Examining Teachers' Intention to integrate Robotics-based Storytelling Activities in Primary Schools

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Abstract—Though expanding computational thinking to primary school students has become more prevalent, there is a lack of appropriate didactics. Educational robotics offers a possible approach. However, innovations can only find their way into the classroom if teachers find them feasible and meaningful. Thus, appropriate training and further education of teachers are becoming a necessity. This paper reports on investigating professional development for teachers in programming robots by integrating the method of storytelling in their teaching. It draws on the Technology Usage Inventory (TUI) model to explore how an interdisciplinary intervention with programmable robots, combined with the storytelling method Tell, Draw & Code can influence the intention to use them in the classroom. Comparing the pre-and post-test and the qualitative data analysis shows a significant increase in positive attitudes towards the use of robots. The learning scenarios produced by the participants show how implementation can succeed. These findings highlight the need for teachers to explore, reflect, and experience the potential of new technologies as part of their teacher development to implement innovations sustainably. The quasi-experimental study shows that this problem-based and interdisciplinary didactic setting is particularly well received by teachers because it promotes computational thinking, narrative, and reading skills in primary school students in equal measure, and it can be easily taught and transferred.

Keywords—educational robotics, primary school, professional teacher development, storytelling

1 Introduction

The importance of computational thinking (CT) and the introduction of computer science education in primary school have increased worldwide and are strongly recommended by educational scientists and researchers [1]. Several recent reviews document educational interventions [2], teacher development [3] and assessments concerning this problem-solving competence [4–6].

The demand for people with 21st-century skills to solve future problems and challenges, both in the workplace and in everyday life, highlights the need to implement computational thinking in primary education [7] and prepare teachers accordingly [8]. What is already common practice in many countries, namely, to familiarize the youngest in the education system with computer science education [9], will become an issue with its anchoring as cross-curricular competence development in the next Austrian primary school curriculum [10] as cross-curricular competence development. For this reason, implementation and didactics relevant to digital education are gaining importance [6]. In Austria, there are only a few isolated initiatives [11] to implement computer science teaching already in primary school.

Educational robotics offers a possible approach to introduce computer science education at the primary level as a didactic tool to promote computational thinking. Therefore, coding is already implemented in many countries [12]. Intuitive and problem-based activities [13] enhance children's critical thinking and problem-solving thinking skills [2] and can change their attitudes towards computing [14]. In addition to traditional approaches, robotics activities are particularly motivating when introduced combining other disciplines [7]. One possibility is to use them in combination with the narrative method of storytelling [15]. However, essential aspects in implementing innovations in the education system are teachers' willingness [16] and to provide them with appropriate knowledge [17], and infrastructure [18]. To teach coding, the teachers must be well-prepared, and the training program must build self-efficacy and address teacher's beliefs in importance and applicability [19].

To reach many teachers and provide a viable concept for primary schools, researchers and practitioners have designed a learning environment that aims to implement computer science education and promote computational thinking skills using storytelling. The research project's overarching aim is to investigate the characteristics of an interdisciplinary learning environment focusing on robotics and storytelling to support primary school students to promote their computational thinking skills. The study contributes to the body of knowledge about interdisciplinary teaching of computational thinking in primary schools and its feasibility for implementation. The findings are of practical importance to researchers and teachers, as designing robotics-based storytelling activities can be an appropriate approach for introducing computer science instruction and promotes literacy, narrative, and writing skills in equal measure. In addition, this study aims to establish the Tell, Draw & Code method as a viable didactic concept for research in the pedagogical field, to investigate the measurement of CT in other settings and to drive relevant research.

This paper reports on the professional development for teachers in programming and implementing the intervention with programmable robots in combination with the storytelling method to explore the extent to which teachers are influenced to incorporate educational robotics in their future teaching. The following research questions aim to be answered:

- *To what extent do interaction and teaching with programmable robots influence primary school teachers' intention to use robots in their classrooms?*
- *What experiences were gained through the intervention?*

