraduate teacher education programme studies, they have compulsory pedagogical practice in the 3rd and 4th years.

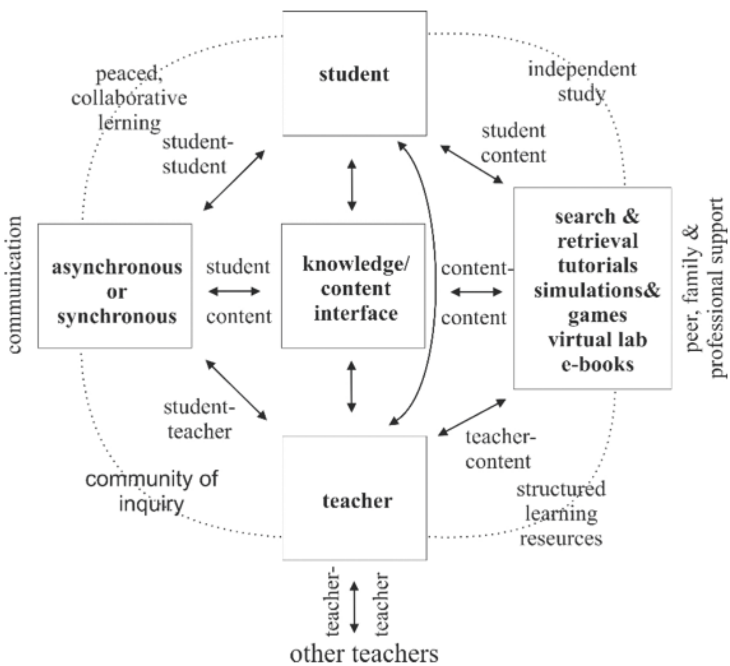
With the pandemic declaration, education providers in different countries received different instructional guidance. One of the first and the most in-depth forms of guidance was made by UNESCO INRULED and the Smart Learning Institute of Beijing Normal University (SLIBNU) on 15 March 2020. They published a handbook on the promotion of flexible learning during educational disruptions, which provides guidelines and guides for teachers in the new situation (Huang et al., 2020). In China, the Chinese Ministry of Education launched an initiative named 'Disrupted Classes, Undisrupted Learning'. Its purpose was to provide flexible online learning from theory to vivid examples and touching stories based on millions of teachers and students. In Slovenia, at the start of the pandemic, government institutions did not provide any model guidance for teachers about the transformation of the learning process. The Ministry of Education, Science and Sport set up a single online entry point (www.sio.si) to support teachers in conducting distance education. This point provides access to various online classrooms, e-learning materials, video conferencing, and similar tools for distance learning purposes. ARNES, the Academic and Research Network of Slovenia, also set up a new video conferencing service, Arnes VID.

Online learning models

Online learning models originate from distance learning's first-generation model, also known as the 'correspondence model' (Peters, 1994). Print-based correspondence was conducted between the teaching staff (teachers) and participants; this is known as the classical didactic triangle. eL models for e-learning purposes further evolved. They differ according to theories of eL (objectivism, behaviourism, cognitivism, constructivism, connectivism) and according to the target group, so-called for business eL, strategic-learning, pedagogical models, web learning models, and so on (Dabbagh, 2005; Tsai, 2009). Examples of models are the strategic eL Model (Madar & Willis, 2014), Gagne's nine events of instruction model (Gagne et al., 1998), ADDIE model (Kurt, 2017), the community of inquiry model (Picciano, 2017), among others. An overview of the eL proposed model can be found in the work of Suryawanshi and Suryawanshi (2015). Online learning models evolved with rising education technology e-learning models. Anderson's Online Learning Model (Anderson, 2011) was an attempt to build a common integrated theory of online education that could subsume all other models with the exception of the face-to-face interaction in formal classrooms, Figure 1. It demonstrates the instructional flow within the two sides and represents the beginnings of the model from the distance education perspective. Anderson intended to deepen our understanding of this complex educational context.

Figure 1

Anderson's online learning model

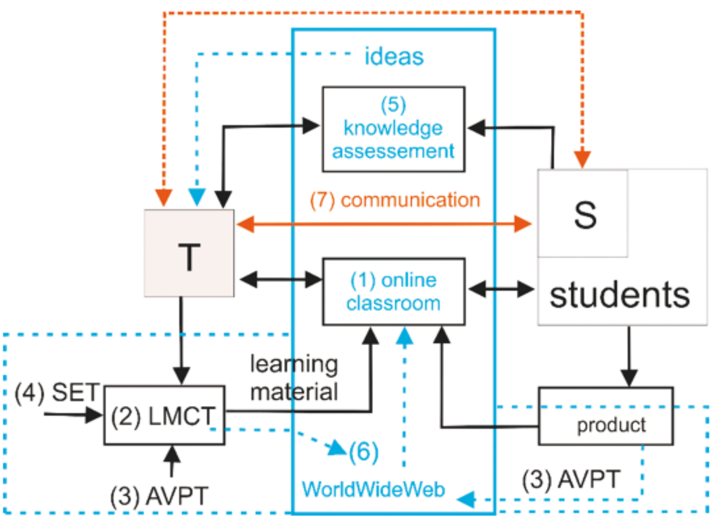


Note. Adapted from Anderson, 2011.

Anderson's model was upgraded by Bosch (2016) to the Blending with Purpose model, which is an integrated model encompassing the face-to-face component of blended learning. Recently a multimodal model that attempts to integrate the work of several other major theorists and model builders was proposed for online education in general (Picciano, 2017). It is based on pedagogical purpose and expands the blending with purpose model approach. It adds several new components (e.g., community, interaction, and self-paced, independent instruction) while focusing on online learning. In a recent study, a group of researchers developed a conceptual model to encapsulate the core processes of education provision (Orr et al., 2018). The concept originates from the theory-based design developed by Dabbagh (2005) to combine strategies, learning techniques, and pedagogy. The group focused on higher education, whereas the findings can be transferred to lower levels of education.

Figure 2

Intuitive model for online learning.



