MASTER'S THESIS

'De impact van Learning Analytics-ondersteunend Learning Design op de TPACK-kennis en motivatie van basisschoolleraren: de casestudy van FoLA²'

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Award date:
2024

Awarding institution:
Faculty of Educational Sciences

Link to publication

Open Universiteit

'De impact van Learning Analytics-ondersteunend Learning Design op de TPACK-kennis en motivatie van basisschoolleraren: de casestudy van FoLA²'

'The Impact of Learning Analytics-Supported Learning Design on Primary Education Teachers' TPACK Knowledge and Motivation: The Case Study of FoLA²'

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Datum:	18-04-2024

Abstract

This study investigated the influence of a Learning Analytics (LA)-supported Learning Design (LD) tool, named FoLA², on the Technological Pedagogical Content Knowledge (TPACK) and motivation of primary school teachers. The research aimed to examine the impact of this tool on teachers' TPACK knowledge and motivation. The main research question was: 'To what extent did the implementation of FoLA² influence the TPACK knowledge and motivation of primary education teachers compared to those who did not implement it?' The study was conducted at a Dutch primary school using a quasi-experimental research design. A primary school team consisting of 18 participants served as an intact group, randomly divided into a control and experimental group, and were measured through pretest, posttest, and follow-up. The main results showed a significant improvement in TPACK from pretest to posttest among participants, but no significant differences were observed between groups using different methods. Regarding all motivation levels, no significant differences were found between the groups using the FoLA² method and the control group. The main conclusions and implications suggest that the use of LA-supported LD with FoLA² had no significant effect on teachers' motivation or their TPACK compared to those who used their own method. However, the research emphasizes the importance of continued exploration of the complex relationship between LA-supported LD, contextual factors, and teacher outcomes in primary education. The research also underscores the need for a holistic approach in designing future research, integrating both quantitative and qualitative analyses and considering various other variables, such as self-efficacy and student outcomes.

Keywords: FoLA², learning analytics, learning design, primary education, teacher

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The Impact of Learning Analytics-Supported Learning Design on Primary Education Teachers' TPACK Knowledge and Motivation: The Case Study of FoLA²

1. Introduction

1.1 Problem Sketch and Purpose

Ongoing technological advancements have made educational technology increasingly indispensable in modern education. Educational technology involves the systematic application of scientific knowledge to enhance the effectiveness of the learning and instructional processes (Kumar, 1996). Consequently, it is imperative for educators to grasp how to seamlessly integrate technology into their teaching methodologies to enhance the overall learning experience (Tigges et al., 2016).

Learning Analytics (LA) stands out as one of the most notable advancements in educational technology (Ferguson, 2012), involving the collection, measurement, analysis, and reporting of data on students and their learning environment to enhance educational practices (Siemens & Long, 2011). LA holds substantial promise in supporting Learning Design (LD) (Amarasinghe et al., 2022), by leveraging data to inform decision-making processes within LD (Persico & Pozzi, 2015; Rienties et al., 2017). Nonetheless, despite its advantages, effectively applying LA to LD presents challenges, notably in aligning LA with LD objectives for learning purposes (Macfadyen et al., 2020).

Existing literature predominantly focuses on the interaction between LA and LD in higher education, particularly in online learning environments (Nguyen et al., 2020), with minimal application in primary education (Dagnino et al., 2018; Shibani et al., 2020).

The Fellowship of Learning Activities and Analytics (FoLA²) exemplifies a tangible application of LA-supported LD (Schmitz et al., 2022), potentially yielding evidence-informed learning activities through the integration of LA and LD. However, evidence

suggests that the implementation of LA-supported LD poses pedagogical and cognitive challenges for educators (Law & Liang, 2020).

Pedagogically, teachers must possess adequate Technological Pedagogical and Content Knowledge (TPACK) to effectively utilize LA and support students' learning processes (Koehler & Mishra, 2009). TPACK serves as a pivotal component of teacher training programs and professional development initiatives (Law & Liang, 2020), ensuring that LA-supported LD activities are pedagogically sound to optimize students' learning experiences (Law & Liang, 2020).

Cognitively, teachers' motivation significantly influences their engagement with LA-supported LD (Thoonen et al., 2011). A lack of motivation or satisfaction among teachers may hinder their willingness to adapt and optimize their teaching methodologies with LA-supported LD (Thoonen et al., 2011).

Considering these challenges, this study aims to delve into the impact of LA-supported LD, focusing on the FoLA² case study, on the TPACK and motivation of primary education teachers.

1.2 Theoretical Frame

In this section, we discuss and bridge the main variables that underpin our study. The discussed variables are (1) LA-supported LD, (2) LA-supported LD and teachers' TPACK, and (3) LA-supported LD and teachers' motivation.

1.2.1 LA-supported LD

LA is a data-driven approach that utilizes learning data to gain insight into the learning process and its context (Siemens & Long, 2011). LD is a pedagogical and educational design process aimed at structuring the learning process to achieve specific learning objectives (Ahmad et al., 2022; Law & Liang, 2020). LA and LD represent two important approaches within education aimed at improving learning processes and outcomes (Macfadyen et al.,

2020). Educators, designers, and students are considered key stakeholders in this regard (Drachsler & Greller, 2012).

LA serves a complementary role within LD by providing teachers with valuable information about students' learning processes and the effectiveness of designed learning activities (Amarasinghe et al., 2022; Persico & Pozzi, 2015). These insights enable teachers to enhance the LD process, for example, by anticipating students' learning processes before and after the implementation of LA-based designs. Such reflective practices foster higher-order learning practices, deeper awareness, and more valid and evidence-based decision-making (Persico & Pozzi, 2015; Mangaroska & Giannakos, 2019). On the other hand, LD aids LA by providing a conceptually sound pedagogical framework (Michos & Hernández-Leo, 2020). This allows LA to be translated into meaningful knowledge that can be applied in specific educational environments (Macfadyen et al., 2020; Mangaroska & Giannakos, 2019).

Despite the importance of aligning LA and LD, there has been limited research on how teachers can effectively design learning activities using LA in authentic learning environments (Mangaroska & Giannakos, 2019). Therefore, empirical research on LA-supported LD tools is necessary to enhance understanding and implementation of LA-supported LD in teacher-designed learning activities (Amarasinghe et al., 2022; Macfadyen et al., 2020). Involving teachers as designers in creating learning activities supported by LA and LD can help teachers grow in their professional development by gathering additional data on effective approaches to LA-supported LD in education (Macfadyen et al., 2020; Mangaroska & Giannakos, 2019; Mor & Mogilevsky, 2013).

Design-based learning also effectively integrates information and communication technology (ICT) in education (Chai et al., 2013; Voogt et al., 2013). However, teachers' design skills may hinder the successful adoption of ICT in education (Koh & Chai, 2016; Tsai & Chai, 2012). To address this challenge, educators often rely on design-based learning to

enhance teachers' TPACK in designing successful technology-supported learning experiences (Yeh et al., 2021). Teachers rely on LA data as an important aspect supporting education and facilitating research methods (Michos & Hernández-Leo, 2020).