2 Theoretical background

2.1 Computational thinking

Education is required to develop students into problem-solving, creative, and empathic individuals [20]. Learning and innovation skills provide students with the mental processes needed to adapt to and improve a modern work environment. Focusing on creativity, critical thinking, communication, collaboration, and computational thinking is essential to prepare students for the future [21]. The term computational thinking (CT) is mostly described as a problem-solving process [20], and there are several definitions and components of this process. BBC Bitesize [22] formulates four main components that make up computational thinking: First, problems are broken down into smaller ones ("decomposition"), then consideration is given to whether a solution exists for a similar problem ("pattern recognition"). Then only the basic information remains ("abstraction"). Finally, a solution strategy can be designed ("algorithm"). International researchers use the term "computational thinking", which was mainly coined by Wings' article [23], in which she proposed "computational thinking" as a basic skill for everyone to integrate computer science in general education. Computational thinking is thus increasingly becoming a key competence for future scientific and technological progress, and it is now more necessary than ever to familiarize learners with informatic thinking [24].

To promote computational thinking even in primary school, problem-based learning is a very popular learning approach [13], to use technological tools to conduct a successful learning process. Problem-based learning (PBL) is a teaching method that uses real-life scenarios and topics familiar to students as a context to develop critical thinking and problem-solving skills [25]. PBL provides a didactic framework for implementing computational thinking because there is much overlap between PBL and computational practices [26]. Bers et al. [27] also mentioned the need for PBL when introducing computer science education and problem-solving thinking.

2.2 Educational robotics

One possibility to foster computational thinking and develop problem-solving strategies for young learners is educational robotics (ER) [28]. Benitti [29] investigated the potential of robotics in schools, identified how robotics could contribute by integrating it as an educational tool in schools, and examined its effectiveness. The use of programming tools provides young learners critical computational approaches to addressing real-world problems [1]. Tzagkaraki et al. [2] list numerous outcomes in their literature review because of using robots, including more successful access to later work environments. Research on coding in primary education is not yet widespread in recent years [30], but there is evidence that young learners benefit from learning about coding [31]. The haptic use of programmable floor robots, such as Bee-bots or Ozobots, makes them particularly suitable for younger children [11]. In the study by [32], it is identified that a non-instructional approach could foster a trial and error behavior. Esteve-Mon et al. [33] describe the robot as a tangible object to interact with the environment through programmed instructions. It can also serve as a tool for developing cognitive skills and fostering creativity. "Robotics activities in education offer opportunities for students to explore, create and apply knowledge to solve real-world problems" [34, p. 2]. Leoste et al. [35] discovered in their study "that robotics has a great potential in merging the best sides of digital storytelling and gamification". Hassenfeld et al. [36] investigated in their study the relationship between students' varying literacy skills and their success in mastering an introductory programming language of KIBO robots. Certainly, the successful integration of robotics into teaching depends on the robot, the activities selected, and the designed material [37].

2.3 The robot ozobot

The robot used in this study is the Ozobot. An Ozobot is a little robot that moves on two wheels and uses color sensors to follow lines and recognize color codes. Working with the Ozobot offers opportunities to playfully and joyfully develop skills that lead to creativity, collaboration and social competence [38]. Due to the easy entry into programming the Ozobot, even younger children can work with the small robots. The simple handling of the Ozobot [39] makes it possible to use this valuable tool and its diverse functionalities in various teaching units and achieve the learning objectives set [40]. Since these small robots can be used at different levels, they are suitable for simple programming and more complex tasks and programming solutions. Ozobots are well suited for interdisciplinary use, for instance, to combine the promotion of literacy and programming competencies [38], and implement storytelling activities [35]. The possibility of applying this robot in different subjects is particularly advantageous for the introduction of computer science education in primary schools, which according to the curriculum and research recommendations [41] should take place in an interdisciplinary manner.

2.4 Professional teacher development

The increasing demand for CT in K-12 education and the introduction of computer science education in primary education [42] have highlighted the need to prepare teachers with the technological, pedagogical and content knowledge (TPACK) necessary for teaching CT [43]. TPACK serves as the theoretical background of the nationwide competency model for educators, the digikomp p model [44], including eight categories of competencies to be achieved. This model provides the basis for the university's professional teacher development in media pedagogy. A subsection is also devoted to the technological perspective and informatics education. To integrate these innovations into primary education, teachers must have the required knowledge [18], self-confidence, and a positive attitude [45] towards this concept. To teach coding, they must be well-prepared, and the training program must build self-efficacy and address teachers' beliefs in importance and applicability [19]. Still, primary school teachers face various obstacles when teaching computer science education. Papadakis et al. [18] identified factors that hinder teachers to incorporate educational robots, with lack of knowledge and lack of infrastructure among the highest rated aspects. Furthermore, teachers may meet many barriers, such as a lack of computers or reliable Internet access, and institutional obstacles in the form of unsupportive principals, lack of legislation, and emotional barriers, including beliefs, attitudes, and dispositions that hinder the use of technology [19]. Many efforts have emerged to prepare teachers to teach coding [27]. Concerning teacher development and its relation to CT Kong [42] considers a lack of high-quality research and there is still a gender gap in the training of computer science education [46].