Note: T = teacher; S = student; LMCT = learning material creating tools; AVPT = audio and video processing tools and SET = specific engineering tools. Adapted from Urankar & Jamšek (2020).

Due to teachers' lack of knowledge regarding online learning models and tools, we proposed an intuitive model for online learning (Urankar & Jamšek, 2020). It is based on Anderson's Online Learning Model (Anderson,

2011) elements but designed from the teacher-user perspective of online or offline tools. The OOFAT model's open tools set dimension concept (e.g., availability, free, freeware and shareware) was considered a starting point (Orr et al., 2018). The updated proposed model is shown in Figure 2. Teachers (T) transform the theoretical lecture content into e-learning materials for students (S), which they acquire on the World Wide Web (WWW) (6) or create partially/entirely by themselves using available online tools (online or on a personal computer) (2–4). The e-learning material is delivered and explained through online classrooms (1). The knowledge acquired from the submitted e-learning materials is assessed using knowledge assessment tools (5) (questionnaires, quizzes, assignments, etc.). If a student's misunderstanding is detected, the teacher carries out audio and/or video communication (7) via online tools or ICT devices. The practical part of the teaching lesson can be translated into the presentation and evaluation of already implemented product examples or given instructions such as technical drawings and technological sheets for making products at home. Pictures or videos (V) of students' products can be uploaded to the online classroom or posted on the WWW.

The online/offline tools set is based on the knowledge of a typical in-service teacher and PSTT. For example, an in-service teacher is mastering Microsoft Office tools and the most widespread online tools with which he has already become acquainted (e.g., YouTube). For the PSTT, tools used during their study are considered. The tools are given in meaningful sets (1–8) according to the model shown in Figure 2: (1) online classrooms tools, (2) e-learning materials creating tools, (3) audio (Af) and video (Vf) processing tools (incorporating capturing and recording functions) tools, (4) specific engineering tools (SET), (5) tools for knowledge assessment, (6) learning content online publishing tools, (7) online video meetings tools and (8) other tools.

(1) **Online classroom tools** are derived from the e-learning management systems into what we know today as 'learning platforms', which provide the possibility of creating and organising/delivering assignments and other e-learning materials, providing feedback information and simple teacher-student communication and more. Arnes is the most widespread online classroom in Slovenia. International, free of charge, learning platforms with a longer appearance include Edmodo, Beenpod, Goclass and newer popular alternatives such as Schoology, Canvas, Google Classroom (new.edmodo.com; beenpod.com; goclass.com; schoology.com; learn.canvas.net; classroom.google.com).

(2) **Learning materials creation tools (LMCT)**. The most basic tools come from Microsoft Office (MS) tools, specifically Word and PowerPoint

(PP). Word can easily generate .pdf documents. PP is much more suitable for the preparation of e-learning materials. In addition to text, pictures and graphs, it allows the insertion of Vf and Af recordings and the creation of animations, as well as user-interactive options. With time-bound animations of playing pictures, Vf, or Af explanations, the delivery of e-learning materials is similar to a step-by-step explanation in the classroom. This way, we can achieve a higher student motivation for the content. Students can view individual slides at their own pace and take time to think, write notes, and similar. Video clips available on YouTube have an advantage compared to PP in greater accessibility, using a range of different devices (computers, phones, tablets, etc.) that have internet access. Students do not need a PP viewer; they can stop the Vf, playback or play it in slower or faster motion, but this is not comparable to PP slides viewing at your own pace.

(3) **Audio and video processing tools (AVPT)**. Watching Vf and listening to the given explanation is more appropriate for students to observe what is happening than to read the subtitles. The following are some of the most widely used and freely available tools among students (OBS, Geforce experience, Bandicam, Speechnotes, Adobe Premiere, Audacity) (obsproject.com; nvidia.com; bandicam.com; speechnotes.co; adobe.com; audacityteam.org.). OBS, Geforce experience, and Bandicam enable high-performance recording from cameras and other outdoor units as well as on-screen events. It can write the spoken text from the video in written form. Original language transcript can be further copied into a web translator and translated. We read the text and transcribe the audio recording of the original video. It can be, for example, from YouTube. These tools allow basic video processing, whereas Adobe Premiere is an example of a more powerful tool. The edited videos are built into educational video material. Audacity is a target tool for recording and editing audio sounds from various external devices and other media. It is easy to use, allows eliminating unnecessary soundtracks and removes noise. It allows you to export files in various formats. Audio files, for instance, explanations of what is happening in the flow of a hydroelectric power plant, can be inserted in the PP presentation.

(4) **Specific engineering tools (SET)** relate to the professional fields of mechanical and electrical engineering. For the primary school level, we provide useful tools for the field of mechanical engineering that enable technical documentation (CiciCAD, Qcad, freeCAD, Google Sketchup and Solid Edge) and some tools related to the electrical circuits (Edison,

Crocodile Clips, Yenka and Phet) (cicicad.si; qcad.org; freecadweb.org; sketchup.com; solidedge.siemens.com; edisonlab.com; crocodile-clips1.com; yenka.com; phet.colorado.edu). QCAD has been translated into the Slovenian language, but it is available free of charge only for a trial duration, while the professional tool Solid Edge is free for educational purposes without truncated features. The Edison tool is free for the trial period. Its main feature is two work surfaces, one with models of real building blocks of electrical circuits and the other with electrical symbols that one can connect into a schematic diagram. Many gauges can be added. There is a truncated version in the Slovenian language, in which the circuit is not shown with symbols and has only a limited number of components/elements. Crocodile Clips is a tool targeted at primary school students. It enables the creation of simulations of electrical circuits operation (including some machine elements). The software is easy to use and enables graphical plotting of the observed parameters. Yenka is an upgraded version of Crocodile Clips simulations. It is a free software tool with no time limits. Electrical circuits can be assembled with real 3D models of electrical components or with symbols of individual electrical elements. The operation of the assembled circuit can be saved as a working simulation. The Phet tool provides online simulations targeted for science and offers a virtual lab. Example of online simulation: depending on the conditions of the electrical parameters in the closed circuit, the light bulbs turn on with different brightness levels not only in the on/off state.

