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A New Concept of the Informatics Curriculum in the Czech Republic: Teacher Reflection on the First Year of the Transition Period

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Abstract: In the Czech Republic, a new concept that proposes an Informatics curriculum for primary schools was prepared to meet the new requirements of the field. For the implementation to be smooth, a two-year transition period was planned from 2021 to 2023. Training seminars were the main tool to help teachers develop missing subject knowledge and didactic skills. After the first year of the transition period, the question was whether the seminars met the needs of teachers. Therefore, the main objective of the investigation was to collect feedback from them (N = 142) in five regions (of 14), consider changes within the first year (from autumn 2021 to autumn 2022), and propose recommendations for the rest of the period (by autumn 2023). The ex post facto method was used. Data were collected by questionnaires in five areas: (1) preference for an original or new concept for a curriculum, (2) and subject knowledge and didactic skills of teachers, (3) school equipment; (4) learning materials and teaching methods used, and (5) experience in online learning and teaching. The results show that in autumn 2022, the support for the new concept increased and the school equipment improved; however, subject knowledge and didactic skills were the weak points. Individualization through the tailoring of the seminars to the needs of teachers represents an efficient way to train them according to their level of knowledge, their preferred form of learning, and the learning content.

Keywords: ICT; Informatics; computational thinking; primary school; curriculum; Czech Republic

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1. Introduction

In contemporary society, computers are part of everyday life, and technology is its inseparable tool, both at home and at work. However, the ways in which use technology efficiently is a skill that should be developed from an early age. As stated by the European Education and Culture Executive Agency (2022) [1] (p. 23), educating learners at school in this field aims to equip them with the basic knowledge to participate, influence, and contribute to the development of the digital world. In the Czech curriculum, due to the fast development of technologies, there is a logical shift in the development of its teaching, from information and communication technologies (ICT) through to Informatics and computational thinking. From a historical point of view, all the knowledge and skills that were closely or remotely connected with 'computers' were included under the term (and subject) information and communication technology. This term was first used in academic research in the 1980s [2], and then in the National Curriculum in England in 2014 [3]; there it was replaced by computing and computer programming later on [4]. At the end of the 1990s, ICT was first implemented in higher education in the Czech Republic, mostly in faculties teaching Informatics and information technologies because these institutions had professional staff and were sufficiently equipped with hardware and software [5]. ICT-enhanced education, e-learning, was introduced gradually at that time, in higher education institutions first and in basic education later on. Its contribution to literacy and competence development was a topic of research at all levels of education [6]. Information became a strong tool, and Informatics is understood as the science of information that focuses on the behavior and structure of any system that generates, stores, processes, and presents information [7]. It considers the interaction and the construction of the interfaces between the information systems and the user [8]. In some (mostly European) languages, e.g., French, Dutch, this term is used as a synonym for Computer Science (CS). To distinguish the terms briefly, we can say that CS deals with computers, while Informatics is concerned with how to use them [8]. "Computer science has produced, at an astonishing and breathtaking pace, amazing technology that has transformed our lives with profound economic and societal impact. . . . Everyone can benefit from thinking computationally", J. M. Wing highlighted [9] (not paged). Therefore, computational thinking (CT) is another skill that should be developed with children within the curriculum. When defining this term, the role of computers differs. For example, Repenning et al. [10] characterize CT as the three-stage process that reiterates three As: abstraction (that is, problem formulation), automation (that is, solution expression), and analysis (that is, solution execution and evaluation). Stages 1 and 2 exploit human abilities, while stage 3 is based on computer affordances. However, other definitions are also widely accepted. For example, according to Denning and Tedre [11], CT is the mental skills and practices needed to (1) design computations that get computers to do work for us and (2) explain and interpret the world as a complex of information processes. The design aspect reflects the engineering tradition, when machines help the people; within the explanation aspect, users seek to understand how computers work. From the initial use of the term computational thinking' by Papert at the end of the 20th century [12], it was also defined by Wing [13], Proctor et al. [14], and many others.

In the first decade of the 21st century, the need for computational thinking was reflected in national curricula that were expected to equip people with the fundamental skills, knowledge, and understanding of computing that everyone would need for the rest of their lives [15]. However, for example, in England, the current National Curriculum for Computing deals with three strands: computer science, information technology, and digital literacy [16]. Ongoing reforms have been carried out in numerous countries, including the Czech Republic. The process is not smooth; therefore, this article contributes to the discovery of the development of the Czech National Informatics curriculum based on feedback collected from teachers.

1.1. PRIM Project

In the Czech Republic, changes to the national curriculum resulted from activities within the PRIM project (Podpora Rozvoje Informatického Myšlení—Support of Computational Thinking Development) [17] that was carried out from October 2017 to September 2020.

The PRIM project proposed changes to the Czech national curriculum, which is called the Framework Education Programme. The programme is structured into several levels according to the age of the learners. In this article, we focus on basic education (FEP BE; Framework Education Programme for Basic Education) [18], that is, learners aged 6–11 (ISCED 1).

Computational thinking, as defined within the PRIM project, is described as the transformation of a seemingly complex problem into a simple one that learners can solve. The process involves the following phases:

- Breaking the problem into a series of smaller parts that are easier to solve (decomposition).
- Considering each part separately, comparing similarities between and within other problems (pattern recognition).
- Taking into account only important features of the problem, while ignoring irrelevant information (abstraction).
- If similar problems are found, adapting to the solutions of them to solve the new ones (generalization).
- Designing simple separate steps to solve small problems (algorithms).

- Once a working solution is discovered, analyzing it to find out if it is helpful or how it can be improved (evaluation) [19].

Although it is clearly visible that computational thinking helps in problem solving, it does not appear automatically and must be taught and developed with the learners. However, teaching computational thinking does not mean teaching learners how to think like a computer; indeed, computers cannot think, and everything computers do, people make happen. Nor does it means teaching learners how to compute. What it does mean is to develop the knowledge, skills, and understanding of how people solve problems. As such, computational thinking cannot be limited to one subject or a course in computing, but it should be implemented throughout all subjects within the curriculum.

In the Czech Republic, the PRIM project was crucial in designing and piloting the transformation of Chapter 5.3 of FEP BE [18] called Information and Communication Technology. A particular emphasis of the project was placed on preparing conditions for the change. After the conditions were established, teaching and learning materials were created within the project, mainly

- 12 textbooks published on the project website [20],
- a system of in-service teacher training that focused on the implementation of a new version of FEP BE in this educational area,
- a system of pre-service teacher education and training in the area,
- a popularization campaign was carried out to attract public attention to the area of informatics, including computational thinking, and thus to support the interest of learners in IT and other technical professions [17].