Angeli et al. [47] provided a conceptualization of TPACK for the construct of CT. However, this conceptualization focuses on the knowledge necessary to teach courses aligned to a specific didactic design independently. However, for any new educational technology to be successfully implemented and used in K-12 classrooms, teachers must be aware of new educational technology tools available and accept the technology as having practical benefits. Moreover, they should have confidence in their ability to use the technology [48] and have opportunities for experimentation to minimize risks. Similarly, Schina et al. [3, p.11] identified this problem in their literature review: "As well as learning about ER and gaining confidence with ER resources, the teachers need to become familiar with pedagogical approaches to ER activities and the implementation of the curriculum in school contexts". In innovation research [16], it is assumed that the more the factors mentioned are fulfilled, the more reliably and quickly innovation is adopted and spread. In their study, Rogers et al. [49] revealed teachers' positive perspectives on the use of educational robotics after they completed teacher training that taught the integrated STEM approach and then implemented the pedagogical approach.

Kong et al. [42] identified several important factors for successful teacher training. Effective teacher development should take place over an extended period. Teachers need to be active participants and not passive recipients of knowledge. School context and opportunities for practice and reflection are imperative, with the best development happening when there is an opportunity for sharing. However, content knowledge alone is not enough. Teachers also need to learn appropriate methods and didactic designs since it is essential to implement computer science education that the teachers will accept. Acceptance research, for instance by [50], contributes to educational knowledge by investigating suitable didactic approaches and methods for teachers. The model chosen for this research is the Technology Usage Inventory (TUI) acceptance model [51], which is described in more detail in the following section.

3 Framework

3.1 Technology usage inventory

In assessing teachers' attitudes towards using programmable robots as an introduction to computer science education, the Technology Usage Inventory (TUI) questionnaire developed by [51] was used. This survey instrument is a further development of the technology acceptance questionnaire by [50] and [52]. The further development mainly concerns psychological factors which are not sufficiently considered in the instruments used so far. The original procedure contains the following eight scales: Curiosity, Anxiety, Interest, Ease of Use, Immersion, Usefulness, Skepticism, and Accessibility [51]. Their internal consistencies range from $\alpha = .70$ to $\alpha = .92$. An adapted form (see Figure 1) of the questionnaire was used, as the scale "Immersion" was not relevant for this study. Instead, the scale "Necessity" ($\alpha = .92$) was added.

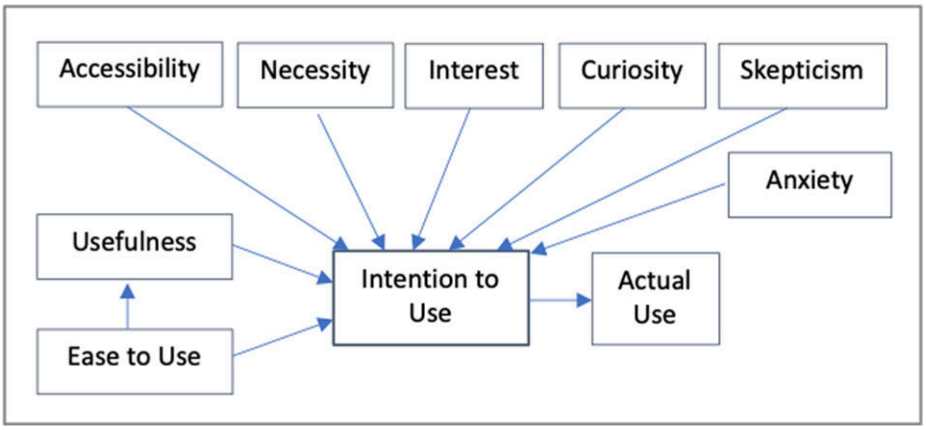

Fig. 1. TUI model adapted

3.2 Teacher training course

The courses were conducted as part of the professional teacher development of the University of Teacher Education over two half-days in the summer semester of 2021. The courses consisted of lectures and activities. Both courses were designed the same. But one of the two courses included in the study was designed followed by a four-week intervention period. The training aimed to provide teachers with a simple and playful approach to introduce computer science education at the primary level and to familiarize them with programmable floor robots, such as Bee-bots and Ozobots.