(5) **Knowledge assessment tools**. There are many different tools available on the World Wide Web. The following are just the three most commonly used, free tools with different usability domains (Google Forms, Kahoot, Quizizz) (docs.google.com; kahoot.com; quizizz.com). Google Forms is the most widely used tool developed for multiple operating systems and for mobile phones and tablets. With the created surveys, quizzes, assignments, we can easily gain insight into the understanding and knowledge of students. We can generate many different question types. Forms can be designed by adding images, videos, logos, copying, moving, creating paragraphs, enabling logical skipping of questions. Responses to completed forms are collected in an ongoing, transparent and automatic basis in the form of response data and charts. The collected data can be further analysed. Kahoot is a tool for composing quizzes. It is most suitable for checking the understanding of knowledge during regular school lessons as it provides immediate feedback to the teacher. Quizzes in other applications are more suitable for consolidating

knowledge (e.g., 1ka or quizzes in Google Forms), where there are several options for creating different types of questions that students solve individually. The created quiz can be shared with students with code or through portals such as Google Classroom, Remind, Canvas, Schoology, MS Teams and Twitter.

(6) **Learning content online publishing tools**. We can use various web portals to collect and share the created materials. The best known is YouTube, although Arnes Video was recently created for educational purposes (YouTube.com, video.arnes.si). Furthermore, one can use the Padlet tool, which allows "sharing; for instance. a group of students can share the collected materials (for instance: product pictures, tests, video contributions, etc.).

(7) **Online video meetings tools**. In particular, two tools have been introduced for educational purposes, MS Teams and Zoom (teamsdemo.office.com, zoom.us), which are available free of charge for educational purposes in truncated versions. MS Teams has been developed for computers and mobile devices. Participants can conduct web meetings, video conferencing (up to 250), video and voice calls, chat, screen sharing, file sharing, instant messaging and set wallpapers. It offers the ability to add many different applications, messaging and receiving assignments, grading, recording meetings, whiteboard writing, adding various web applications, and similar. The tool breaks down online learning and can also be used as an online classroom. Another tool is Zoom. The free version has a time limit for video conferencing meetings and the number of meeting participants. The paid version allows more features for more enjoyable and efficient online learning.

(8) **Other tools**. There are three tools included in this group. The first, Pinterest (pinterest.com), is dedicated to finding ideas for making learning materials. Another, already mentioned, YouTube, is a tool that teachers like for making their teaching materials public. The tool We-transfer (wetransfer.com) is intended for transferring larger files. These are often longer video files of higher resolution.

A study (Lebeličnik et al., 2015) categorising online learning activities according to the principles of the Universal Design for Learning (UDL) model and examining the use of ICT by students of pedagogical disciplines compared to students of other disciplines revealed a difference between them. Student teachers were more likely than their peers to use activities to create an inclusive learning environment, while non-teaching students used more sophisticated

ICT learning activities. These research findings suggest a need to promote more ICT learning activities for students of pedagogical programmes, particularly those that involve interaction, collaborative learning and planning and organising one's own learning.

Aims and research questions

Our main purpose in the present study is to analyse the level of distance learning model implementation during pedagogical teaching practice for PSTT in a situation for which neither PSTT, teachers-mentors, nor the students in the school were prepared. Due to the possibility of another pandemic and the need to implement online learning throughout the engineering education vertical, the paper's purpose is to serve as an example of good pedagogical practice. We are mainly concerned with the basic intuitive online learning model and with the evaluation of teaching practice being executed during the first and the second Covid-19 waves. To cope with education lockdown periods and study purposes, we have incorporated teaching practice into a proposed modified online learning model that best suits our needs and takes advantage of the state of primary school educational technology.

RQ1: How has Covid-19 affected the first teaching practice in the 2019/2020 academic year during 6–10 April 2020?

RQ2: How has Covid-19 affected second teaching practice in the 2020/2021 academic year during 1–24 December 2020 and 11–25 January 2021?

RQ3: Is there a difference between the first and the second pedagogical practices?

RQ4: In what ways was practical work carried out during remote lessons in both pedagogical practices?

RQ5: How did students perceive the workload during the remote teaching periods?

Method

This chapter analyses two samples of PSTT and two research instruments: a distance learning diary and a semi-structured interview. The research process is presented and described.

Participants

The research sample consisted of six 3rd year students, five of whom were female and one male aged 21, and five 4th year students, two of whom were female and three male, aged 22-23, undergraduate students.

Part one encompasses online teaching practice carried out in the 2019/2020 academic year during 6–10 April 2020 for six PSTT from the 3rd year of the undergraduate study and during 14–20 April 2020 for five PSTT from the 4th year of undergraduate study at 11 different primary schools in different parts of Slovenia (Ljubljana, Prevalje, Braslovče, Bohinjska Bistrica, Novo Mesto, Ajdovščina). All PSTT had different in-service technology teacher-mentors, who has a proper professional title (mentor or higher)m and there are enough hours of the Design and Technology subject to execute the teaching practice requirements.

Part two encompasses online teaching practice carried out in the 2020/2021 academic year during 1–24 of December 2020 and 11–25 of January 2021 for five PSTT from the 3rd year of the undergraduate study, and eight PSTT from the 4th year of undergraduate study at 13 different primary schools in different parts of Slovenia (Ljubljana, Prevalje, Bohinjska Bistrica, Novo Mesto, Ajdovščina, Trzin).

PSTT from the Faculty of Education of the University of Ljubljana participated in the study, completing online teaching practice at primary school regarding Design & Technology-related compulsory/optional subjects. In traditional, face-to-face teaching practice for 3rd and 4th years PSTT, during the spring period, the required scope of teaching practice is at least five learning performances and one learning performance during the winter period. One learning performance includes making a lesson plan for one lesson unit, the mentor teacher's previous observation, and the implementation of the lesson plan. All teaching practice activities are given in an electronic document report as a teaching practice diary that will serve as an instrument for gathering data.