1.2. From Original to the New Concept of the Czech National Curriculum of Informatics

In the first version of FEP BE published in 2007, the learning content that was the focus of this research was developed in Chapter 5.3 Information and communication technologies [18]. The chapter included three subchapters as follows: Introduction to the work with a computer, Information search and communication, and Information processing and application for primary school learners (aged 6–11). The further development of these areas was reflected in two subchapters, Information search and communication, and Information processing and application for lower secondary school learners (aged 11–15).

Based on the results of the PRIM project, in the latest revision of FEP BE published in 2021, Chapter 5.3 is called Informatics. According to the statistics presented by the European Commission et al., in 2020/21, teaching Informatics was a matter of the decision of local/school autonomy and the learning content was integrated into other subjects in grades 1–5 (ISCED 1). However, in the same document, the term ICT is used as a synonym for Informatics, which is confusing from the perspective of view of the new concept [1] (p. 24).

Within this new concept, changes were made to the structure of the chapter. Currently, the learning content is structured into four subchapters: Data, information and modeling, Algorithm development and programming, Information systems, and Digital technologies for primary schools. The other four sub-chapters with identical titles focus on the further development of knowledge in these areas at the lower secondary school level.

The new concept of FEP BE in Informatics states that digital competency is expected to develop within the learning contents of other subjects. However, the problem is that the learning content of other subjects was not developed and defined within FEP BE because Chapter 5.3 had been revised before the chapters on other subjects (or education areas). To eliminate this problem, in 2021, a two-year transition period was established in the FEP BE for Informatics, which provides time to make and coordinate changes in other subjects and to bridge the gap caused by the lack of qualified teachers, insufficient equipment in schools, etc. The learning content of other subjects is expected to be revised during this period and digital competency will be implemented in the learning content of other subjects. The new concept of Chapter 5.3 Informatics will be compulsory for all basic schools from September 2023. Meanwhile, there is time to make the necessary changes. However, currently (in December 2022), the process of FEP BE revision in other subjects, except for Informatics, is behind schedule; the final version is expected to come into force in September 2025 [21], that is, two years later than the new concept of Informatics is planned to start, which will surely cause problems in various fields of education.

Thus, an important question for teaching practice is whether computational thinking can be successfully developed in primary school learners under these conditions, that is, if (1) there is a discrepancy in the timeline caused by state authorities and (2) whether the preparedness of teachers (subject knowledge and didactic skills) and schools (hardware and software equipment) was monitored before the changes were proposed. If there are weak points in any of these areas, we can hardly expect computational thinking to be sufficiently reflected in the learning content and taught to primary school learners.

From the viewpoint of the literature review, two groups of works relate to this topic. To avoid doubling, we explain where they are available. First, works on the local results of the PRIM project that were presented mainly at local seminars held within the PRIM project [17] were mostly not published in world-recognized or other databases, and thus cannot be cited. Second, works providing definitions of terms used in the new concept of the Informatics curriculum are cited with the definitions and discussed at the end of the article within the Discussion section.

2. Materials and Methods

From September 2021 to August 2023, Informatics will be taught according to two curricula: either the original concept (2007) or the new concept of Informatics (2021). Within the two-year transition period (September 2021 to August 2023), schools are expected to prepare conditions for the implementation of the new concept that comes into effect from 1 September 2023. To follow the new concept for the curriculum, it is logical that teaching starts in primary schools. During the transition period, it is acceptable to implement new approaches in any grade of basic education (ISCED 1, 2). In this research, the focus is on primary schools (ISCED 1) [22].

2.1. Research Objective and Expectations

Reflecting the two-year transition period mentioned above, two rounds of investigation were carried out: (1) Round 1 in autumn 2021, which monitored the starting conditions of the transition period, and (2) Round 2 in autumn 2022, which described the state one year later, that is, at the beginning of the second year of the transition period.

The question is as follows: what changes happened during the transition period from autumn 2021 to autumn 2022 in schools regarding the new concept of the curriculum of Informatics towards the teaching of computational thinking?

The main research objective is to collect feedback on changes and developments within the transition period from the teachers of selected primary schools, and to compare their attitudes and opinions.

Five areas are considered: (1) preference for an original or new concept of teaching ICT/Informatics, (2) subject knowledge and didactic skills of teachers, (3) school equipment for teaching Informatics in single education areas, that is, in data, information, modeling, algorithms and programming, information systems, and digital technologies, (4) learning materials and teaching methods, and (5) teachers' experience in online distance learning and online distance teaching.

In particular, we investigate and consider whether there is any development in the field (process) of the new concept of the Informatics curriculum implementation in primary schools in the first year of the transition period, that is, from autumn 2021 to autumn 2022; we also investigate whether there are some changes in teacher opinions and experience, and if so, what they are.

The research questions (RQ) are set as follows:

RQ1: Will teachers express a higher preference for the new concept of teaching ICT/Informatics in autumn 2022 compared to autumn 2021?

RQ2: Will all teachers consider their subject knowledge and didactic skills appropriate for the new concept of the Informatics curriculum in autumn 2022?
RQ3: Will teachers think that school equipment is better in autumn 2022 compared to autumn 2021?
RQ4: Do teachers use the same learning materials and teaching methods in autumn 2022 compared to autumn 2021?
RQ5: Will teachers' experience in online distance learning and online distance teaching increase in autumn 2022 compared to 2021?

We expect that after the first year of the transition period, not all teachers will agree with the new concept of teaching Informatics, for various reasons, mainly because of uncertainty in subject knowledge and didactic skills; however, we also expect that during the year, the school equipment will improve step-by-step, which will finally result in a decrease in the number of opponents of the new concept.

2.2. Research Method, Tool, Sample

Data were collected ex-post-facto using the questionnaire method.

Two questionnaires were used. Questionnaire 1 (Q1) was applied in autumn 2021 as Round 1 of the research and consisted of 15 items. Questionnaire 2 (Q2) was administered in autumn 2022 as Round 2 and contained 25 items. The items covered the five areas described above. Four levels were used in Likert scales: 1: high, 2: rather high, 3: rather low, 4: low; or 1: fully satisfied, 2: rather satisfied, 3: rather dissatisfied, 4: fully dissatisfied; or 1: yes, 2: rather yes, 3: rather not, 4: not.