At the beginning of the training, the participants were given theoretical knowledge about computational concepts and practices [1;20;22]. In addition, the application of problem-based learning tasks was discussed. Afterwards, they were familiarized with the functioning and coding of the Ozobots. One difficulty was to provide practical experience with the robots, as all classes at the university were only held online due to the Corona pandemic. The Ozobot's functioning was shown using the document camera so that all could at least see the Ozobot and its codes. To give participants insight into didactics, they were shown videos that were still filmed in the classroom using the programmable robot. The participants had further practice opportunities using the Ozobot simulator https://games.ozoblockly.com/shapetracer-freeform as well as the Ozobot-App. This setting made it possible to simulate the robot's functioning well, and there was no disadvantage due to the online situation. The second part of the training offered the participants possibilities for the interdisciplinary use of the Ozobot. Above all, they were introduced to the didactic design of the Tell, Draw & Code method. In detail, the topics of the workshops are listed in Table 1.

Table 1. Topics of the professional teacher development

Professional Teacher Development The Teacher Training Program Included the Following Topics:
Computational Thinking, problem-solving thinking process
CT concepts and practices
Problem-based learning
Introduction to the functioning and application of the Ozobot
Coding the Ozobot via the visual programming language Ozoblockly
Possible interdisciplinary applications in primary school lessons
Didactic setting: Tell, Draw & Code method
Possibilities for designing the robotics-based learning environment
Exchange about further ideas for the implementation of the method

3.3 Didactic design—tell, draw & code

The didactic design chosen was an approach called Tell, Draw & Code by the authors. This method aims to implement computational thinking connecting creative narrative and writing processes. When introducing simple programming languages, literary texts become a vehicle for coding and decoding language. In the context of creative action, the language of computer science is linked to the course of action through graphic representations. Texts or stories are first structured, and then the plot or content is represented graphically. This transformation requires problem-solving strategies that the children in dialogical negotiation processes apply. The contextualization of informatics problems and the creative presentation of the stories in visual form should sustainably promote the children's narrative language.

The division into groups is particularly suitable for solving the problem-oriented task together and in a goal-oriented manner. The robot used in this study is the Ozobot (see chapter 2.3). The students' task is to read a text or invent a story and graphically represent the plot of the story in the context of a creative action. The texts or stories are first structured by having students consider and decide which characters are needed, which activities are depicted, and in what order. Then the path of the Ozobot and necessary details are drawn as the story sequence requires. Therefore, the computational concept of sequences is applied. After that, codes are drawn or sticked according to the storyline. So, the Ozobot can execute the commands, for example, become faster, afraid of the Gruffalo. By doing this, the concept of conditions is promoted.

A successful application of this method with Bee-bots is documented in a research study by the authors [53].

4 The study

4.1 The participants

The quasi-experimental pre-post-test study occurred within a professional teacher development in the summer semester of 2021. The teachers voluntarily participated in the teacher training and in the study. Group 1 (n=7) consisting of seven female primary school teachers with an average age of about 38 years. Group 2 (n=16) consisting of 15 females and one male primary school teacher with an average age of about 36 years. The participants are primary school teachers and have no or extremely limited experience in computer science education. They have only application skills but no programming competencies.

Two teacher training courses were conducted to provide teachers with knowledge about computer science education and concepts for practical implementation in primary education. The training introduces computer science education, particularly the development of computational thinking, i.e., the promotion of problem-solving competence, and how it can be implemented, for example, with programmable robots. The participants were introduced to the Bee-bot, the Blue-bot, and Ozobot robots and shown how to use programmable robots in the classroom. One course was designed as a workshop only, and the second consisted of a seminar and an intervention that lasted four weeks. The teacher development was held as an online workshop because university courses at the time of the Corona pandemic could only occur online due to the legal basis.