Sample size encompasses all together 56 lesson plan activities from submitted teaching practice diaries from PSTT for the compulsory primary school Design and Technology subject for students aged 12–15 years at 15 different primary schools in different parts of Slovenia carried out during online teaching practice by a total of 11 PSTT and 16 in-service technology teacher-mentor in the academic years 2019/2020 and 2020/2021.

Instruments

The research was conducted using two research instruments: a diary of students' pedagogical practice and a semi-structured interview with each student. PSTT pedagogical practice diaries were analysed during two periods when the pedagogical practice was conducted remotely: April 2020, December 2020, and January 2021. The entries in the practice diary are a collection of information about the student's online activities, the use of online tools, the advantages and disadvantages of didactic distance learning with web applications/animations, videos, and all other online tools.

Our empirical study investigates our recently developed intuitive model for distance learning. It will enable determining the level of distance learning model implementation during obligatory pedagogical teaching practice for PSTT. The intuitive model is described, and relevant distant e-learning models are given.

The research methodology is as follows. Diary encompasses all activities that were executed during teaching practice in detail. These activities can be divided into three subgroups: teacher's observation, lesson plan making, and lesson plan implementation. Lesson plans will be divided according to cognitive taxonomy objectives into three types: conceptual understanding, fluency/procedural skills and application. According to the Design and Technology curriculum, lessons types are evenly represented. We assume that online learning can result in one predominant lesson type. Furthermore, distance learning model elements will be determined in lesson plan making and implementation activity. All activities will be further evaluated with regard to online/offline learning tools from e-learning platforms to engineering education field-specific tools explained in detail in the followed. For quantitative description, only basic statistics will be used (sum and percentage), whereas for qualitative description, the intuitive distance learning model applied to the teaching practice diary content will be used. Pedagogical practice activities are equated to implementing traditional teaching practise lesson plans.

A semi-structured interview was conducted with each student to obtain additional information or opinions about the implementation of pedagogical practices for teaching engineering and technology through distance education. Students answered nine open-ended questions: specifics of communication and collaboration with the teacher-mentor, ways of gathering information for learning content preparation, difficulties in finding and installing new online tools on their computers, specifics of learning new online tools for learning content preparation, specifics of each online tool, success of targeted learning content preparation with newly introduced online tools, teacher-mentor satisfaction with student learning preparation, student satisfaction with prepared learning content and distance education, and much more that students wanted to share. Students answered the questions without any time limit via the MS Teams portal.

Data analysis

In order to monitor the implementation of the pedagogical practice and distance learning, a new structure of the pedagogical practice diary was created just before the start of the pedagogical practice. The analysis of the final version of the submitted diaries of pedagogical distance practice for students of the 3rd and 4th years of the Technology study programme took place after the submission of the diaries for review and evaluation.

The second part of the study consists of semi-structured interviews with all 3rd- and 4th-year students who completed the pedagogical practice via the familiar MS Teams online environment. Immediately following completion of the pedagogical practice, interviews were conducted with 3rd-year students on 21 April 2020. Interviews with 4th-year students followed on 22 April 2020.

The study was conducted using a descriptive method of educational research. A mixed-methods research approach was used for the analysis. The analysis of the pedagogical practice diaries was quantitative, and the semi-structured interviews' analysis was qualitative. A qualitative research approach is used to analyse the data obtained from data collection techniques: pedagogical practice diaries and semi-structured interviews. The analysis of pedagogical practice diaries in distance education is an independent data collection technique.

Results

The results are presented in the following order. First, the participants are given, followed by a description of the gathered data sample. Collected teaching practice diary data are divided and presented in two parts. The parts partition is timed. During the first period, in-service technology teacher-mentors did not obtain any guidance. Teaching practice was independently under in-service technology teacher-mentor mentoring, considering only school pandemic directives. During the second period, in-service technology teacher-mentors were given directions to guide teaching practice towards an intuitive online learning model.

Tables 1-3 show the main teaching practice diary data. All diary data are presented according to activities (first column), divided into Teacher's Observation, Lesson Plan, and Other. In traditional, face-to-face teaching practice, the student would first observe an in-service technology teacher-mentor lesson implementation before making his/her own lesson to continue the observed lesson. For this purpose, the Lesson Plan column is divided into subcolumns for making and implementing. Under the Lesson Making subcolumns are content material, attachment, and lesson type. The content material number shows how many different toolsets were used. This number is further broken down in Tables 2 and 4 according to distance learning model elements to toolsets (1–8) defined under the Introduction and context sections. The attachment column in Tables 1 and 3 tells us how many lessons topic supporting materials were prepared, whereas lesson type indicates the objectives' taxonomy level. Under lesson implementing columns are webinar lesson and knowledge assessment. Online/offline tools from the toolsets (1–8) are given here. Under the last column in Tables 1 and 3, Other, only information regarding how the activity was performed between teacher/mentor/students according to the intuitive distance learning model is given (e.g., by using a personal computer, smart mobile phone, or other ICT device).

Results for the first teaching practice period are shown in Table 1. There was only 14% out of the expected 100% teacher's observation activities. Half of them were not related to any lesson plan activity, which would be otherwise expected. In most cases (88.4%), PSTT were involved in making lesson plans, whereas only in 4.7% did they also perform lesson plan implementation in online contact (webinar) with the students. In an additional 7%, they were in contact with the students, assessing their knowledge by using either quiz tools or pictures together with a product. In all cases, 25 assessments consisted of 25 questions. The most common lesson type was, as expected, conceptual understanding. In 37.2% of cases, it was combined with fluency/procedural skills lesson type. The application type, which would otherwise predominate during the teaching practice, was detected only in 14% of cases.

Table 1

Results for online teaching practice for pre-service technology teachers PSTT for the first teaching practice period where content material and attachment number present several possible components.