The number of items was different in the questionnaires because some of the items from Q1 were worked out in several ones in Q2 to obtain detailed answers. However, the content was identical so that we could ask questions and compare the results. Questionnaire 1 contained four items that required multiple-choice answers, two Likert scale evaluations, and nine open answers. Questionnaire 2 included five items with multiple-choice answers, five Likert scale evaluations, and 15 open answers. For example, subject knowledge and didactic skills were considered on a four-level Likert scale; preference for the concept, teaching the subject, the use of teaching materials and the form of attendance to teacher training seminars could be expressed through the combination of multiple-choice answers; experience in online teaching and learning, and other comments from the respondents, were collected through open answers.

In total, 52 teachers participated in Round 1 of the investigation (female: 92%) and 90 teachers participated in Round 2 (female: 87%). The structure based on the length of teachers' teaching practice is displayed in Table 1. Before the investigation started, all respondents were informed about the research methodology and gave their written consent to participate in the investigation.

Table 1. The length of teaching practice in the respondents.

Interval of Teaching Practice (Years)	Teachers in Round 1 (%)	Teachers in Round 2 (%)
0–5	26	39
6–10	10	12
11–15	12	8
16–20	10	11
21–25	6	9
26–30	20	12
31+	16	9

The data show that the respondents' length of teaching practice in the sample is different. While in Round 1, in autumn 2021, 26% of teachers had teaching practice that was five years long or less and 36% were in service for 26 years and more, in Round 2, in autumn 2022, 39% of respondents were in the 0–5 year group and 21% were in the 26+ year group. The numbers of respondents in the other groups are rather similar; they rank from 6–12%. The questionnaires were personally distributed by university students who were pre-service teachers of Informatics, during their three-week long teaching practice at monitored primary schools. The questionnaires were filled out by their mentors, teachers of Informatics. Most of the schools are located in the same region as the university (Northwest of the Czech Republic), or in the place of the students' permanent residence (other 4 regions out of 14—North, West, Central region, and Prague). This covers approximately one third of the Czech territory. The schools where data were collected are bound by an agreement to provide didactic support and teaching practice to the pre-service teachers. The agreement guarantees a high level of school teaching quality. However, it does not mean that teachers (mentors) do not have opposite opinions on some educational problems. As we can see in the following, they showed a wide range of the opinions.

A respondent represents one school in the research sample. The Czech Republic is a country of 10.5 million inhabitants (density 135/km^2, median 260/km^2), situated in central Europe. In total, there are 4214 schools [23] in 6258 municipalities [24].

The only city with a population of 1,000,000+ is the capital, Prague; five towns are close to 100,000, and the population of 12 towns is between 50,000 and 100,000 of inhabitants. On the other hand, there are almost 6000 of villages and small towns with a population below 5000. As displayed in Table 2, the schools participating in the research were located in villages, small towns, towns and cities, so we can state that both urban and rural schools were included in the sample; the terms 'suburban' and 'inner-city schools' are not used in the Czech education environment and statistics. Both the school equipment and the teacher qualification requirements are identical in urban and rural schools. However, in practice, due to the lack of teachers in Czech schools in general, partially qualified or pre-service teachers may work in rural schools.

Table 2. Rural and urban schools in the research sample.

Inhabitants	<5000	5001–10,000	10,001–25,000	25,001–50,000	50,001–100,000	100,000+
Schools in sample (%)	28	10	27	12	21	2

3. Results

The results are structured into the five areas described above, compared for Round 1 and Round 2, compared, and displayed in figures if appropriate.

3.1. Results for RQ1: Preference for a Concept

First, respondents declared whether they preferred the original curriculum (2007) or the latest revision (2021). In Round 1, 45 teachers (87%) designed and conducted their lessons according to the original curriculum. At the same time, 37 of them (71%) indicated their preference for this original concept. In other words, eight teachers were in contradiction: they follow the original concept in their lessons but they prefer the new concept. They state that the development of computational thinking in learners is important; however, they argue that there is not enough time devoted to it, either within a single subject or throughout all subjects. On the other hand, they appreciated that learners are expected to have a higher level of digital competency, which will definitely help in case of online distance learning in the future and in their autonomous learning in general. Contrary to this, they mention that there is much emphasis on programming, a lack of equipment in schools to teach some topics, a lack of time (lesson load), it is not properly defined how the learning contents should be implemented in other subjects, and that the qualification of teachers is not sufficient, etc. Thus, there is not much support for the new concept of teaching Informatics. As the implementation started a few months before the administration of the questionnaire, teachers did not make any serious recommendations as to how the new concept should be improved.

In Round 2, a large shift was detected in this field—95% of respondents declared that they were teaching Informatics according to the new concept proposed for the curriculum. This means that only 5% of them continued to teach according to the original curriculum. However, only 23% of the respondents taught the lessons personally; 26% of them stated that the subject was taught by another primary school teacher or by a lower secondary school teacher of Informatics from the same institution (41%). In total, 4% of schools were not teaching Informatics as a separate subject, but were implementing the learning content into other subjects. In total, this approach was supported by 61% of respondents, who agree with the idea that Informatics should be naturally implemented in all subjects of primary school and thus understood within a wide range of them, not as a separate subject taught in the 4th and 5th grades of primary school. In 6% of schools, the subject of Informatics was not taught at all, which means that 11% of schools included in the research sample had not started teaching according to the new concept for the curriculum.

Conclusion for RQ1: Teachers express a higher preference for the new concept of teaching ICT/Informatics in autumn 2022 than in autumn 2021.

3.2. Results for RQ2: Subject Knowledge and Didactic Skills of Teachers

Second, the professional qualification of the teachers was the focus. The requirements for teacher qualification are high. All teachers in the Czech Republic are expected to have a master's degree in teaching and in selected subjects. Primary school teachers usually have specialization in didactics, that is, in teaching 6–11-year old pupils, and a foreign language, or music, arts, Informatics, or another subject.

Results are presented as (a) the respondents' feelings, that is, whether teachers felt adequately qualified to teach Informatics according to the new concept; and (b) how teachers evaluated their subject knowledge and didactic skills in four areas of the new concept, that is, in data, information, modeling, algorithm development and programming, information systems, and digital technologies.

In Round 1, only 4% of teachers stated that they felt adequately qualified for the new concept, while 75% were not sure about their qualification (17% of them felt rather qualified; 58% felt rather not qualified), and 21% of them did not think that they were qualified for this learning content. They expected that algorithms and programming would be difficult topics for learners; this included the implementation of the learning content in other subjects, particularly in the mother tongue, foreign languages, geography, and others. Due to their lack of experience with the new concept, they did not speculate upon the possible problems. However, some of them commented that they had not had experience during their university studies and follow-up training of teaching within a concept such as the new one.