Group 1 (n=7) also conducted an intervention after the workshop. They implemented the Tell, Draw & Code method and then reflected on this interdisciplinary teaching unit. Group 2 (n=16) participated only in the workshop. Because there was no planned intervention for group 2, it could be seen as a control group. In order not to put them at an ethical disadvantage, group 2 was offered the Ozobots for testing later. In Figure 2 the design of the quantitative study is presented.

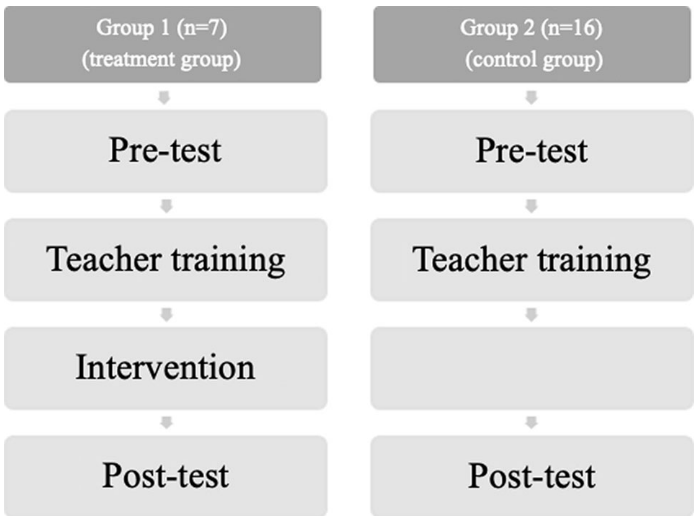

Fig. 2. Design of the quantitative study

4.2 The survey

Pre- and post-test were conducted by using an online questionnaire on the LimeSurvey platform. The pre-test questionnaire consists of 31 items, 2 relate to demographic data and 29 to the TUI model. The post-test consists of 26 items, 2 demographic questions, 24 relate to the TUI model. The scales anxiety (ANX) and curiosity (CUR) were only asked in the pre-test, as recommended by the authors of the questionnaire [51]. The four-part Likert scale (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree) was chosen as the response format.

The quantitative data were analyzed with descriptive statistics using SPSS 26. To examine a change in participants' attitudes before and after the intervention, the scales INT, SKE, ETU, USE, NEC, ITU were used. The t-test was used to compare significant mean values. This test is particularly suitable for comparing two dependent samples [54]. For the qualitative part, group 1 was asked to reflect in writing on their experiences. The participants' reflections provided the data for the qualitative results after the implementation of the intervention. The following questions were suggested for reflection: What do you think of the Tell, Draw & Code method for introducing computer science education? Was there any indication that problem-solving thinking was promoted in the course of this intervention? Which framework conditions influence the work with the robots? The statements were coded and analyzed using quantitative content analysis [55].

5 Results

The presentation of the results is organized as follows. First, three examples of settings planned and conducted by the participants are shown. Then, the quantitative survey results are presented, investigating how interaction and teaching with programmable robots influence primary school teachers' intention to use robots in their classrooms. Finally, the question about the experiences gained through the intervention is answered.

5.1 Settings

The participants chose the Ozobot for their lesson planning. The following examples illustrate the settings and topics they chose and how they implemented them.

Retelling a fairy tale: The fairy tale Little Red Riding Hood was repeated by the students (see Figure 3). Afterward, the pupils had to act out the plot of the fairy tale with the Ozobot. The Ozobot took on the role of Little Red Riding Hood. The codes were used to visualize specific actions, for instance, getting faster seeing the wolf.

Fig. 3. Retelling a fairy tale

Creating a story: The pupils' task was to invent a story on a current topic. The pupils chose the theme of the European Football Championship (see Figure 4). One team consisted of well-known football players, the others of superheroes. A pitch was drawn, and the ball's path was marked with lines and codes so that the Ozobot, which represented the ball here, could pass from one player to the next and find its way into the goal. The particular aspect was that one student of the group had the role of the reporter and commented on the game. At the same time, this football match was also filmed.

Fig. 4. Creating a story

Retelling a book: The book Gruffalo was read to the students (see Figure 5). Then they were divided into groups. The problem-based task was to retell the story by drawing lines for the Ozobot and coding the plot. In the end, all groups presented their artifacts and gave each other feedback.