Activity	Teacher´s Observation	Lesson plan					Other Device
		Making			Implementing		
		Content material	Attachment	Lesson type	Webinar lesson	Knowledge assessment	
1		2	3	1, 3	Zoom	Sketch, picture, product	1
2		1	1	3			1
3			1	3			1
4		4		1			1
5	1	1	1	1, 2		Quiz (25)	1
6		1		1			1
7; 8		2	2	1, 2			1*
9; 10		2	2	1, 2			1
11		2	2	1, 2		Quiz (25)	1

Activity	Teacher´s Observation	Lesson plan					Other Device
		Making		Implementing			
		Content material	Attachment	Lesson type	Webinar lesson	Knowledge assessment	
12		1	4	1			1
13	1	1					1
14			3	3			1
15	1	1	3	3			1*
16	1						1
17; 18		3	1	1, 2			1
19; 20		4		1			1
21; 22; 23		5		1			1
24; 25		5	3	1, 2			1
26		5	2	1, 3		picture, product	1
27		2	3	1, 2			1*
28; 29	1						1
30; 31		4	1	1			1
32		2	3	1			1
33		5	4	1			1
34		5	2	1, 2			1
35		3	1	1			1
36; 37		4	2	1			1*; 1
38; 39		2	1	1			1
40		4	2	1, 2	Zoom		1*
41; 42		4	2	1, 2			1
43		3	2	1, 2			1
Sum	6	38	32	35(1); 16(2); 6(3)	2	4	43(6*)
%	14,0	88,4	25,6	81(1); 37(2); 14(3)	4,7	9,3	100(14)

Note. Lesson type 1 = conceptual understanding; 2 = fluency/procedural skills; 3 = application and * = smart phone.

Table 2

Teaching practice for pre-service technology teachers PSTT during the first teaching practice period.

Activity	Lesson plan making									
	Content Material						Attachement			
	Text	PPT	Pictures	Video	Websites W1	Websites W2	WS/I	Questi-onnaries	Product Sketch	Engineering specific
1			6		6		1		1	E1(2)
2					3					E1(1)
3										E1(1)
4	1	1	8		3	3				
5					6	3		Q1		
6	1				4	2				
7				V1, V9, V12	3	2	1			E7(1)
8	1	1		V3(1)			1	Q3		
10				V3(2)				Q1		E1(1)
9; 11	1				10; 11	0; 4		Q2(2)		
12				V5(1)				Q2		E5(3)
13					10					
14								Q2	1	E6(1)
15				V1(1)			1	Q3(2)		E6(1)
16	/									
17	1	1	3					Q2		
18	1			V3(1); V4(2)	1	1				E7(1)
19; 20	1	1	9; 10;		9; 8;					
21; 22; 23	1	1	5; 30; 35	V3(1;1;1); V4(1;1;1)	2; 12; 25	0; 0; 4				
24	1	1	12	V3(1); V4(2)	3			Q4		
25	1	1	15	V3(1)	12		1	Q5		
26	1	1	12	V3(1)			1		1	
27			6		5			Q2		E3(2)
28; 29	/									
30	1	1	3	V3(1)	5					
31	1	1	12	V4(2)						
32		1	33				1			E2(1); E8(1)
33	1	1	35	V3(1)	11		1	Q5		E7(1); E8(1)
34	1	1	17	V3(1)	12			Q5(2)		
35	1			V6(1); V7(1); V8(1)	10	5				
36	1		1	V2(1); V3(1)	10	3			1	

Activity	Lesson plan making									
	Content Material						Attachement			
	Text	PPT	Pictures	Video	Websites		WS/I	Questi-onnaries	Product Sketch	Engineering specific
					W1	W2				
37	1	1		V3(3); V9(3); V10(3); V11(3)	7	4		Q6(2)		
38; 39			1; 12		3; 8;					
40; 41; 42	1	1		V1(1;0;0); V2(0;1;1); V3(10;0;1); V9(1;1;0); 10(1;1;0); V11(0;1;0)	17; 5; 8;	7; 2; 2,		Q6; Q1; Q6		E4(1;1;0); E10(0;0;1)
43	1	1			5	3		Q6		E8(7)
Sum	26	21	20	22	30		8	19	4	16
%	60,5	48,8	46,5	51,2	69,8		16,6	44,2	9,3	37,2

Note. Table 1 break down results for making lesson plan section where: PPT = Powerpoint tool; WS = worksheet; I = instructions; Vi = video tool; Wi = web site; Qi = questionnaire tool; Ei = engineering-specific tool.

Table 2 shows a breakdown of Table 1 for making the lesson plan section. It presents the lesson plan structure. Lesson plans in 60.5% of cases consist of a text document covering lesson content that is supplemented by PP presentation in 48.8%, pictures in 46.5%, Vf in 51.2%, and websites in 69.8% of cases. Eleven different video tools were used: V1 – smartphone application; V2 – Dictaphone; V3- PPT; V4 – Loom; V5 – Bandicam; V6 – Speechnotes- transcript; V7 – Adobe Premiere Pro CC 2017; V8 – Adobe Audition; V9 – Audacity; V10 – Nvidia GeForce Experience and V11 – ShotCut. The number in parentheses indicates how many video clips were used for the lesson plan, ranging from 1 to 10. In most cases, one video clip is used. Website supplementation for lesson plans can be divided into two distinctive usages: as YouTube videos or other websites relevant to the content, but videos are not predominant. The numbers in website column W1 tell us how many different URLs (Uniform Resource Locator) were used, and in column W2 how many YouTube videos were shown. Typically, one webpage was selected and more YouTube videos, up to 25. Worksheets that supported lesson content delivery were prepared in 16.6% and questionnaires in 44.2 % of cases. Six different tools for making questionnaires for teaching lesson educational objectives achievement level were used: Q1 – Kahoot; Q2 – Google Forms; Q3 – Quizziz; Q4 – Word; Q5 – PPT; Q6 – 1ka; Q7 – Mentimeter; Q8 – H5P and Q9 – Scratch where the Google Forms were the most often used. Students were making products during the implementation of the teaching lesson in 9.3% of cases, and SET were used in 37.2%. These tools were: E1 – SolidWorks;

E2 – Solid Edge; E3 – Phet; E4 – Yenka; E5 – Crocodile Clips; E6 – Qcad; E7 – Edison; E8 – Gimp; E9 – Open Board and E10 – PP.