In Round 2, the situation did not change much. Similarly, 5% of teachers thought that they were qualified for the new concept; 62% of them were not sure about their qualification (21% of them felt rather qualified; 41% felt rather not qualified), and 33% did not think that they were qualified for this learning content. Compared to autumn 2021, the number of those who were not sure about their qualification for the new concept decreased by 13% in autumn 2022; however, there were 12% more respondents who did not feel qualified at all. In other words, in autumn 2022, there was still a group of enthusiasts who were ready and qualified for the new concept, but they was not many (5%). Furthermore, there was a rather large group of realists (62%) who were open and honest and stated they were in doubt about their knowledge and ability to teach according to the new concept; however, this number is 13% lower than a year before. Contrary to this, there were 12% more respondents who stated that they were not prepared at all. This polarization of teacher opinions could be caused by the fact that they had a closer insight into the new concept during the first year of the transition period when they started the preparation of the school educational programme, shared experience with an enthusiastic colleague, etc., and they can now see where their knowledge lacks. However, in total, these results show that most teachers were not prepared for teaching according to the new concept of the Informatics curriculum, and much needs to be achieved during the second year of the transition period.

The main complaint that teachers had was that they were not prepared for this learning content during their university studies, and this was reflected in the PRIM project [17]. According to the programme of teacher training seminars displayed on the project web page, the content of these included all four areas of the new concept of the Informatics curriculum and a wide range of teaching methods. However, it is difficult to review a few months later what the real content was. More than half of the seminars (54%) were conducted online in the mother tongue, so all the teachers could attend. However, almost half of the respondents gave the usual reasons as to why online seminars did not suit them; this included, for example, that they did not appreciate the online form (rather not—30%, not—14% compared to yes—36%, rather yes—20%). This was, for example, because of the teaching style and/or a lack of face-to-face contact, which they understood to be part of the individualized approach that they needed to understand the difficult topics.

Despite the attendance of seminars during the first year of the transition period, which aimed to prepare them for teaching the new learning content, teachers were still not sure about their subject knowledge and didactic skills. Regarding the content, more than half of the respondents gave a positive reply to the question of whether the seminars helped them prepare for teaching Informatics according to the new concept; however, others were disappointed with the content. In an additional open-answer item, none of the respondents mentioned the content of the seminar(s) or what they particularly missed. On one hand, this shows their uncertainty in the subject knowledge and didactic skills; on the other side, it is difficult to help them if the lecturer does not know what to focus on. On top of that, if the seminar was carried out online with a minimum individualized approach, learning efficiency is low and teacher motivation decreases, along with their support for the new concept in the curriculum.

Reflecting the above mentioned, teachers evaluated their subject knowledge and didactic skills regarding four educational areas in the new concept: data, information, modeling (DIM); algorithms and programming (AP); information systems (IS); and digital technologies (DT), where 1 means the highest level of skills and knowledge, and 4 means the lowest level.

In this research, the professional qualification includes two inseparable areas: subject knowledge and didactic skills. In Round 1, in the questionnaire, both areas were considered by the respondents under one item, while in Round 2, each area was reflected in a separate item. As a consequence, the results of Round 1 are displayed in Figure 1 (left) as didactic skills and subject knowledge, the results of Round 2 are displayed in Figure 1 (middle) as subject knowledge, and the results of Round 2 are displayed in Figure 1 (right) as didactic skills. The results are displayed in percent.

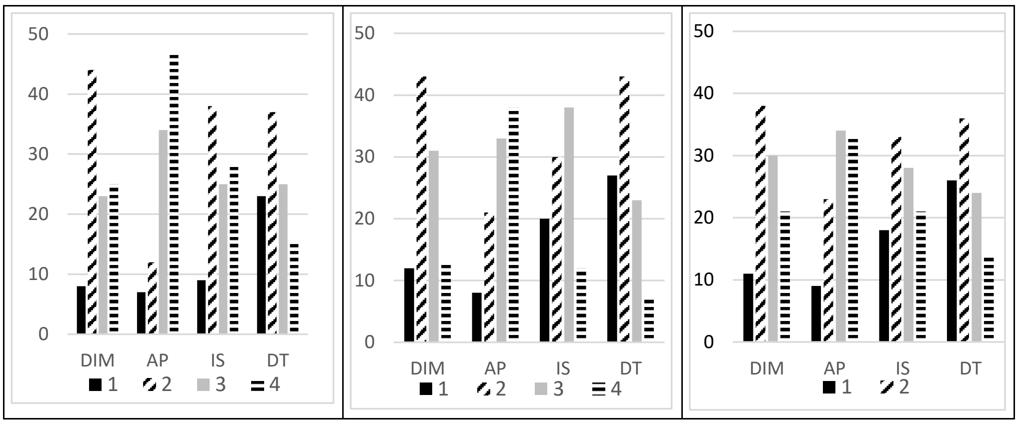

Figure 1. Subject knowledge and didactic skills of teachers (**left**) in Round 1; Subject knowledge of teachers (**middle**) in Round 2; Didactic skills of teachers (**right**) in Round 2: self-reflection (%). (DIM: data, information, modeling; AP: algorithms, programming; IS: information systems; DT: digital technologies; 1: the highest level of skills and knowledge; 4: the lowest level of skills and knowledge).

In Round 1, as we can see in Figure 1 (left), teachers did not value their subject knowledge and didactic skills highly. Only 23% of them thought that they reached a high level (1) in digital skills (DT), but this was below 10% in DIM, AP and IT. They mostly stated that their level was rather high (2) in three educational areas (44% in DIM, 38% in IS, 37% in DT). In the same areas, the number of respondents who considered the level of their skills and knowledge to be rather low oscillates around 25%, with the exception of 15% at the low level (4) in DT. Contrary to this result, in the area of algorithms and pro-gramming (AP), almost half of the respondents (47%) stated that the level of their subject knowledge and didactic skills was low (4), and 34% of the respondents considered their skills and knowledge in AP to be rather low (3). In total, 81% were not satisfied with the level of their subject knowledge and didactic skills in the area of algorithms and pro-gramming. In sum, they reached an appropriate level of digital skills; however, particu-larly teachers who obtained their qualification years ago and were not trained in teaching the latest topics were unsure about their subject knowledge and didactic skills in order to meet the requirements of the new concept in the curriculum. However, these teachers should not expect to improve though passive training; they are expected to improve and update their knowledge themselves. However, some of them are overloaded, demotivated, and not interested in further education at all. Unfortunately, they have experienced several 'new concepts' that did not have the opportunity to show their potential, so they think this curriculum will be the next.