Fig. 5. Retelling a book

5.2 Evaluation pre-/post-test

The pre-test was carried out right at the beginning of both workshops. The post-test was conducted after the course and the intervention. In the treatment group, 6 of the 7 participants completed the intervention and answered the second questionnaire. In the control group, 13 of the 16 participants also answered the post-test completely.

For both groups, an increase in factors influencing intention to use can be identified. Interesting is the fact that both groups already show a high value in the pre-test for the necessity (NEC) of implementing computer science education (treatment group: M=3.22/SD=0.69, control group: M=3.44/SD=0.67) and for the intention (ITU) (treatment group: M=3.00/SD=0.56, control group: M=3.13/SD=0.60) to use it. Both scales also show an increase in scores on the post-test.

The post hoc paired samples t-test (Table 2) was used to compare pre-and post-test changes in teachers' attitudes of the treatment group after the intervention.

Table 2. Post hoc paired samples t-test (treatment group)

Variable	Mean Difference	SD	t	df	Sig	Cohen's d^2
INT	.778	.981	1,941	5	.110	0,423
SKE	–.1.01	.632	3.873	5	.012	–0,530
ETU	.112	.689	.395	5	.709	0,581
USE	.708	1.355	1.281	5	.256	0,752
ACC	.723	.772	2.291	5	.071	0,126
NEC	.501	.742	1.651	5	.160	0,588
ITU	.721	.611	2.892	5	.034	0,620

This table of the treatment group shows a significant difference between teachers' combined robot-related attitudes and intentions before and after the intervention.

Particularly effects are found in the relevant variables *Ease to Use* (ETU) (d=0,581) and *Usefulness* (USE) (d=0,752) which indicates a high intention to use. The increased value of the relevant factors was also observed in the control group. But there the effect size was smaller than in the group that also carried out the intervention.

The visualization of the changes in teachers' responses (Figure 6) clearly shows that although an increase is recognizable in both groups due to the teaching of didactic approaches during the training. If the programmable robots were also used in class, this led to a higher increase in factors such as ETU, USE, NEC, ITU. However, it is also recognized that the skepticism of both groups is decreasing. However, it is also evident that the positive attitude towards using of programmable robots in the classroom increases even more after the intervention.

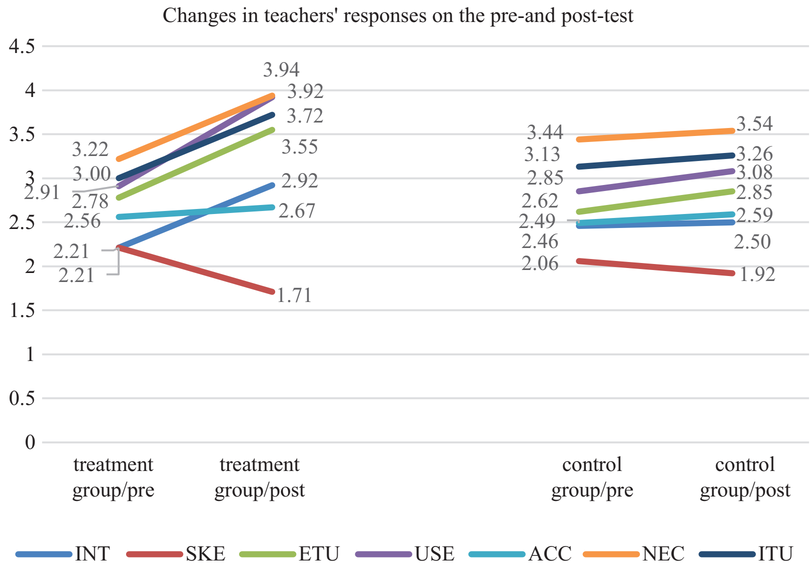

Fig. 6. Comparing pre-post-test/treatment and control group

5.3 Qualitative findings

The qualitative data was collected from the teachers who carried out the intervention. Although they were a little skeptical at the beginning about combining storytelling and introducing computer science education, in the end, they were all very enthusiastic and grateful to have been able to participate in this research project.