Results for the second teaching practice period are shown in Table 3. There were no teachers' observation activities. In all the cases, PSTT were involved in making lesson plans, and almost half of them (46.2%) also implemented the prepared lesson plan mainly using Zoom. The percentage for knowledge assessment is much higher in this case (53.9%). The most commonly used tool was Sketch. The predominant lesson type was conceptual understanding combined with fluency/procedural skills (38.5%). In 30.8% of cases, lesson types were combined with an application type. For teaching practice purposes, PSTT were using personal computers in all cases and only in 12.5% did they combine it with a smartphone, as shown in Table 1 and Table 3.

Table 3

Results for online teaching practice for pre-service technology teachers PSTT for the second teaching practice period where content material and attachment number present several possible components.

Activity	Teacher´s Observation	Lesson plan					Other Device
		Making			Implementing		
		Content material	Attachment	Lesson type	Webinar lesson	Knowledge assessment	
1		5	3	1, 3		Sketch	1
2		5	2	1, 2, 3		Sketch	1
3		5	1	1, 2	Zoom		1
4		5	1	1	Zoom		1
5		5	3	1, 2	Zoom		1
6		5	3	1	Zoom		1
7		5	3	1, 2		Word	1
8		4	3	1, 2			1*
9		5	3	1, 2			1
10		4	4	1, 3		Sketch	1
11		3	2	1	MS Teams	Quiz	1
12		2	2	1, 3	Zoom	Sketch	1
13		2	2	1		Quiz	1
Sum	0	13,0	13,0	13(1); 6(2); 4(3)	6	7	13(1); 1(1*)
%	0	100,0	100,0	100(1); 46(2); 30(3)	46,2	53,9	100(1); 7,7(1*)

Note. Lesson type 1 = conceptual understanding; 2 = fluency/procedural skills; 3 =application and * = smartphone.

Table 4 shows Table 3 break down for making lesson plan section. It presents the lesson plan structure. The lesson plan in 84.6% of cases consists of a text document covering lesson content supplemented by a PowerPoint presentation in 84.6%, pictures in 76.9% and video clips in 76.9% of cases, and websites in all the cases. Five different video tools were used: V3 – PPT; V12 – Screencast-O-Matic; V13 – Gimp; V14 – H5P, and V15 – Scratch. From 1 to 10 video clips were used for the lesson plan. In 60% of cases, three or more videos were selected. A website supplementation was present in all cases. In 84.6% of cases, two websites were selected with an additional 1 to 12 YouTube videos. Worksheets for lesson content delivery support were prepared in 84.6% of cases and in the same percentage for questionnaires. Six different tools for making questionnaires were used: Q2 – Google Forms; Q4 – Word; Q5 - PPT; Q7 – Mentimeter; Q8 – H5P and Q9 – Scratch. Word tool was the most often used. Students were making products only in one case. Specific engineering tools were used in 23,1 %. These tools were: E1 – SolidWorks; E6 – Qcad, and E9 – Open Board.

Table 4

Teaching practice for pre-service technology teachers PSTT during the second teaching practice period.

Activity	Lesson plan making									
	Content Material						Attachement			
	Text	PPT	Pictures	Video	Websites		WS/I	Questi-onnaries	Product	Engineering specific
					W1	W2				
1	1	1	30			2	1		1	E6 (8)
2	1	1	10	V3(10)	3		1	Q4		
3	1	1	17	V15(10)	3	5		Q7		
4	1	1	50	V3(5)	3	3	1			
5	1	1	5	V14(3)	12	3	1	Q2		
6	1	1	18	V3(1)	4	2	2	Q5(2)*		
7	1	1	3	V16(3)	1	2	1	Q8		
8	1	1		V16(3)	1	2	1	Q8		
9	1	1	10	V17(1)	10	2	1	Q9		
10		1	1	V3(1)	2	2	1	Q2		E1 (1)
11	1	1		V3(1)	12	3	1	Q5*		
12	1				1	1		Q4*		E9 (2)
13			10		9	1	1	Q4		
Sum	11	11	10		13		11		1	3
%	84,6	84,6	76,9		100,0		84,6		7,7	23,1

Note. Table 3 breaks down results for making lesson plan section: PPT = Powerpoint tool; WS = worksheet; I = instructions; V_i = video tool; W_i = web site; Qi = questionnaire tool; E_i = engineering specific tool.

Distance learning model elements used tools are extracted from Table 1, Table 3, and teaching practice diaries for both teaching practice periods and are given in sets 1–8 according to Figure 2: (1) – online classrooms tools, (2) – learning material creating tools, (3) – audio (A) and video (V) processing tools, (4) – specific engineering tools, (5) – tools for knowledge assessment, (6) – learning content online publishing tools, (7) – online video meetings tools and (8) – other tools.

(1) **Online classroom tools**. During the first teaching practice period in 9 of 11 primary schools where online teaching practice was conducted, 82% of students used the Arnes classroom, based on the Moodle web system, while in the remaining two schools, they used their own online classrooms. During the second teaching practice period in 11 of 13 primary schools where online teaching practice was conducted, 84.6% of students used the Arnes classroom. The remaining two schools used their own online classrooms.

(2) **Learning materials creation tools (LMCT)**. To implement distance learning PSTT prepared e-learning materials for students. According to Table 2 and Table 4, e-learning materials could be in the form of PP, pictures, Vf, websites hyperlinks, worksheets, questionnaires, engineering-specific material like drafts, schematic diagrams, drawings, technological sheets, electrical circuits, and similar. Furthermore, the method of making and the type of tools used depended on the topic. For text documents, only Word was used. For slide presentations, only PowerPoint was used. Although many free tools are available, this was expected since both come in the MS Office package for which the schools have bought licences. Even for creating Vf, PowerPoint (V3) is the most frequently used by PSTT at 43.5% (Table 4). It enables the creation of simple presentations by inserting various text parts, pasted images, video and audio recordings, and prepared animations into a didactically meaningfully whole. The presentations prepared in this way were mostly passed on to the students, who were able to review the new learning contents independently, at their own pace. In 25% of cases, the produced PP presentation was exported as a Vf and passed on to the students. Students could also stop/watch the video again if necessary. Fewer students (13.5%) produced e-learning material based on Word texts with supplements (video, worksheet or engineering specific like schematic diagrams, drawing, technological sheet, electrical circuit, etc.). Most often, it is in the case of the lesson content summaries and worksheets used for new learning content introduction/acquisition.