1.2.2 LA-supported LD and teachers' TPACK

Teachers with limited knowledge of LD can pose a barrier to effective technology-mediated education, where TPACK is crucial (Koh & Chai, 2016; Tsai & Chai, 2012). Therefore, support in LD is necessary to enhance teachers' TPACK knowledge, which is essential for designing successful technology-integrated learning experiences (Yeh et al., 2021). In this context, teachers rely on LA-data as an important tool (Michos & Hernández-Leo, 2020).

TPACK refers to the technological, pedagogical, and content knowledge crucial for teachers in designing effective learning. The concept of TPACK, developed by Mishra and Koehler (2006), builds upon Shulman's Pedagogical Content Knowledge (PCK; 1986). TPACK encompasses the use of various technologies to teach subject matter and is fundamental for meaningful, context-specific technology-enriched instruction by teachers (Koehler & Mishra, 2008). To effectively apply TPACK, teachers need to understand how technology can represent concepts, how pedagogical technologies can be effectively utilized, and how technologies can address educational problems (Koehler & Mishra, 2009). A teacher's TPACK comprises scores in seven different dimensions: content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK; Chai & Koh, 2013, p. 33). Recently, a new dimension has been added, namely contextual knowledge, which acts as an enveloping layer around these dimensions (Mishra, 2019, p. 2).

The literature demonstrates a bidirectional relationship between LD and teachers' TPACK. Mishra and Koehler (2006) argue that teachers' TPACK significantly influences their design process of technology enhanced learning when developing authentic design-oriented activities. Teachers with higher TPACK are better able to plan technology enhanced learning, where a high level of CK, PK, and TK is essential for designing effective lessons (Chai & Koh, 2017). LD can also contribute to the development of teachers' TPACK. Koehler and Mishra (2008) emphasize that teachers can best develop TPACK through 'learning by design'. Chai et al. (2013) underline this and argue that teachers who design instructional materials focused on 21st-century skills can significantly enhance their TPACK. Additionally, Koh et al. (2015) demonstrate that teachers' perception of their own design skills predicts their TPACK. The active involvement of teachers as designers of lessons integrating technology within an iterative design process is crucial (Koehler et al., 2007; Mishra & Koehler, 2006). This involvement enhances teachers' TPACK knowledge as they face concrete educational problems and must synthesize and iteratively adjust their CK, PK, and TK until the problem is resolved (Koh et al., 2015). Voogt et al. (2013) describes that involving teachers in designing technology enhanced learning for authentic design problems is a significant strategy in developing TPACK. Yeh et al. (2021) add that designing technology enhanced learning in teams related to an educational problem promotes the development of TPACK because teachers share knowledge and learn from each other's expertise.

Although the relationship between LD and teachers' TPACK has been extensively examined, the influence of LA has not been thoroughly studied. Laurillard et al. (2018) developed an LA tool for LD and emphasized that when teachers contribute as designers, they enhance their PK, increase knowledge exchange, and better integrate TPACK. This underscores the importance of incorporating LA into the interaction between LA-supported LD and teachers' TPACK. Furthermore, Chai et al. (2013) stress that merely improving

teachers' TPACK knowledge is insufficient for the widespread application of technologies in education. They argue that it is also important to investigate other psychological perspectives of teachers, such as personal factors. From this perspective, it is interesting to explore teachers' motivation regarding the use of LA-supported LD.

1.2.3 LA-supported LD and teachers' motivation

Motivation is generally regarded as an inner force that propels people into action (Han & Yin, 2016). For teachers, motivation is based on personal values that drive them to choose and maintain the teaching profession. An important theoretical approach that enhances teacher motivation is self-determination theory (SDT; Ryan & Deci, 2017; Vansteenkiste et al., 2020).

SDT emphasizes three fundamental psychological needs: autonomy (i.e., the need to act psychologically free without pressure), relatedness (i.e., the need for emotional bonds, affection, and care from others), and competence (i.e., feeling effective in one's own environment, having confidence in one's abilities) (ABC; Ryan & Deci, 2000). Research shows that when these needs of teachers are fulfilled, they are more motivated, satisfied with their work, dedicated to the organization, and proud of their job, thereby enhancing their performance (e.g., Gagné et al., 2015).

A holistic approach to LA and LD can fulfill teachers' need for autonomy (A) by enabling them to adapt their teaching style to meet the needs of their students (Shibani et al., 2020). This is achieved by utilizing relevant and useful information about students' learning processes (Dagnino et al., 2018; Kaliisa et al., 2020). Such adaptation has been proven effective in improving students' learning outcomes and motivating teachers (Wen & Song, 2011).

Moreover, research indicates that teachers consider the social and communicative aspects of LA tools as significant motivators. It satisfies teachers' need for relatedness (B) when LA tools encourage collaboration among teachers (Dagnino et al., 2018).

The knowledge and skills required for using LA and LD can motivate teachers to support LD using LA (Dollinger et al., 2019; Shibani et al., 2020), as it may enhance teachers' sense of competence (C). Integration of LA and LD provides an evidence-based method that gives teachers confidence in their effectiveness as educators. Additionally, the use of LA tools saves time, which also contributes to teachers' motivation (Shibani et al., 2020). However, Dollinger et al. (2019) emphasize that transparency in data analysis is essential for acceptance, while a lack of support within the organization can be demotivating. An abundance of and inadequate LA data can also pose challenges for teachers (Dagnino et al., 2018).

A shortcoming in the literature is the predominant focus on teachers in higher education and limited attention to primary education (Dagnino et al., 2018; Shibani et al., 2020). Since primary education teachers have a unique role in educating and developing young learners (PO-Raad et al., 2022), it is crucial to examine their perspective on motivation and the use of LA and LD. While recommendations exist in the Netherlands for primary education teachers to improve their teaching using LA (Stichting Klasse et al., 2016), empirical evidence in this context is lacking, indicating the necessity for further research.

1.3 Current Study

This study aimed to address gaps in the literature regarding the influence of LA-supported LD on primary education teachers' TPACK knowledge and motivation. Employing a quasi-experimental approach, FoLA² was utilized as the primary tool (Schmitz et al., 2022). Due to practical or ethical considerations, intact groups are commonly utilized in educational research, resulting in quasi-experimental designs where participants are not randomly

assigned to groups (Creswell & Guetterman, 2021). In this study, a primary school team was utilized as an intact group, randomly divided into control and experimental groups, to investigate the impact of LA-supported LD. Utilizing pretest, posttest, and follow-up data collection methods aimed to minimize time-related biases (Gravetter & Forzano, 2018). The principal aim of this study was to assess the effects of FoLA² on primary education teachers' TPACK knowledge and motivation. It is essential to note that the primary focus was not on evaluating the quality of learning activity design.

The research questions of this study aimed to address the lack of empirical research on the impact of LA-supported LD tools on TPACK knowledge and motivation of teachers in primary education. The main research question was: 'To what extent did the implementation of FoLA² influence the TPACK knowledge and motivation of primary education teachers compared to those who did not implement it?' Various sub-research questions were proposed to explore this question.