General findings. All teachers started introducing the Ozobots, and then they implemented the didactic design of the Tell, Draw& Code method described in chapter 3.3 in different settings. The common opinion was that working with programmable robots was found to be enriching. Teachers and students were enthusiastic and fascinated by the robot Ozobot. "I can well imagine the use of Ozobots in many areas in primary school. It is very engaging for the children and a good introduction to programming"

(T_3). Another teacher (T_1) wrote: "It was my first time working with Ozobots, but I knew it from Instagram." Of course, the importance of didactic use was also pointed out. "The meaningful use must be well planned so that the challenging character is maintained" (T_5). The participants confirmed that the storytelling method is a viable approach to introduce computer science education in primary schools in an interdisciplinary way. One teacher (T_1) considered the Tell, Draw & Code approach "a very suitable method to give the first feeling in this direction". The method of storytelling was also very well received by the participants because "the children are even more motivated to tell stories through the Ozobots (T_2)." It was also mentioned that compared to the Bee-Bots, Ozobots inspire more creativity because the programming allows many more ideas to be realized. If one would like to name a disadvantage, then that would be the acquisition costs. They were seen as the only hurdle in working with programmable robots.

Trial and error. The reflections reported that it was mainly through trial and error the first experiences with programming the Ozobot were made. "At the beginning, the children were still very hesitant to draw the lines and did not glue on any sticking dots. As time went by, they became more and more courageous and tried out different strengths of the lines and different codes" (T_1). Another teacher (T_3) reported that "through successes, but also failures, they found the right solution". Another participant (T_4) described having observed this strategy in her class as well, but that she also intervened to support it: "Through trial and error and tips from me, the problems were solved."

Communication and collaboration. Most teachers found the division of the groups into three or four suitable. One teacher (T_3) was rather skeptical and reflected that "only two children (instead of three to four) per Ozobot would have intensified the experience and made all group members think. So often, only one to two children engaged intensively with it". Discussions to arrive at problem-solving strategies were observed by all teachers. "Especially the width of the lines and the distance between the sticking dots caused discussions again and again" (T_5).

In general, the feedback was that the collaboration within the groups worked well but that it was also quite soon clear who took on which role within the group. This statement was also confirmed by teacher T_3, "but it quickly became clear who was in charge".

Problem-solving thinking. Children approached the problem-based tasks "very openly and very curiously" (T_3). There were different strategies to code the story. Some groups only briefly thought about how to start representing the story. "Two groups started right away by drawing the first lines of the plot and then thought about the next steps and coding" (T_4). Other groups first planned the whole story and then started with the visualization. The teachers (T_1–T_6) observed that the code table was used repeatedly to use the appropriate commands. The children tackled the task very seriously. One Teacher (T_2) kept that, "when creating the Gruffalo story, the children checked the book to retell the story exactly and reproduce details precisely". The individual steps were also constantly checked to see if the Ozobot was behaving in a way that suited the story and if they had used the proper codes (T_3).

Framework conditions. The teachers were also asked about framework conditions leading to successful implementation. The responses can be summarized as the following aspects which the participants considered to be effective:

- good group composition
- small groups
- functioning, previously charged bots
- no time pressure
- problem-based tasks

6 Discussion

The study applied the TUI model [51] to investigate teachers' attitudes toward the use of robots in primary school and the benefits of robots using an appropriate concept in the classroom. This understanding can contribute to knowledge about implementing computer science education and more positive attitudes towards robotics integration. The method Tell, Draw & Code describes integrating programmable robots into the traditional narrative and writing skills. Engaging in creating own stories or examining literary texts found in children's books and controlling the robots in a challenging and motivating way can synergize the learning process. The stories come alive in a particular way by changing the written language to visual language and spoken language. Furthermore, the method Tell, Draw & Code offers a promising didactic approach to introduce computer science education in primary school, extend the language in creative activities, and use it to develop problem-solving strategies to help students become creative, problem-solving individuals as required [20]. In particular, this setting, which supports computational thinking and communication skills [34], provides a replicable learning design for teachers.

This study investigated the influence of interaction and teaching with programmable robots on primary school teachers' intention to use robots in their classroom and teachers' perspectives on integrating the Tell, Draw & Code method for educational robotics regarding their teacher professional development and pedagogical practice in the classroom. The robots used were the Ozobots, which can also be described as a suitable tool [39] for young learners in this study. The participants completed pre-post-tests questionnaires of their perceptions towards the use of programmable robots. One group had the opportunity to design lessons and to try out the programmable robots in their teaching. This group delivers the findings of the qualitative research. Accordingly, this section offers some reflections and a set of conclusions related to the study conducted.