In Figure 1 (middle), the data collected in Round 2 are displayed. They deal with the subject knowledge of respondents. Similar to Round 1, large differences can be seen in this figure, mainly in the area of DT. Most teachers thought that their level of subject knowledge was rather high (2) in DIM and DT (43% each), followed by 30% in IS; compared to this, 21% of respondents considered their subject knowledge rather high in AP. A high level of knowledge was detected with 27% in DT, 20% in IS, and 12% in DIM; the smallest group was in AP, with 8%. In AP, most respondents declared that they had a rather low (33%) and low (38%) level of knowledge, that is, 71% in total.

In Figure 1 (right), the data collected in Round 2 are displayed. They deal with the didactic skills of respondents. In this figure, the results do not differ much. Most teachers considered their level of skills to be rather high (2) in DIM (38%), DT (36%), and IS (33%). The results in these areas were quite close to each other in the rather low level (3), when reaching 30% in DIM, 28% in IS, and 24% in DT. The low level (4) was detected in DIM and IS (21% each), and 14% in DT. In contrast, in AP, results in the rather low and low levels were similar (34% and 33%), that is, in total, 67% of teachers were not well prepared and trained for teaching according to the new concept in the curriculum.

When considering results in this area, the question of whether the learning content of the seminars prepared teachers for the new concept in the curriculum appears again. As more than half of the respondents attended one seminar at a minimum, we expect that they attended seminars on the areas in which their subject knowledge and didactic skills were low, that is, mainly algorithms and programming. However, based on the data presented above, more training is needed even now. As seen in the left, middle, and right parts of Figure 1, 39% of teachers who graduated from universities five years or less before Round 1 started did not consider their knowledge and skills high or rather high in most areas, mainly in algorithms and programming, and information systems.

Conclusion for RQ2: Not all teachers consider their subject knowledge and didactic skills appropriate for the new concept of the Informatics curriculum in autumn 2022.

3.3. Results for RQ3: School Equipment for Teaching Informatics

Third, the school equipment was monitored for the educational areas included in the new concept. As in Figure 1, four areas (DIM, AP, IS, DT) were considered and evaluated (1 means I am fully satisfied with the equipment in this area'; 4 means I am not satisfied at all'). The results are displayed in percent in Figure 2.

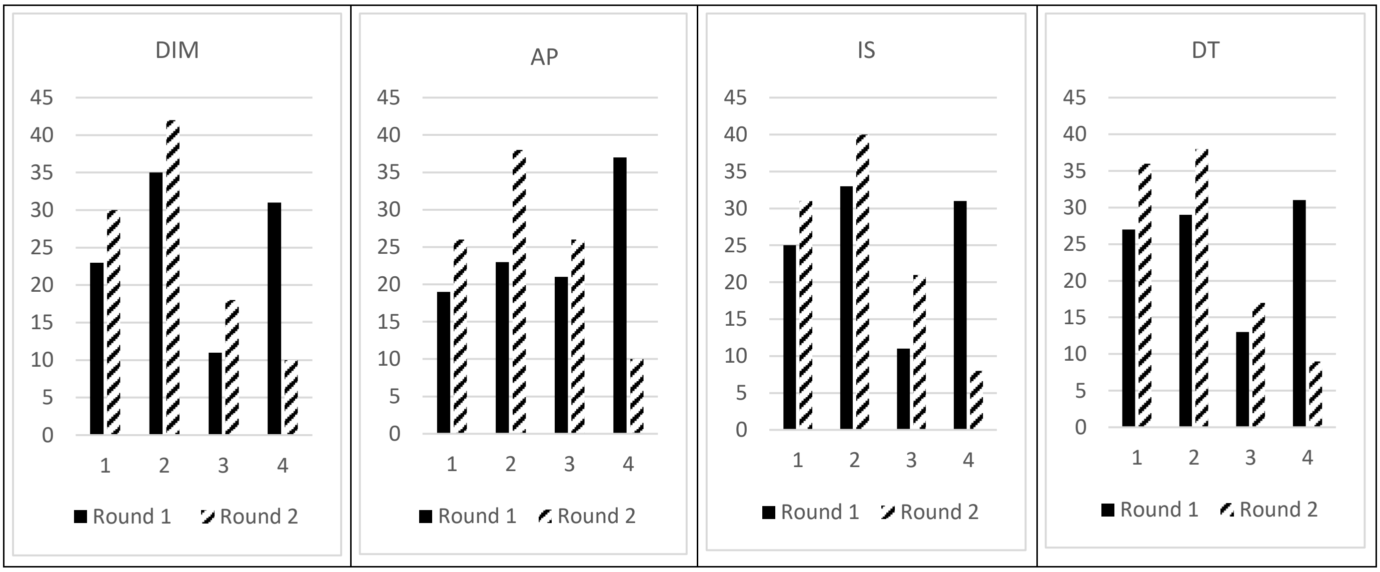

Figure 2. School equipment in Round 1 compared to Round 2 (%) in DIM: data, information, modeling; AP: algorithms, programming; IS: information systems; DT: digital technologies; 1: teachers are fully satisfied with the equipment in the education area; 4: teachers are not satisfied at all.

The lowest level of satisfaction (4) was detected in the area of algorithms and programming in Round 1, when it reached more than 35%. However, approximately1/3 of teachers were also not satisfied with the equipment in other areas. In Round 2, the equipment of the schools improved. Approximately 2/3 of the teachers were fully or rather satisfied with the equipment in the area of data, information, and modeling (35%). A rather low level of satisfaction with the equipment (below 15%) was detected in all areas excluding algorithms and programming (AP).

Conclusion for RQ3: Teachers think that in autumn 2022 the school equipment is better compared to autumn 2021.

3.4. Results for RQ4: Learning Materials and Teaching Methods

Fourth, in terms of learning materials, the data show that most teachers used textbooks for teaching the subject, in particular, two types of textbooks. If the teachers adhered to the original concept, they used the textbook Introduction to Informatics for Primary Schools [25]. Of the 71% of teachers who gave their preference for the original concept, 40% of them used this textbook. The others, who followed the new concept, used any of the textbooks created within the PRIM project and are of different structure and content. These textbooks focus on computational thinking and digital competency development, emphasized learners' autonomous work in problem-solving, and provide teachers with didactic games, worksheets, experiments, etc. They underwent a 2.5-year long piloting program at ten primary schools and were adjusted according to the received feedback. Each textbook focuses on a selected part of one of the area (DIM, AP, IS, DT). As a whole, the textbooks show how to teach the learning content in a new way that follows the new concept of the Informatics curriculum and to develop computational thinking. Teachers could decide whether they used all the materials in the textbooks or picked up only some of them.