The first sub-research question (RQ1) was: 'What was the effect of FoLA² on the TPACK knowledge of primary education teachers when developing a learning activity via LA-supported LD?' This aimed to determine if LA-supported LD through FoLA² indeed enhanced teachers' TPACK knowledge. Prior studies have shown that collaborative development of technology-supported lessons is associated with improved TPACK knowledge (Koehler et al., 2007; Mishra & Koehler, 2006). By exchanging knowledge and skills, teachers adapted their Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) to address educational challenges (Koh et al., 2015).

The second sub-research question (RQ2) was: 'What was the effect of FoLA² on the motivation of primary education teachers when developing a learning activity via LA-supported LD?' This aimed to determine if LA-supported LD indeed improved teachers' motivation. Previous research indicates that integrating elements of LA-supported LD

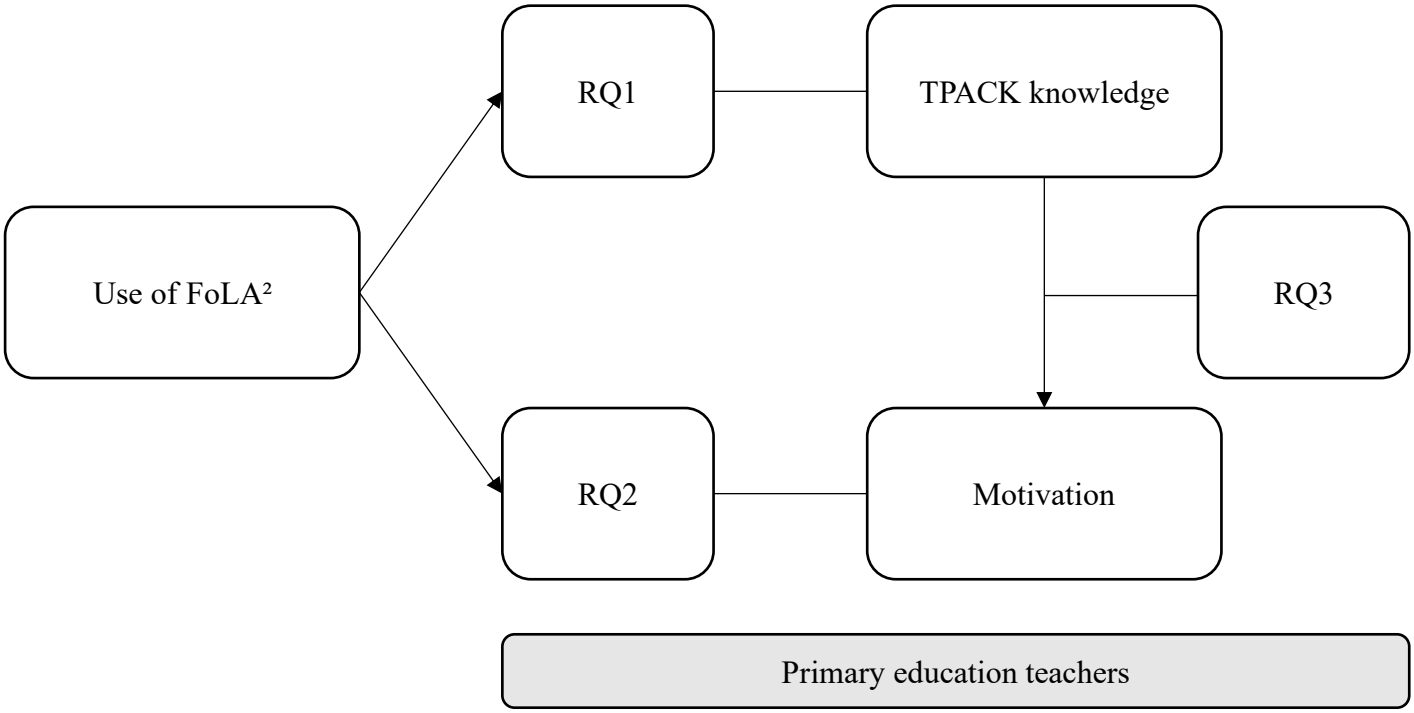
positively impacts teachers' psychological needs (ABC), potentially enhancing motivation (Ryan & Deci, 2017; Vansteenkiste et al., 2020). Collaborative and evidence-based design of learning activities using LA and LD can facilitate this effect (Dagnino et al., 2018; Kaliisa et al., 2020; Shibani et al., 2020). In this study, motivation (including and excluding satisfaction) was examined.

The third sub-research question (RQ3) was: 'To what extent was there a relationship between the TPACK knowledge of primary education teachers and their motivation when designing a learning activity using LA-supported LD via FoLA²?' This aimed to explore the correlation between TPACK knowledge and motivation (including and excluding satisfaction) of primary education teachers within the context of LA-supported LD, to gain a deeper understanding of the interaction between these variables. Previous research suggests that increasing teachers' professional knowledge contributes to strengthening their sense of competence, which in turn positively influences their motivation for professional tasks (Dollinger et al., 2019; Shibani et al., 2020; Gagné et al., 2015).

These research questions aimed to compare the TPACK knowledge and motivation (including and excluding satisfaction) of primary education teachers who used FoLA² when designing a learning activity with those who did not (see Figure 1). Additionally, the relationship between TPACK knowledge and motivation was explored. The research questions were evaluated to (1) determine any significant differences between the two groups and (2) gain a deeper understanding of the relationship and sequence between TPACK knowledge and motivation.

Figure 1

Conceptual Model of this Study



2. Method

2.1 Participants and ethical considerations

The study was conducted within a regularly primary school setting situated in the southern region of the Netherlands. This school enrolled a total of 252 students distributed across nine groups, ranging from group 1/2 to group 8. The staff contained 22 individuals, including 17 certified teachers, three non-teaching staff members, and two teacher trainees.

The research focused on primary education staff members from a regular primary school in the Netherlands. The sample consisted of 18 participants (male: 33%, female: 67%), selected through convenience sampling and randomly assigned to a control group ($N = 8$) and an experimental group ($N = 10$). Experimental methodologies, as suggested by Cohen et al. (2007: 102) and Gall et al. (1996), can be effectively conducted with fifteen participants.

To ensure adherence to ethical considerations, participants received a letter from the school administration regarding their consent and permission to participate in the experiment. They were informed that their involvement was voluntary, anonymous, and required their informed consent. A comprehensive description of the study, including objectives, data collection procedures, participant protection measures, and a sample consent form, was submitted to the Ethical Research Council of the Open University in the Netherlands (cETO).

Internal validity was maintained by comparing the scores of both groups on a descriptive questionnaire (see Appendix D) to assess comparability (Creswell & Guetterman, 2021). Both groups exhibited similar distributions concerning teaching experience and perceptions of comfort and experience with LD and LA. Most participants had 10 years or more of teaching experience (72%), followed by five years or less (22%), and between five and ten years (6%). Between 56% and 67% of participants indicated feeling either uncomfortable or inexperienced with LD and LA. Scores for LD and LA knowledge ranged from 'no knowledge' to 'neutral knowledge'. Participants' self-assessed scores for LD knowledge were similar between the control group (M = 1.63, SD = 0.91) and the experimental group (M = 1.60, SD = 1.07), as well as for LA knowledge between the control group (M = 2.25, SD = 0.89) and the experimental group (M = 2.40, SD = 1.07).