(3) **Audio and video processing tools (AVPT)**. Vf took second place as the most essential part of a lesson plan e-learning material. According to the obtained results, PSTT used a large variety (17, specifically) of freely available tools that they learned during their studies or were advised by their mentors. PowerPoint (V3) was the most frequent AVPT followed by GeForce Experience (V12) (8.7%); Dictaphone (V2), Loom (V4) and Audacity (V11), all at 6.5 %; smartphone applications (V1), Adobe Premiere Pro CC 2017 (V9), ShotCut (V13) and H5P (V16) all at 4.3% (Table 2 and Table 4). Geforce enables high-performance recording from cameras and other outdoor units, as well as on-screen events (lectures, seminars, video conferences). The largest proportion of students used Dictaphone to record sound due to its simplicity. One student recorded the sound with a smartphone and subsequently processed it with the Audacity tool. One student recorded speech by using Dictaphone and subsequently edited it with Adobe Audition; 18 % of students used SharеX and Nvidia GeForce Experience to record full or partial screen. Individual students prepared videos with Bandicam and Loom. One student recorded the original video in English with a transcript and translation (Google Translate) in Slovenian. Just under half of the students, 45%, further processed the captured footage, mostly in Adobe Premiere, and one student did so in Shotcut.

(4) **Specific engineering tools (SET)**. Tools used for learning topics from the technical documentation were the most frequently used of the SET. PSTT used different tools: Solid works in 20%, Qcad in 15%, and Solid Edge in 5% of cases. PSTT became acquainted with the last two tools during their studies, whereas they learned Solidworks (independently or on the recommendation by their teacher mentor). In the case of learning topics related to electrical circuits, 15% of students used Yenka and 10% Edison. Phet online simulation (a virtual laboratory) and the Crocodile Clips tool were both used in 5% of cases.

(5) **Knowledge assessment tools**. To analyse the acquired knowledge and understanding level from the given e-learning material, 51,8 % of PSTT created quizzes/questionnaires as a part of the lesson plan. The most often used are Google Forms (Q2) 27,6 % followed by word (Q4) 17,2 %, 1ka (Q6) 13,8 %, PPT (Q5) 13,8 %, Kahoot (Q1) 10,3 %, H5P (Q8) 6,9 %, Mentimeter (Q7) 3,4 % and Scratch (Q9) 3,4 %.

(6) **Learning content online publishing tools**. The largest number of PSTT (41.7%) posted the creation of e-learning material on the ZOOM web portal; 25% of them were allowed to publish on the web portal of

Slovenian educational video content, Arnes Video; 16.6% of them posted the creation of teaching materials on the MS Teams web portal. Half that amount (8.3%) of PSTT posted the creation of e-learning material on the YouTube portal and the in-service technology teacher-mentor's Google online classroom.

(7) **Online video meetings tools**. Only a few PSTT had the opportunity to meet students via video conferencing, of which 87.5% used Zoom and 12.5% MS Teams.

(8) **Other tools**. Among the remaining relevant to lesson plan making or implementing tools, a tool for transferring larger files, WeTransfer, was used. For examples and ideas of learning content, most PSTT (92.3%) searched on YouTube.

Table 5 presents the lesson plan structure with the online tools used by students of the pedagogical study programme and the students of other study programmes who participated in the 2015 survey. Students of the pedagogy study programme provide a lesson plan consisting of a text document covering the lesson content (82%) supplemented by a PowerPoint presentation (64%) and by video/sound recordings (12%) and websites (74%). Students of the pedagogy study programme also implemented the prepared lesson plan as webinar instruction in 28% of cases, but most of them used other tools 90% of the time. Students of the nonpedagogy study programme provide a lesson plan consisting of a text document covering the lesson content in 86.4% of cases, supplemented by a PowerPoint presentation (31.8%) and by video/sound recordings (1.1%) and websites (85.2%= of cases. Students of the nonpedagogy study programme also implemented the prepared lesson plan as webinar instruction in 13.6% of cases but with the large majority (96.6%) using other tools.

Table 5

The online tools used by students of the pedagogical study programme and students of other study programmes who participated in the 2015 survey.

Students of/ %	Lesson plan - making							Lesson plan	
	Content Material					Attachment		Implementing	
	Text	PPT	Pictures	Video Sound	Websites	WS/I	Questi-onnaries	Other tools	Webinar lesson
Pedagog. Study program	82	64		12	74			90	28
NON Pedagog. Study program	86,4	31,8		1,1	85,2			96,6	13,6

Note. Students results for making lesson plans, where: PPT = PowerPoint tool; WS = worksheet, I = instruction, where the number of content material represents the percentage of use of possible text, PPT, video/audio and website content. Students' results for implementing lesson plans using possible other tools and webinar lessons, for which the number represents the percentage of use of other tools and webinar lessons. Adapted from Lebeničnik et al., 2015.

The results of the research show that PSTT, pre-service technology teachers appeared to be heavily involved in e-learning activities and used most of the online tools mentioned in the 2015 survey (online classroom, online lectures, video viewing, use of other e-learning content and videos, combined text/image/video tools, quizzes, voice recognition, One Note, Zoom, etc.) and other specific online tools.

Discussion & Conclusions

At the start of the pandemic, no clear guidelines and directives from the Ministry of Education, Science and Sport were given in Slovenia for teachers regarding how to implement distance learning (at all levels). Distance learning was new for all participating primary school students and in-service technology teacher-mentors. While attempting to overcome the online learning issues, in-service technology teacher-mentors encouraged the implementation of online teaching practice. The research results of the first phase of pedagogical practice in 2019/2020 show that PSTT were not mentored by permanent teachers of technology in the educational process in the initial phase of pedagogical practice. In-service technology teacher-mentors were directed to integrate PSTT in establishing online learning to the greatest extent possible. The most predominant PSTT engagement was e-learning material preparation, as can be seen from Table 1. All in-service technology teacher-mentors were following the proposed intuitive learning model for teaching the subject Design and Technology. As teaching practice took place in the initial part of the online learning implementation, there was considerable confusion and many changes in the implementation. For example, in the Design and Technology subject, students received homework. At first, they had to send homework by email; then, they submitted it to the school's online classroom, and later they had to send it to the Google classroom. This resulted in uncertainty about what they had to submit and whether they had submitted it successfully.