Each textbook consists of (a) an introductory part, in which the authors describe how to work with the textbook, what aids are needed for the lessons and the software to install, (b) learner worksheets, which contain various tasks and problems to be solved by learners in school lessons or at home, and (c) a teacher booklet, which provides didactic recommendations on how to teach the topic in the efficient and interesting way. Textbooks cannot be purchased in the printed form but are available online or can be downloaded free of charge. An e-version enables one to update the learning content any time if needed. In addition, it makes no sense to print them—learners can see and work with the worksheets on the screen or interactive board, and teachers can read the booklets on their device [20].

Teachers supporting the new concept also used materials from teacher training seminars or the PPUČ project (Podpora Práce UČitelů—Support to teachers' work) [26], they shared materials from educational web pages or from the Internet in general, printed them, and designed their own worksheets, etc. Some teachers (11%) combined various sources, including video-recordings. Hardly any teacher (2%) stated that they explored e-applications or online courses bought by the school.

Based on the collected data, we can guess that the teachers who followed the original concept (2007) combined the work with the textbooks that were published at the time the concept was designed and the use of computers (notebooks) for practical exercises. If there were not enough computers in schools, learners could share one in twos or threes, which allowed them to work in teams. Therefore, a lack of equipment does not reduce the quality of the lessons.

Not a single teacher mentioned the project work as a didactic method; one teacher referred to the participation of learners in a project carried out by another school. We expected that the work of different projects would be what teachers would implement in teaching. We hope that this method is widely applied in the new concept in the future.

Compared to this poor result discovered in Czech schools, Hsu et al. [27] conducted a meta-review of studies published in academic journals from 2006 to 2017 with a focus on adopted learning strategies. They discovered that project-based learning, problem-based learning, cooperative learning and game-based learning were used primarily in teaching computational thinking, while aesthetic experience, design-based learning, and storytelling were relatively less frequently adopted.

In Round 2, where 95% of respondents declared that they taught Informatics according to the new concept of the curriculum, 78% of them stated that the textbooks created within the PRIM projects were the main learning materials. No changes were made to the textbooks described in Round 1 (last update of the project web page was on 15 February 2019) [28]. The others (17%) also used these textbooks, but they considered other sources to be more useful for teaching: web pages on teaching Informatics and computational thinking development (10%), applications (8%), digital materials created by other teachers (13%), printed and digital materials created by themselves (15%). Project work was not mentioned in Round 2; in practical exercises, 22% of teachers organized work in pairs or small teams, mostly because of the lack of school equipment (notebooks). Thus, we can see that the range of teaching methods was not wide. Digital technologies offer many more tools than the teachers mentioned. Not exploring them could be caused by various reasons, e.g., the rather low level of subject knowledge and didactic skills of some teachers, as described above.

Conclusion for RQ4: Teachers use the same learning materials and teaching methods in autumn 2022 compared to autumn 2021.

3.5. Results for RQ5: Teachers' Experience in Online Distance Learning and Online Distance Teaching Informatics

In the Czech Republic, online distance instruction was conducted in two main periods. They differ in several features; the most important are the length of the periods and the attendance of online distance lessons. The first period covered four months (from March to June 2020). Due to the insufficient equipment of the learners, in terms of hardware and access to the Internet, the attendance of the lessons was voluntary. In most learners and teachers, this was their first experience of online distance instruction, which means that this approach was new to them; at the beginning, they were interested in working online, despite lacking some digital skills. Everyone expected that this period would last two to three weeks, and everyone was willing to overcome potential problems. However, this period lasted almost four months, and didactic and technical problems caused stress for both parties. The second period started in the second half of September 2020 (there were summer holidays in July and August) and finished in the second half of May 2021, that is, after eight months. Before this period, teachers and learners were briefly trained in online distance instruction, mainly in face-to-face seminars, and several acts and directions were published by the Ministry of Education. They made the attendance of online distance lessons compulsory, and thus the equipment of schools with hardware improved substantially. As a result, the main precondition for online distance instruction was met; all learners and teachers had a computer (notebook) and Internet access was available.

Two questions about online distance teaching and learning were included in the questionnaires because we expected that teachers could find some features connecting the new concept of teaching Informatics with online distance instruction, e.g., the need for computational thinking in autonomous online distance work or for improving the digital competency.

In Round 1, 92% of respondents stated that they had experience in online distance teaching. Surprisingly, none of them mentioned their own experience in online distance learning. Their experience in online distance teaching related to the two periods described above. The teaching occurred before the new concept of Informatics was introduced. Therefore, the new concept is not reflected in the teachers' responses to online distance teaching. They exploited platforms and tools, e.g., MS Team, Zoom, Google Classroom, Google Meet, and others. The main method was explanation through the shared screen, so that the learners were in visual contact with the teachers. The learning materials were mostly prepared by themselves: presentations to explain the learning content, online tests and exercises with feedback to practice new knowledge and skills were created in Kahoot [29], Wordwall [30], learningapps [31], and other Google tools; quizzes were used primarily at the beginning of lessons to motivate learners, and video-recordings were appreciated at any time during the lessons. Thus, the learning content was available in an illustrative and clear way. Most teachers emphasized that online distance lessons should not be longer than 30 min to keep learners' full attention. On homework, learners could work with computers, notebooks, tablets, or smartphones. The homework activities contributed to the development of autonomy in learning and problem-solving within computational thinking, although it was not mentioned in the concept at that time.

In Round 2, 25% of teachers stated that they did not have experience in teaching online; they belonged to the group of young teachers with 0–5-year long teaching practice (see Table 1). Of the others, some kept complaining about technical problems and the Internet access (5%); they considered the lack of personal contact to be a substantial constraint in the process of education (5%), and were stressed by this way of teaching (7%). On the other hand, a quiet home environment was appreciated by 13% of respondents, as well as no commuting to work (11%), saving time and making more activities within a day (17%); teaching a seriously ill learner according to the individual learning plan online was also mentioned. Some young teachers made their first steps towards this way of teaching when they carried out various online distance activities (8%), using Scratch [32] or other applications (14%). In total, 5% of teachers emphasized that they used appropriate applications not only in Informatics, but in all subjects to make lessons more varied and involve the learners (5%); we expect that these are the respondents who supported the implementation of ICT/Informatics in all subjects, not teaching it as a separate one (see part 3.1 Preference for a concept).

What changed substantially in Round 2 was the teachers' experience of learning online. Compared to Round 1, when none of the respondents mentioned their own experience in online distance learning, one year later, in Round 2, 69% of teachers had attended one online seminar or webinar at a minimum (respondents did not differentiate between these two terms, but used them according to their habits). This result may also be understood as the reflection of their autonomy in learning because 77% of the respondents in Round 2 reached their university degree in the part-time form, which requires more autonomy [33], compared to 62% of the respondents in the full-time form of study. The seminars were held under the auspices of the PRIM project as one of the sustainable outcomes. Furthermore, similar to online distance teaching, some respondents lacked personal contact (4%) but appreciated the home environment (37%), more time for learning (28%), no commuting (11%), teacher didactic approach and digital competency (6%).