2.2 Materials

In this study, FoLA² was employed as an intervention to design a learning activity using LA-supported LD.

2.2.1 Fellowship of Learning Activities and Analytics (FoLA²)

FoLA² is a serious board game designed to facilitate the designing of learning activities through a systematic process (Schmitz et al., 2022a). Serious games employ gaming technology for educational purposes rather than entertainment (Anastasiadis et al., 2018; Michael & Chen, 2005). Previous research has utilized serious board games, such as FoLA²,

for various educational contexts, including patient safety (Ward et al., 2019) and agricultural development (Alegria et al., 2020). FoLA² is classified as a serious board game because it aims to provide users with a meaningful experience and foster problem-solving skills (Susi et al., 2007). It follows the Design Cycle for Education (DC4E) outlined by Scheffel et al. (2021), which consists of eight steps for designing learning activities within a 40 to 60-minute timeframe. The initial phase involves role assignment (step 0), defining objectives and target populations (step 1), and identifying challenges (step 2). This is followed by the combination phase, which includes gathering inspiration (step 3) and analyzing selected learning activities (step 4). Lastly, the realization phase entails engaging with didactic components (step 5), presenting measurement choices (step 6), evaluating activities (step 7), and incorporating adjustments based on feedback (step 8) (Scheffel et al., 2021; Schmitz et al., 2022). Moreover, serious games like FoLA² strive to create realistic learning environments to enhance authenticity and enable practical learning experiences within professional contexts (Susi et al., 2007). FoLA² empowers players to integrate LA and technology effectively into lesson planning, providing a realistic platform for applying professional concepts and skills. This integration enhances authentic learning processes and facilitates the incorporation of activities into broader curricula (Schmitz et al., 2022). Additionally, serious games aim to achieve educational objectives through engaging gameplay experiences (Susi et al., 2007). FoLA²'s objective is to design learning activities aligned with educational goals while integrating LA and technology to enhance player experiences through interactive gameplay. Furthermore, serious games foster natural communication that mirrors real-world interactions (Susi et al., 2007). FoLA² encourages collaboration among educational professionals, researchers, and practitioners to tackle educational challenges. Players engage in discussions regarding learning activity design, the potential integration of LA and technology, and other relevant topics. In conclusion, serious games incorporate game mechanisms with elements

that reflect real-world contexts (Susi et al., 2007). FoLA² includes role cards, a physical game board (referred to as 'Open Universiteit' in the Dutch version), and playing cards (Schmitz et al., 2022a). These components, including blue cards for actor interactions (teacher, student, teaching material, and learning environment), purple cards for learning activity types, red cards for technological learning support, and yellow cards for expected behaviors, contribute to a holistic educational gaming experience. Additionally, the red and yellow cards feature green sections outlining LA options.

2.3 Measurements

This study employs the following questionnaires, which will be explained in the subsequent subparagraphs: TPACK (Schmidt et al., 2009), IMI (Ryan, 1982), and a demographic questionnaire (Appendix D). The questionnaires are adapted, and experts in educational technology assess their content validity for relevance, clarity, and coverage (Lawshe, 1975). All variables examined in the questionnaires below have been considered interval data due to the total scores of each subscale, which represent the cumulative result of four or more questions (Boone & Boone, 2012).

2.3.1 Preservice Teachers' Knowledge of Teaching and Technology (TPACK)

This study examined the impact of FoLA² on the TPACK knowledge of primary education teachers. To measure this relationship, we adapted the Survey of Preservice Teachers' Knowledge of Teaching and Technology (TPACK) by Schmidt et al. (2009). This questionnaire assesses seven knowledge domains within the TPACK framework and has been used in previous studies (Baran et al., 2011) with a reliability between $\alpha = .75$ to .92 (Schmidt et al., 2009). Schmid et al. (2020) shortened the questionnaire to 28 items, showing high internal consistency ($\alpha = 0.77$ to 0.91) according to George and Mallery (2001). In this study, the validity analysis revealed a Cronbach's α of 0.89 for the total TPACK score.

For this study, the questionnaire of Schmid et al. (2020) was modified to focus on learning activity design. The participants were assigned the task of designing a learning activity, with the experimental group using FoLA² as a supportive tool. The questionnaire consisted of 28 items, rated on a five-point Likert scale ranging from 'strongly disagree' [1] to 'strongly agree' [5]. These items assess Pedagogical Knowledge (one to four), Content Knowledge (five to eight), Technology Knowledge (nine to 12), Pedagogical Content Knowledge (13 to 16), Technological Pedagogical Knowledge (17 to 20), Technology Content Knowledge (21 to 24), and Technology Pedagogical Content Knowledge (25 to 28). An example item was, '*I can design a learning activity that appropriately combines the learning content, technologies, and teaching approaches by using FoLA²*'. Appendix A presents these questions, which have been translated into Dutch for the convenience of the participants.

2.3.2 Intrinsic Motivation Inventory (IMI)

The impact of FoLA² on the motivation scores of primary education teachers during the design of learning activities was explored utilizing an adapted version of the IMI (Ryan, 1982), which has been widely used in previous studies (Ryan et al., 1991). The IMI's psychometric properties were evaluated by McAuley et al. (1989) through confirmatory factor analysis in the context of a competitive sport. Results indicated good internal consistency for the four subscales of the IMI, with a combined α value of .85. The individual subscales showed the following α values: interest α = .78, perceived competence α = .80, perceived choice α = .84, and pressure α = .68. A subscale satisfaction was added based on the E-Learner Satisfaction (ELS; Wang, 2003). Hu & Hui (2012) previously modified the ELS to assess satisfaction in different learning groups using technology. The congruence coefficient for satisfaction exceeded Harman's (1976) threshold of 0.80, validating the subscale consistent performance.

This study modified the IMI version from McAuley et al. (1989) to focus on learning activity design. The questionnaire comprised 29 items divided into five subscales, rated on a seven-point Likert scale, ranging from strongly disagree [1] to strongly agree [7]: interest (one, five, eight, ten, 14, 17, and 20), perceived competence (four, seven, 12, 16, and 22), perceived choice (three, 11, 15, 19, and 21), and pressure (two, six, nine, 13, and 18), and satisfaction (23 to 29). An example item was *'I felt pressured while designing a learning activity using FoLA²*". In this study, we employed this questionnaire to investigate motivation, including satisfaction (IMISAT), which encompassed all 29 items. Furthermore, we independently examined motivation using 17 items across the initial four subscales (IMI), while satisfaction alone is assessed through 12 items within the final, singular subscale (SAT). See Appendix B (motivation) and C (satisfaction) for this Dutch questionnaire. In this study, the total score for IMISAT had a Cronbach's α of 0.92, for IMI 0.93, and for SAT 0.89.

2.4 Procedure

After obtaining ethical approval from cETO, permission was sought from the school management to conduct the research at their location and for the participation of their staff. All authorized education staff were invited to participate (see Figure 2).