In this study, a pedagogical approach and knowledge about educational robotics were offered to the participants because problems can arise from the teachers' lack of knowledge and didactic concepts, as already also stated in [18] and [28]. In general, as mentioned by [3] and [48], it can be stated that the implementation of educational innovations in primary schools is a challenge for teachers. Both pre-service training and in-service training are essential for teaching success to promote learning that prepares students for the challenges of the 21st century [21] and the willingness to incorporate educational robotics [17]. In this regard, insightful viewpoints of teachers in relation to science and their teaching could be obtained.

The quantitative data analysis results show that the teaching of didactic approaches during teacher professional development leads to an increase in the positive attitude of the participants. Similar to previous studies [47], the positive attitude towards intention to use and the necessity of implementation increases even more if the teachers also have the opportunity of practical implementation. Most participants also indicated that the robots were easy to use, indicating that further use may be a given [48]. The research shows that teachers today have a very positive attitude towards implementing computer science education in primary schools and the use of programmable robots for this purpose. However, the study also clarifies that training teachers and offering didactic approaches can increase positive attitudes towards innovation [16] can be achieved. The handling [42] and the experiences gained enable some teachers to overcome the fear of programming and open up new teaching approaches.

This study also underlines the importance of equipping teachers with pedagogical, technical, and content knowledge [43] as well as self-confidence and a positive attitude [45] to implement computer teaching and achieve an approach to computational thinking. The study results show that this interdisciplinary use of learning robots in primary school can contribute to a successful learning process in a very motivating way which was also revealed in the study by [49]. It can be concluded that the approach of robotics-based storytelling activities promotes the integration of computer science education and the learning of computational thinking, similar to the study on the implementation of a STEM approach [49].

The storytelling concept promoted positive attitudes among teachers and positively affected teachers' intention to use and their knowledge. Similarly, students' cooperative work, increased communication, and an approach to problem-solving thinking emerged from it.

7 Conclusion and future work

This study provided empirical evidence that teacher development and the possibility of interacting with the robots effectively changed participants' attitudes towards implementing computer science education in primary education. The evaluation was based on objective tests and self-assessments, overcoming problems related to initial skepticism.

The findings presented reveal that the selection of an appropriate robot and an effective didactic approach lead to the successful integration of robotics, as also mentioned by [37]. In contrast to other storytelling-based approaches, such as those mentioned by [34] or [35], integrating Tell, Draw & Code, is not only about teaching 21st century skills and an introduction to computer science education. This method is also intended to foster basic skills such as reading and writing at the same time. For already, a correlation between programming KIBO robots and literacy skills are described in [36].

The students and teachers involved in the intervention developed informatics competencies that can be taken up and further developed in other storytelling and writing projects. Moreover, our method of integrating storytelling activities can potentially serve as a support tool for weaker students. The innovative approach linking narrative language, visual language, and programming language through Ozobots can thus be sustainably introduced into everyday school life and shows that computer science teaching can be realized as interdisciplinary competence development through the new curriculum. By implementing the Tell, Draw & Code method, teachers can experience a pedagogical model that they can implement in their primary school teaching.

This study suggests the viable approach, the Tell, Draw & Code method, which offers computational thinking and helps students structuring stories for better reading and understanding. In fact, we believe that this didactic design has the potential for promoting computational thinking and this method is interesting for research especially concerning the measurement of CT, because it can serve as a basic didactic concept for an intervention. Ideas worth exploring include, in particular:

- Integrating the Tell, Draw & Code method, which helps learners visualize and reflect on the text, and as a resource for teachers to make their instruction more effective.
- Adopting this approach to other programmable robots and programming languages to extend its impact and validate computational thinking concepts.

Future work is planned to study pre-service teachers' attitudes towards using programmable robots, implementing the Tell, Draw & Code method, and comparing the results with the research presented here.

8 Limitation

Due to the Corona pandemic, the number of participants in the teacher professional development robotics workshops was generally lower than usual. Thus, this study also had a relatively small number of participants. Nevertheless, the researchers were content to be able to carry out this study at all. Conducting the research was not always guaranteed due to the restrictions and the distance learning carried out from time to time.

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