Conclusion for RQ5: Teachers' experience in online distance learning and online distance teaching is different in autumn 2022 compared to autumn 2021.

Although improvement was detected in several areas, there is still much to do in others, mainly updating the subject knowledge and didactic skills of teachers. In this field, teacher training through online or face-to-face seminars plays an important role. Ensuring the didactic quality of the seminars is a big challenge for the second year of the transition period and a way how educational objectives of the new concept of the Informatics curriculum towards computational thinking development can be achieved.

4. Discussion and Recommendation for the Second Year of the Transition Period

Although there are some partial improvements, there are at least three features that play a negative role during the transition period: (1) timeline of the FEP BE implementation in Informatics and other subjects; (2) learning content of the new concept of the Informatics curriculum and the seminars on teaching according to the new concept; (3) an increase in knowledge on computational thinking.

4.1. Ad (1) Timeline of the FEP BE Implementation in Informatics and Other Subjects

Since autumn 2021, the Framework Education Programme for Basic Education has been under revision by a group of experts set by the Czech Ministry of Education, Youth and Sports. Public and expert discussions about the revision are summarized in Jitersky et al. [20]. The main directions of the FEP BE revision arise from the Strategy for the Education Policy of the Czech Republic up to 2030 [34]. The document provides not only the description of the current state, but, in particular, it is expected to propose methods that lead towards the expected objectives and learning outcomes. The problem is that Chapter 5.3 Informatics was excluded from the list of other subjects and was revised ahead, as mentioned above; problems related to the new concept of the Informatics curriculum are not discussed in this document [21]. The revised version of FEP BE, which implements digital literacy in all subjects, is expected to come into force from September 2025, while the new concept of the Informatics curriculum will be applied from September 2023. Thus, the deadlines are incompatible: there is a two-year gap between September 2023 and 2025, which means that the learning content of chapter 5.3 Informatics cannot be taught within other subjects for two years (as required by the new concept of the Informatics curriculum) if the revision of FEP BE is not finished and the curricula of these subjects are not set. Consequently, computational thinking cannot be developed to the maximum extent under these conditions.

4.2. Ad (2) Learning Content of the New Concept of the Informatics Curriculum and the Seminars

The new Czech concept of the Informatics curriculum (Informatics is used as a synonym for Computer science below) partly arises from the National Curriculum in England [11]. In this concept, the name was also changed from ICT to computing, which instead of others, included more emphasis on computing than computer science and programming; the 'sequencing instruction' aspects formed the new Computer science content [35]. Furthermore, it applies computational thinking, which aims to prepare the next generation of problem-solvers [15]. The authors of the National Curriculum understood that computational thinking is an essential part of education from early childhood [36]. Practical skills are replaced by understanding how computer and information systems work; skills can be developed further on. Various resources, including lesson plans, are available on educational web pages for those who plan to integrate them into the lessons [13].

This approach substantiates the topics selected for the new concept in the Czech Republic. Computational thinking development shifts Informatics from a subject that supports digital literacy towards a full-bodied and well-rounded subject in the STEM

(Science, Technology, Engineering, Mathematics) field that is an inseparable part of the 21st century education. Identical trends can be found in the educational systems of other countries, including those geographically close to the Czech Republic, e.g., Poland, where the subject of Computing has been taught for five years, or in the Slovak Republic, where within Informatics, primary school children have been learning programming and working with robotic sets for 13 years [37].

In accord with this, many countries implemented Informatics (Computer science) as a subject in primary education to train learners in creating computer programs and using Scratch as a common approach to teaching computer science.

Heintz et al. [38] reviewed how ten countries (Australia, England, Estonia, Finland, New Zealand, Norway, Sweden, Republic of Korea, Poland, USA) reflected computer science in their curricula, and discovered the following features: digital competencies are taught together with programming, or as a broader subject of computer science or computing; computational thinking is rarely mentioned explicitly; and that the most common model is to make computer science content compulsory in primary school and elective in secondary school, however, a few countries make it compulsory in both, while other countries introduce it in secondary school only. As mentioned several times, some of the features are included in the Czech new concept.

Furthermore, in the past, some authors have stated that teaching programming to children is the first step to computational thinking, and the learning should start as early as possible (e.g., [39–41]).

Contrary to this, others have emphasized that computational thinking could also be acquired by other means, for example, educational robotics [42], Scratch Jr [43], or even through ethics lessons, as described by Seoane Pardo [44]; however, he studied 14–16-year-old students.

These approaches are reflected to some extent in the new Czech concept of the Informatics curriculum. However, as the findings of our investigation show, the current problems lie in teachers' (feelings of) insufficient subject knowledge and didactic skills. This is the reason why the role of the PRIM project is crucial. Despite the fact that the project was completed in September 2020, seminars that are expected to improve teachers' professional knowledge and didactic skills are still held under the auspices of the project as a sustainable outcome of the project. In spite of the changes that were detected after the first year of the transition period, teachers (1) still do not feel appropriately qualified for teaching according to the new concept of the Informatics curriculum and do not appreciate their subject knowledge and didactic skills highly; and (2) more than half of them state that the seminars held in the last year did not help much. In other words, neither the learning content (knowledge of DIM, AP, IS, DT, and how to teach them), nor the form of seminars (face-to-face or online) were appreciated. However, now, a few months later, we cannot objectively consider whether the criticism was well-founded, or if the problem may be caused, for example, by the one-size-never-fits-all approach [45] of online seminars, or what the problems were rooted in.

'Tailor the seminar to your needs' is the approach we recommend to apply. Although it is not new, it can help in this case, mainly if the seminars are held as 'mini-seminars', i.e., if pairs or very small groups of learners participate in each mini-seminar. Furthermore, it is generally accepted in teaching that if a learner does not succeed in learning, the teacher analyzes the process and sets measures towards improving the learning outcomes. In most cases, it means that the learning process is individualized to some extent. Let teachers do the same when deciding what seminars to attend. Within this process, they should consider the following criteria:

- the level of entrance knowledge, that is, whether they are beginners, intermediate, or advanced learners (according to their feeling);
- the preferred form of learning, that is, whether they prefer to attend face-to-face or online seminars;
- the learning content, that is, what they need to acquire DIM, AP, IS, DT, teaching DIM, teaching AP, teaching IS, or teaching DT.