The research comprised four phases. In the first phase, participants completed a demographic questionnaire regarding their knowledge and experience related to LA and LD. Participants received a personal invitation on paper from the researcher explaining the purpose, questionnaire, and expectations, with a two-week period to indicate their participation. Participants were reminded after one week. They were then randomly divided into control and experimental groups, ensuring comparable scores on their knowledge and experience with LA and LD.

In the second phase, two weeks prior to the intervention, participants completed a pretest questionnaire to assess their prior TPACK knowledge and motivation. Both

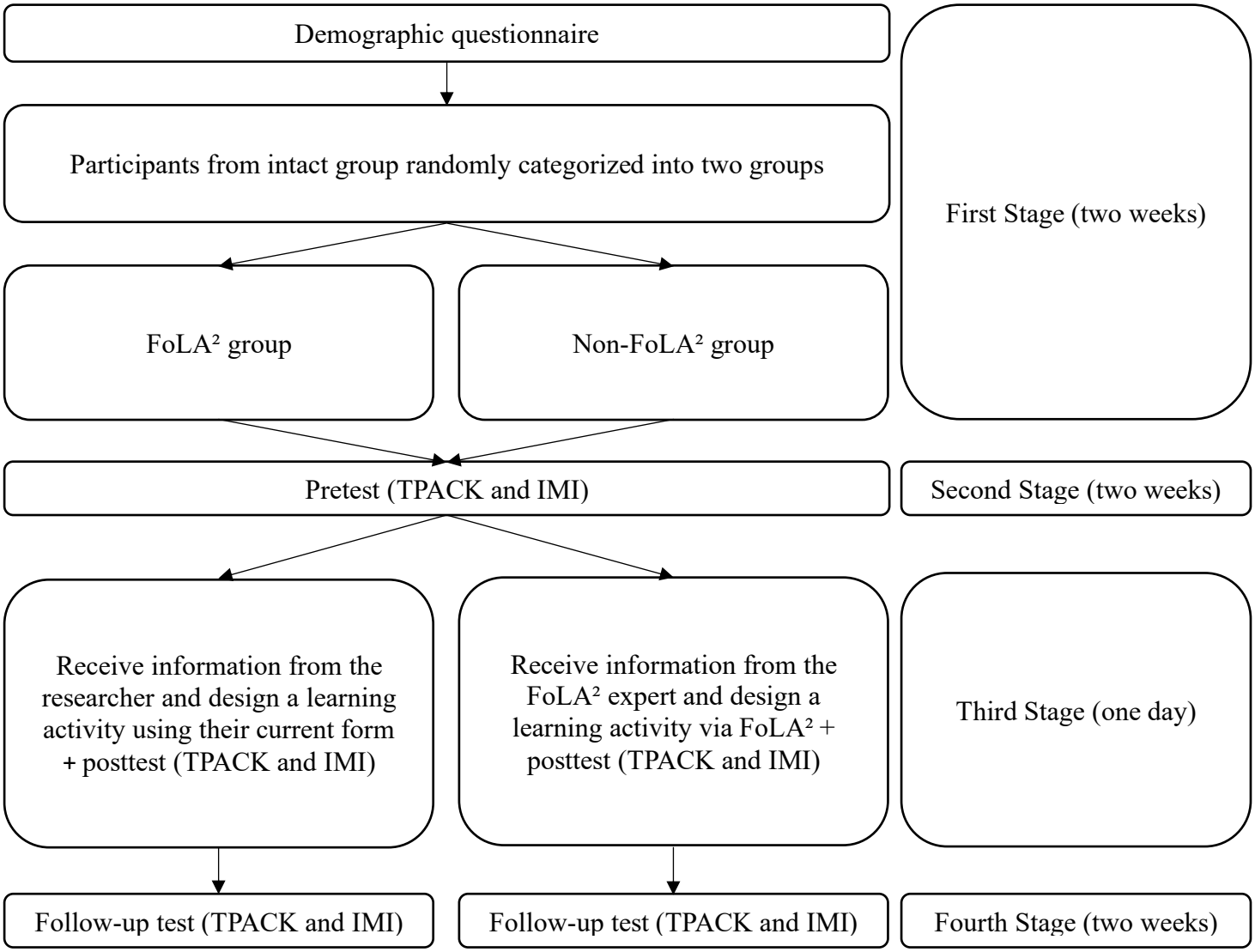
questionnaires were briefly explained and took 30 minutes to complete. Participants were required to complete the questionnaire at least one week before the intervention and were reminded after four days to reduce potential testing effects (Doughty & Long, 2008).

During the third phase of the study, the intervention took place at the primary school. The researcher welcomed all participants in the auditorium and provided them with concise information about what LA and LD entail. Participants were then divided into the control and experimental groups across two different classrooms. Both groups underwent the intervention simultaneously: the control group received information from the researcher and was tasked with designing a learning activity for 6th graders using their current thematic preparation format (see Appendix E), while the experimental group received the same information from the FoLA² expert and designed a learning activity with FoLA². This design process lasted for 60 minutes. Both groups had access to the same thematic educational materials, including a theme textbook, workbook, and website. The learning objective was identical for both groups: to convey energy concepts such as gas, electricity, energy-efficient practices, and the identification of energy-consuming household appliances. Additional criteria for a serious board game included the use of technology in a supportive role and the use of LA for data collection and analysis on the learning process. Immediately after the intervention, a posttest of 30 minutes was administered in the respective classrooms, after which the participants were thanked for their participation in the intervention.

In the fourth phase, one week after the intervention, all participants received a follow-up test questionnaire. The procedures remained consistent throughout all testing sessions. Potential systematic differences between the control and experimental groups were minimized, and task duration was monitored and incorporated into the results (Creswell & Guetterman, 2021).

Figure 2

Procedure of this study



2.5 Data-Analysis

The research questions were analyzed using the statistical software *Jamovi*, with a significance level of $p < .05$. The intervention, whether FoLA² was implemented, was considered a categorical variable, while TPACK, motivation including satisfaction (IMISAT), motivation (IMI), and satisfaction (SAT) were treated as continuous interval variables.

For the first two research questions, a two-way repeated measures ANOVA was conducted four times, with sphericity directly checked (Field, 2013). The intervention,

whether FoLA² was implemented, served as the independent variable, while TPACK, IMISAT, IMI, and SAT were considered the dependent variables. This examined the influence of the intervention on both TPACK and participants' motivation, with repeated measurements within the same individuals. The intervention was treated as a between-subject factor, while TPACK and all motivation variables were within-subject factors, measured across three time points: pretest (A), posttest (B), and follow-up test (C). In case of a significant main effect, uncorrected post-hoc comparisons were conducted using paired t-tests to determine between which measurements significance was observed.

For the third research question, four linear regression analyses were conducted between TPACK as the independent variable and IMISAT, IMI, and SAT as dependent variables. This focused on the R^2 value and the beta coefficient to understand the relationship between TPACK and motivation.

Prior to conducting the ANOVAs, an inspection of the data was carried out for all variables. Data inspection included appropriate normality tests for smaller samples (Yap & Nomadiah, 2011), such as the Shapiro-Wilk test (1965), supplemented by the Anderson-Darling test (1952) as an additional sensitivity test. Histograms and Q-plots were inspected to identify potential outliers. Additionally, for the regressions, heteroskedasticity was further checked using the Breusch-Pagan test (1979), with an additional visual inspection of a scatterplot. Autocorrelation was examined using the Durbin-Watson test, and finally, the Q-plot of standardized residuals was evaluated.