The results show that in the second phase of teaching practice, we provided detailed instructions to technology teachers-in-training on effectively incorporating PSTT into the instructional process. In this case, they performed as the intuitive learning model suggests, which resulted in boosting online learning, which became meaningful. PSTT and in-service technology teacher-mentors recognised its values and advantages. The level of distance learning model implementation was found to be reached in all the separate elements, but only in 15.4% of cases was the model fully implemented. Compared to the first teaching practice phase, we could observe a difference: 25% fewer technical drawings, 30% more web pages included in the lesson plan, 150% to 200% more time dedicated to all activities related to e-learning material preparation, 200 % to 300 % more prepared attachments to the lesson plan, such as worksheets and questionnaires, 150% more published e-learning materials, 500% more webinars performed and 600% more homework assessment. During online learning, the predominant lesson type was conceptual understanding, which is not the case during normal teaching practice conditions. Lesson plan objectives were set at lower taxonomy levels as lessons were based on using more deduction methods in which students only listen to and/or read lesson material.

The research results show that the disadvantages of online learning were present. PSTT found that it was more difficult to follow online learning for less able students and students with special needs, which was reflected in a lower level of motivation to learn. They lacked guidance and additional explanation; only a few of these students had family support. While independent literature study is self-evident to PSTT, it was something new for students. Capable students were less likely to have problems with online learning than other students who already needed more explanation under normal circumstances. Not all students had equal access to ICT. Some students were left to fend for themselves; some had the help of family. It turned out to be important that the e-learning materials for students were given in the Slovenian language. In the knowledge test, the questions/tasks with image support were better understood and resolved.

In the practical work specific to the subject of design and technology, the results show that despite the restriction of materials and tools accessible at home, some advantages were seen. Publishing and sharing images/videos of students' products raised their work motivation. Parents' help and cooperation and significantly improved student products were observed in cases in which well-equipped home workshops were available to students.

Slovenian teachers were significantly forced to produce teaching materials than, for example, English-speaking teachers in Ireland. The latter mostly benefited from an extensive database of already produced materials. They also had extensive work guidelines after only one month from the start of the pandemic (Burke & Dempsey, 2020).

According to the studies overview done by Orr et al. (2018), it was observed that a large majority (92%) of all distance and online education studies conclude that distance and online education is at least as effective, if not better, than traditional education. Around 3% of the studies show that the traditional face-to-face format is more effective, and the remaining studies cannot demonstrate improvement (Nguyen, 2015). These studies, however, show that the rigorous methodology of the earlier ones is lacking. In terms of high standard meta-analyses, Means et al. (2010) found a positive but small significant difference in favour of online learning. Lack (2013) concluded that there is not enough evidence one way or another. Means et al. (2013) reported that the advantage of online learning over face-to-face classes was significant in those studies contrasting blended learning with traditional face-to-face instruction but not in those studies contrasting purely online with face-to-face conditions.

The research results show that PSTT believes that online learning will never replace genuine face-to-face conversation with students; however, they have realised the true importance and applicability of the technology in all possible areas of our lives. In the context of teaching practice, we observed for the first time the emergence of collaboration between PSTT and in-service technology teacher-mentor as PSTT were more technologically and ICT literate. The consequence of such collaboration was the higher quality of the learning material produced, which played a key role in this situation.

PSTT covered distance/online learning and blended learning in the 1st year of the postgraduate teacher study programme at the Faculty of Education of the University of Ljubljana. They are fully trained for distance learning execution, whereas PSTT of the undergraduate teacher study programme are not. This is also why only basic, well-known tools that enable distance learning model elements were mostly used. During the first teaching practice period, in-service teachers obtained only some general directives regarding distance learning from the Ministry of Education, Science and Sport related to the type of portal, webinar, and e-learning material they could use. However, suggested e-learning material for the technology domain was unavailable due to the Institute of Education site being under construction. The results of our study suggest that only a clear guide with instructions for in-service teachers to enforce new learning methods, such as online learning, could have been successful during the Covid-19 pandemic.

The results of our study show that by adopting the intuitive distance/online learning model, in-service technology teacher-mentors and PSTT became aware of the benefits of this learning method and the need to modernise traditional teaching. Covid-19 pandemic is beneficial for teaching modernisation toward blended learning. Only with modern learning strategies does modern educational technology gain meaning and immeasurable potential for motivating students. The findings can be applied to the engineering education domain regardless of education level for regular teaching/learning purposes to enable a more robust education process if the pandemic repeats in the future.

Limitations of the research: it would be useful to increase the sample of the research and include the performance of pedagogical practice of students from other Slovenian universities and present the results of foreign universities; it would be useful to conduct a structured interview to better generalise the results; since the epidemic is an exceptional state, not all invited teacher-mentors chose to conduct distance learning placements with students, the future teachers of technology.

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Biographical note

Bernarda Urankar, MSc, is teaching assistant in the field of engineering education and didactics of technical education at the University of Ljubljana, Faculty of Education, Slovenia and PhD student at the Faculty of Education, University of Ljubljana, Slovenia. Her research interests include the impact of online teaching in pre-university and university education, and the development of methodological and didactic material in engineering (with a focus on the experimental part of teaching) suitable for hybrid forms of engineering education.

Janez Jamšek, PhD, is assistant professor in the field of engineering education and didactics of technical education at the University of Ljubljana, Faculty of Education, Slovenia. His main research areas are biomedicine engineering, methods for nonlinear dynamics system analysis, mechanical drives: bearings noise & vibration analysis diagnosis and prognosis, engineering education, didactics of technical education: active learning strategies, high order thinking, developing critical thinking and engineering innovativeness, problem solving and technological literacy.