To cover all criteria, 48 short mini-seminars should be prepared. The practice should show how long means 'short'. If the mini-seminars are online, they can be available 24/7 with discussion in the pre-defined times. For the face-to-face mini-seminars, teachers can register online for the pairs or mini-groups on the date of the seminars so that organizers can prepare an adequate schedule. If some gaps appear, there definitely will be somebody to discuss with meanwhile. Thus, carrying short mini-seminars does not take much additional time from teachers—each one will select and attend those that fit their needs. The only problem preparing 48 mini-seminars. We think that the work should be performed by the PRIM project solvers, instead of in the half-day full-room seminars that they held in the past. This large-scale format did not bring the expected contribution and must be changed. Individualization, primarily the possibility of tailoring seminars to teachers' needs and attending them in a pair or small group could be a way of improving the preparedness of Czech teachers for the new concept of the Informatics curriculum.

In autumn 2022, the National Pedagogic Institute held a seminar called DigiRoadshow in each region [46]. The organizers invited the headmasters of schools to a half-day face-to-face seminar to provide them with the latest information and samples of good practice. We can guess that such an event, which was targeted at school managers and not at those qualified in Informatics, could help in some problems; however, this should have been accompanied by follow-up seminars for teachers, or the teachers should have participated in pairs with the headmasters. Thus, they could have discussed potential questions and solved problems on site, sharing them with other school representatives.

The process of commenting on the revised FEP BE closed in December 2022; the process of designing a new concept of FEP BE (except Informatics) starts in January 2023.

4.3. Ad (3) Development in Computational Thinking

In addition, we ask the question of how the development of (knowledge in) computational thinking can be considered or measured within the two-year transition period. No didactic tests were designed within the PRIM project that could be used for this purpose, no internationally recognized tests were piloted for the Czech language, and no international versions were recommended for use. For example, the computational thinking of the 5th-grade learners was evaluated by Chen et al. [47]. When developing an instrument, they emphasized that there are two main problems in the field: first, there is a lack of consensus in terms of CT definitions; first, many of them are vague, which works as a barrier to the assessment; second, many primary school learners have limited programming experience, which requires an instrument that is administered on the pre-test/post-test basis.

Within the process of piloting the curriculum, teachers' and the public (parents') opinions on learners' knowledge were only discussed, mostly in various public online discussion groups. The discussion was not managed, the questions were neither systematically prepared, by, e.g., project solvers, nor were answers analyzed and reflected in the concept. The serious feedback was collected from a team of experts who, in most cases, were not the teachers of Informatics. Thus, they were able to provide a theoretical reflection on the concept. As a consequence, if there were more teachers in the team of experts, the need for a tool to consider to what extent the new concept of the Informatics curriculum contributes to computational thinking development would be clearly visible during the transition period. If we had the tool, the data could have been collected, the results compared, and a potential increase in knowledge would have been discovered.

From this point of view, Angeli and Giannakos [48] propose to devote systematic research efforts mainly to the definition of computational thinking (CT) skills for each school grade level or developmental level, and to the verification of pedagogical strategies and technologies for teaching CT and the professional development of teachers in CT. In particular, they emphasize that "teachers need to be systematically prepared in terms of how to design CT learning activities, how to teach CT, how to assess CT, and how to use technologies to teach CT concepts. Thus, teacher professional development programs must be implemented for in-service teachers, while at the same time teacher educators must find ways to integrate the teaching of CT in their pre-service courses for the better preparation of pre-service teachers." (not paged) The assessment of CT skills is not well developed. Thus, this is one of the challenges in the field in order to discover whether a holistic approach or a concentration on partial skills within the context of authentic problem-solving across the subjects is preferred.

Given that computational thinking is still an unresolved issue, Román-González et al. [49] introduce a set of tools for testing CT from different perspectives: the Computational Thinking Test, the Bebras Tasks, and Dr. Scratch. They designed a comprehensive model that intends to assess CT at every cognitive level of Bloom's revised taxonomy.

Last but not least, what is frequently criticized within the whole Czech education system is the time load: Informatics is taught one hour per week in one grade in primary schools and in all grades of lower secondary schools. This load is not considered sufficient to acquire the required learning content [50].

However, the lack of qualified teachers is an important problem in the new concept. There is a lack of students enrolled in teaching Informatics at the higher education level, irrespective of whether the study programme is taught at the faculties of education, faculties of science, or others. Students of/graduates from Informatics prefer working in IT companies to teaching, particularly because of a higher salary. Therefore, new teachers do not graduate and the age of the teaching staff in schools is increasing [51]. Teaching part-time, if accepted by IT experts, does not result in permanent positions. The high age of the teachers was proved by the structure of the sample in our investigation; this can also be detected in national statistics [52].

5. Conclusions

The article contributes to a better understanding of the new concept of the Informatics curriculum development. The development is considered from the point of view of learning content and the preparedness of the educational system (mainly teachers and schools) for the change. Data were collected after the first year of the two-year transition period and compared with the starting situation [53]. Based on the results, didactic recommendations were proposed for the second year of the transition period. The main tool to help teachers were teacher training seminars, which were mainly short mini-seminars precisely tailored to teachers' needs when reflecting their level of knowledge, preference to the form of learning, and the learning content.

In conclusion, we should admit that the results discovered in this investigation are not good so that the new concept of the Informatics curriculum could be successfully implemented from September 2023.

Of course, the results of this investigation are limited by the gender structure of the sample. However, it follows the gender structure of teachers within the education system in the Czech Republic [54]. The sample is also geographically limited to five regions out of fourteen, but both rural and urban schools are included, and the teachers participating in the research have various lengths of teaching practice.

Now, there is a last chance to make changes (improvements) to the system in the second year of the transition period in the preparation of teachers according to the new concept of the Informatics curriculum. Examples of good practices, challenges, and the implications of developing CT in young learners are listed, analyzed, and discussed within the review of empirical studies on the use of educational technologies for CT development [55]. On the PRIM project web page, new lesson plans [56] are available that give more samples of how CT can be developed in the Czech educational environment. For the final year of the transition period, this is a helpful tool that can be directly applied in lessons, or can inspire teachers to design their own.

The question asked by Stamatios [57], of whether CT should be taught in preschoolers, is not the topic of the day in the Czech Republic. First, the transition period of the new concept of the Informatics curriculum should be finished, and only then, a new concept for preschoolers could start, we think.

If we understand CT in accord with Dolgopolovas and Dagiene [58], namely as an advanced educational approach, methodology, and community, that aims to enhance a set of learners' digital competences and that has a huge impact on modern education and society, we look holistically at CT and its perspective. This is the approach recommended by the new concept of the Informatics curriculum.

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