3. Results

3.1 Descriptive statistics

Table 1 provides an overview of the descriptive statistics of the participants for the following variables: TPACK, motivation including satisfaction (IMISAT), motivation (IMI), and satisfaction (SAT).

Table 1

Descriptive statistics participants

	N	Minimum	Maximum	*M*	*SD*
TPACK	*18*	2.79	4.50	3.42	0.46
IMISAT	*18*	3.90	6.06	5.34	0.57
IMI	*18*	3.60	5.17	4.59	0.45
SAT	*18*	4.19	6.95	6.07	0.75

3.2 Data Assumptions

Upon inspecting the data for variables related to the first two research questions, no significant deviations were observed during the normality tests and plots, except for variable A_SAT. Both the Shapiro-Wilk test (p = .01) and the Anderson-Darling test (p = .02) indicated a significant effect for A_SAT. Despite the absence of clear outliers, it was decided to proceed with the ANOVAs cautiously. However, it is important to exercise caution when interpreting the results of A_SAT. For the third research question, data inspection revealed no significant deviations in test results. Visual examination of the plots displayed a reasonable line, suggesting that the assumptions for linear regression were satisfied, thus enabling the intended analyses to be carried out.

3.3 TPACK-knowledge

The results showed a significant improvement in TPACK of participants from pretest to posttest. After conducting Mauchly's test of sphericity, it was confirmed that there was no violation of sphericity, enabling us to proceed with analyzing the main effect of time. The results indicated a significant main effect, $F(2, 32) = 5.63$, p = .01, with a moderate effect size of $\boldsymbol{\eta}^2$ = .26. Subsequently, uncorrected post-hoc comparisons were performed using paired t-tests. These comparisons revealed that the TPACK score at the posttest was significantly

higher (*M* = 3.62, *SE* = 0.08) compared to the pretest (*M* = 3.31, *SE* = 0.13), with a significance level of *p* = .01 and a moderate Cohen's *d* of -0.73, along with a 95% confidence interval of [-1.24, -0.20]. However, no significant differences were observed between the groups employing different methods. These findings are summarized in Table 2. Moreover, the analysis demonstrated that both groups exhibited higher scores at each measurement moment. While the experimental group displayed lower scores after the immediate posttest, none of these differences reached statistical significance.

Table 2

The differences of TPACK between the two conditions in three phases

Variable	Phases	Conditions	N	*M*	*SD*
	Pretest	Control	*8*	3.54	.46
		Experimental	*10*	3.13	.59
TPACK	Posttest	Control	*8*	3.74	.42
		Experimental	*10*	3.52	.28
	Follow-up test	Control	*8*	3.75	.43
		Experimental	*10*	3.27	.59

3.4 Motivation

Following the intervention with FoLA² compared to the own format intervention, no significant difference was found in IMISAT, IMI, and SAT. Despite consistently lower scores reported by the experimental group across all the motivation variables compared to the control group across all measurements, this disparity did not reach statistical significance. Tables 3, 4, and 5 illustrated stable scores for the control group, whereas the experimental group's scores showed slight increases at each measurement point, without any significant deviations.

Table 3

The differences of IMISAT between the two conditions in three phases

Variable	Phases	Conditions	N	*M*	*SD*
	Pretest	Control	*8*	5.31	0.63
		Experimental	*10*	4.94	0.61
IMISAT	Posttest	Control	*8*	5.32	0.71
		Experimental	*10*	5.13	0.56
	Follow-up test	Control	*8*	5.26	0.73
		Experimental	*10*	5.13	0.50

Table 4

The differences of IMI between the two conditions in three phases

Variable	Phases	Conditions	N	*M*	*SD*
	Pretest	Control	*8*	4.54	0.46
		Experimental	*10*	4.39	0.49
IMI	Posttest	Control	*8*	4.55	0.54
		Experimental	*10*	4.49	0.48
	Follow-up test	Control	*8*	4.55	0.52
		Experimental	*10*	4.47	0.43

Table 5

The differences of SAT between the two conditions in three phases

Variable	Phases	Conditions	N	*M*	*SD*
	Pretest	Control	*8*	6.09	0.85
		Experimental	*10*	5.50	0.86
IMI	Posttest	Control	*8*	6.09	0.89
		Experimental	*10*	5.77	0.78
	Follow-up test	Control	*8*	5.96	0.97
		Experimental	*10*	5.79	0.62

3.5 TPACK-knowledge and Motivation

The linear regression analysis revealed significant correlations between TPACK and the motivation variables. TPACK emerged as a significant predictor of IMISAT (β = 0.90; $t(16) = 4.07$; $p < .001$), explaining a substantial portion of the variance in IMISAT ($R^2 = .51$; $F(1.16) = 16.6$; $p < .001$). Additionally, TPACK served as a significant predictor of IMI (β = 0.73; $t(16) = 4.44$; $p < .001$), explaining a significant proportion of the variance in IMI ($R^2 = .55$; $F(1.16) = 19.7$; $p < .001$). Similarly, TPACK predicted significant differences in SAT (β = 1.06; $t(16) = 3.40$; $p < .01$), explaining a notable portion of the variance in SAT ($R^2 = .42$; $F(1.16) = 19.7$; $p < .001$).

4. Discussions

This study aimed to investigate the effects of LA-supported LD, specifically using FoLA², on the TPACK and motivation of primary education teachers. Through the first research question, we examined how the use of FoLA² influenced the TPACK of primary education teachers in LA-supported LD. We hypothesized that the experimental group, utilizing FoLA², would demonstrate a greater improvement in TPACK than the control group,

who used their own format. This hypothesis was based on previous findings indicating that active engagement of teachers in design processes can contribute to the development of TPACK (Koehler & Mishra, 2008; Koh et al., 2015; Voogt et al., 2013; Yeh et al., 2021). The research revealed a significant main effect between pre- and post-measurement of TPACK among primary education teachers after the intervention. Despite higher TPACK scores post-intervention, no significant differences were observed between the groups employing different methods. The absence of significant differences between the experimental and control groups may be explained by earlier findings emphasizing the positive influence of LD on TPACK. LD, particularly through 'learning by design' (Koehler & Mishra, 2008), can promote TPACK by involving teachers in designing learning activities (Voogt et al., 2013) in teams through knowledge sharing and collaborative learning for authentic educational problems (Yeh et al., 2021). These design aspects were utilized in both groups. Remarkably, the control group consistently scored higher, including in the pre-measurement. This might indicate a coincidentally higher perception of their TPACK knowledge, which in turn influences their design process (Mishra & Koehler, 2006). However, caution is warranted in this interpretation given the non-significant differences between the groups in this study.

The second research question examined how the use of FoLA² influenced the motivation of primary education teachers in LA-supported LD. We investigated motivation including satisfaction, motivation, and satisfaction. We expected that the experimental group, using FoLA², would show a greater improvement in motivation including satisfaction, motivation, and satisfaction than the control group, who used their own format. This expectation stemmed from results of previous studies consistently showing that the use of LD has a positive impact on teacher motivation. These studies have shown that when teachers can adjust their teaching styles based on data about their students' learning processes (Shibani et al., 2020), they feel more engaged (Dagnino et al., 2018), more motivated (Wen & Song,

2011), and experience a greater sense of competence (Dollinger et al., 2019). However, in this study, no significant association was found between the intervention and motivation including satisfaction, motivation, and satisfaction, both within groups and across different time points. Similarly, the control group consistently scored higher, including in the pre-measurement. The scores of the experimental group increased at each measurement, but without significant differences. This could partly be explained by the fulfillment of ABC needs according to SDT theory, where both the experimental and control groups may have experienced autonomy, relatedness, and competence (Gagné et al., 2015; Ryan & Deci, 2000). It appears that designing learning activities in a group context, with room for input and within a familiar setting, indeed contributes to motivation. The absence of significant differences in motivation between groups post-intervention may be attributed to differences in context and target population compared to previous studies (Dagnino et al., 2018; Dollinger et al., 2019; Shibani et al., 2020; Wen & Song, 2011). The current study appears to be one of the first experimental investigations examining the effect of LA-supported LD on the motivation of teachers in primary education, as recommended by Stichting Klasse et al. (2016).

Finally, we explored whether there is a relationship between the TPACK of primary education teachers and their motivation including satisfaction, motivation, and satisfaction. This third research question aimed to obtain a more comprehensive understanding of the dynamics between these variables. The research revealed a significant correlation between TPACK and the motivation variables. TPACK was identified as a significant predictor of both total motivation including satisfaction and motivation itself, explaining 51% and 55% of the variability respectively. Similarly, TPACK was found to be a significant predictor of satisfaction, explaining 42% of the variance. These findings align with previous research, emphasizing that increasing teachers' professional knowledge contributes to their sense of

competence (Dollinger et al., 2019; Shibani et al., 2020), which in turn can have a positive impact on their motivation for professional tasks (Gagné et al., 2015).

4.1 Limitations

The findings of this study should be interpreted with caution due to several limitations. Firstly, the limited sample size ($N = 18$) from a specific context, namely a regular primary school in the south of the Netherlands, restricts the generalizability of the results to a broader range of primary education teachers (Creswell & Guetterman, 2021). Additionally, the quasi-experimental design of this study makes it susceptible to greater threats to internal validity compared to pure experimental designs, limiting the generalizability of the findings beyond the specific circumstances and context of the research. Factors such as selection bias or confounding variables can influence the results, making it more challenging to establish causal relationships between variables (Creswell & Guetterman, 2021). Lastly, there is a risk that self-report questionnaires may influence scores as respondents may have a limited understanding of their own social functioning (Hollin & Palmer, 2011), and/or provide socially desirable responses (Bech & Mak, 1995).

4.2 Recommendations for Future Research

In all the following recommendations, it is advised to work with larger sample sizes, examining interventions with FoLA² in comparable group sizes, as previously applied in this research and in previous studies (Schmitz et al., 2022a). Firstly, it is recommended to develop objective evaluation criteria for step seven of the FoLA² methodology to measure and quantify the improvement of design quality more accurately. By doing so, researchers can likely make a more precise assessment of the effectiveness of the FoLA² method in enhancing design processes. Additionally, a follow-up study is advised to investigate the effects of assumed improved designs using the developed evaluation criteria in authentic learning practices. The research was conducted in a specific context, namely a regular primary school

in the south of the Netherlands. It would be valuable to examine how the effects of FoLA² vary among primary education teachers in other regions in the Netherlands. In addition to quantitative measurements, qualitative analyses would be valuable to gain deeper insight into teachers' experiences and perceptions regarding FoLA² and its influence on their TPACK and motivation. The research primarily focused on TPACK and motivation including and excluding satisfaction. It would be interesting to explore other relevant variables such as self-efficacy, professional development, and student outcomes to gain a more complete picture of the impact of FoLA² on teachers and students. Lastly, it is recommended to conduct such research through a longitudinal approach, following participants over an extended period. This can provide insight into the long-term effects of LA-supported LD via FoLA² on TPACK, motivation of primary education teachers, and/or other relevant variables (Creswell & Guetterman, 2021).

4.3 Social and Scientific Relevance

Although no significant differences were found, this research holds both societal and scientific relevance. Societally, this research contributes to improving LA-supported LD skills, specifically through the FoLA² methodology. This could potentially lead to more effective use of technology in education, ultimately improving student learning outcomes. Additionally, the research focuses on gaining more insight into the application of LA-supported LD and its effects on TPACK and motivation. This could contribute to the development of teacher professionalization, inform policymakers about the integration of technology in education, and thereby improve the quality of education. From a scientific standpoint, this research contributes to the growing body of evidence on effective learning design practices and promotes evidence-based research in the field of LA-supported learning and instructional design for teachers. The findings of the research provide insight into the complex relationship between the use of LA-supported LD learning and the professional

development of teachers, which is valuable for researchers within the domain of educational science and technology enhanced learning.

4.4 Conclusion

This conclusion provides valuable insights into the complex relationship between LA-supported LD, with a specific focus on FoLA², and its impact on the TPACK and motivation of primary education teachers. While no significant differences were found between the experimental and control groups, the study emphasizes the added value of LA-supported LD in professionalizing primary education teachers by enhancing their TPACK and promoting their motivation.

These findings underscore the need for ongoing research to further understand the complex interactions between LA-supported LD practices, contextual factors, and teacher outcomes in primary education. Additionally, it highlights the necessity of a holistic approach in designing future research, integrating both quantitative and qualitative analyses while considering various other variables, such as self-efficacy and student outcomes. This study contributes to strengthening the evidence base for effective LA-supported LD methods and provides a foundation for further development of learning strategies aimed at improving both teacher professional development and student learning outcomes.

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Appendix A

A. Survey of Preservice Teachers' Knowledge of Teaching and Technology

Response categories: 1 = strongly disagree, 2 = a bit agree, 3 = neutral, 4 = agree, and 5 = strongly agree

The items in this study pertain to the design of a learning activity. The pre-test items are identical for both groups, while the post-test questions differ between the experimental and control groups. The distinction lies in the inclusion of 'by using FoLA²' in the post-test questions for the experimental group, whereas the control group does not have this addition.

	TPACK ITEMS FOR TEACHERS
PEDAGOGICAL KNOWLEDGE	I can adapt my way of designing a learning activity based upon what students currently understand or do not understand [pre-test] I can adapt my way of designing a learning activity by using FoLA² based upon what students currently understand or do not understand [post-test]
	I can adapt my style of designing a learning activity to different students [pre-test] I can adapt my style of designing a learning activity to different students by using FoLA² [post-test]
	I can use a wide range of learning activities when I design a learning activity [pre-test] I can use a wide range of learning activities when I design a learning activity by using ForLA2 [post-test]

	I can assess student learning in multiple ways when designing a learning activity [pre-test] I can assess student learning in multiple ways when designing a learning activity by using ForLA2 [post-test]
CONTENT KNOWLEDGE	I have sufficient subject knowledge about designing a learning activity [pre-test] I have sufficient subject knowledge about designing a learning activity by using FoLA2 [post-test]
	I can use a subject-specific way when designing a learning activity [pre-test] I can use a subject-specific way when designing a learning activity by using FoLA2 [post-test]
	I know the basic theories and concepts that are relevant when designing a learning activity [pre-test] I know the basic theories and concepts that are relevant when designing a learning activity by using FoLA2 [post-test]
	I know the history and development of important learning theories when designing a learning activity [pre-test] I know the history and development of important learning theories when designing a learning activity by using FoLA2 [post-test]
TECHNOLOGICAL KNOWLEDGE	I keep up with important new technologies that are relevant when designing a learning activity [pre-test] I keep up with important new technologies that are relevant when designing a learning activity by using FoLA2 [post-test]

	I frequently play around with the technology when designing a learning activity [pre-test] I frequently play around with the technology when designing a learning activity by using FoLA2 [pre-test]
	I know about a lot of different technologies for designing a learning activity [pre-test] Using FoLA2 helped me to increase my knowledge about different technologies for designing a learning activity [post-test]
	I have the technical skills I need to use technology when designing a learning activity [pre-test] I have the technical skills I need to use technology when designing a learning activity by using FoLA2 [post-test]
PEDAGOGICAL-CONTENT KNOWLEDGE	I know how to select effective teaching approaches to guide student thinking and learning in designing a learning activity [pre-test] I know how to select effective teaching approaches to guide student thinking and learning in designing a learning activity by using FoLA2 [post-test]
	I know how to develop appropriate tasks to promote students complex thinking of the designed learning activity [pre-test] I know how to develop appropriate tasks to promote students complex thinking of the designed learning activity by using FoLA2 [post-test]
	I know how to develop exercises with which students can consolidate (i.e., maintain) their knowledge when designing a learning activity [pre-test]

	I know how to develop exercises with which students can consolidate (i.e., maintain) their knowledge when designing a learning activity by using FoLA2 [post-test]
	I know how to evaluate students' performance when designing a learning activity [pre-test] I know how to evaluate students' performance when designing a learning activity by using FoLA2 [post-test]
TECHNOLOGICAL-PEDAGOGICAL KNOWLEDGE	I can choose technologies that enhance the teaching approaches when designing a learning activity [pre-test] I can choose technologies that enhance the teaching approaches when designing a learning activity by using FoLA2 [post-test]
	I can choose technologies that enhance students' learning when designing a learning activity [pre-test] I can choose technologies that enhance students' learning when designing a learning activity by using FoLA2 [post-test]
	I can adapt the use of the technologies that I am learning about to the learning activity to be designed [pre-test] I can adapt the use of the technologies that I am learning about to the learning activity to be designed by using FoLA2 [post-test]
	I am thinking critically about how to use technology when designing a learning activity [pre-test] I am thinking critically about how to use technology when designing a learning activity by using FoLA2 [post-test]

TECHNOLOGICAL-CONTENT KNOWLEDGE	I know how technological developments have changed the learning content of my designed teaching activity [pre-test] I know how technological developments have changed the learning content of my designed teaching activity by using FoLA2 [post-test]
	I can explain which technologies have been used in research in relation to the learning content when designing a learning activity [pre-test] I can explain which technologies have been used in research in relation to the learning content when designing a learning activity by using FoLA2 [post-test]
	I know which new technologies are currently being developed in relation to the learning content when designing a learning activity [pre-test] I know which new technologies are currently being developed in relation to the learning content when designing a learning activity by using FoLA2 [post-test]
	I know how to use technologies to participate in the scientific conversations in relation to the learning content when designing a learning activity [pre-test] I know how to use technologies to participate in the scientific conversations in relation to the learning content when designing a learning activity by using FoLA2 [post-test]
TECHNOLOGICAL-PEDAGOGICAL-CONTENT KNOWLEDGE	I can use strategies that combine the learning content, technologies, and teaching approaches when designing a learning activity [pre-test] I can use strategies that combine the learning content, technologies, and teaching approaches when designing a learning activity by using FoLA2 [post-test]
	I can choose technologies that enhance the content of the designed learning activity [pre-test]

	I can choose technologies that enhance the content of the designed learning activity by using FoLA2 [post-test]
	I can select technologies when designing a learning activity that enhance what I teach, how I teach, and what students learn [pre-test] I can select technologies when designing a learning activity that enhance what I teach, how I teach, and what students learn by using FoLA2 [post-test]
	I can design a learning activity that appropriately combine the learning content, technologies, and teaching approaches [pre-test] I can design a learning activity that appropriately combine the learning content, technologies, and teaching approaches by using FoLA2 [post-test]

Antwoordcategorieën: 1 = sterk oneens, 2 = een beetje mee eens, 3 = neutraal, 4 = eens en 5 = sterk mee eens

	TPACK ITEMS VOOR PRIMAIR ONDERWIJS (PO) LERAREN
PEDAGOGISCHE KENNIS	Ik kan mijn manier van het ontwerpen van een leeractiviteit aanpassen op basis van wat studenten momenteel begrijpen of niet begrijpen [pre-test] Ik kan mijn manier van het ontwerpen van een leeractiviteit aanpassen door FoLA^2 te gebruiken op basis van wat studenten momenteel begrijpen of niet begrijpen [post-test]
	Ik kan mijn stijl van het ontwerpen van een leeractiviteit aanpassen aan verschillende studenten [pre-test]

	Ik kan mijn stijl van het ontwerpen van een leeractiviteit aanpassen aan verschillende studenten door FoLA^2 [post-test] te gebruiken
	Ik kan een breed scala aan leeractiviteiten gebruiken wanneer ik een leeractiviteit ontwerp [pre-test] Ik kan een breed scala aan leeractiviteiten gebruiken wanneer ik een leeractiviteit ontwerp met behulp van FoLA^2 [post-test]
	Ik kan het leren van studenten op meerdere manieren beoordelen bij het ontwerpen van een leeractiviteit [pre-test] Ik kan het leren van studenten op meerdere manieren beoordelen bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
C ONTENT KENNIS	Ik heb voldoende vakkennis over het ontwerpen van een leeractiviteit [pre-test] Ik heb voldoende vakkennis over het ontwerpen van een leeractiviteit door gebruik te maken van FoLA^2 [post-test]
	Ik kan een vakspecifieke manier gebruiken bij het ontwerpen van een leeractiviteit [pre-test] Ik kan een vakspecifieke manier gebruiken bij het ontwerpen van een leeractiviteit door FoLA^2 [post-test] te gebruiken
	Ik ken de basistheorieën en concepten die relevant zijn bij het ontwerpen van een leeractiviteit [pre-test] Ik ken de basistheorieën en concepten die relevant zijn bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik ken de geschiedenis en ontwikkeling van belangrijke leertheorieën bij het ontwerpen van een leeractiviteit [pre-test]

	Ik ken de geschiedenis en ontwikkeling van belangrijke leertheorieën bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
TECHNOLOGISCHE KENNIS	Ik blijf op de hoogte van belangrijke nieuwe technologieën die relevant zijn bij het ontwerpen van een leeractiviteit [pre-test] Ik blijf op de hoogte van belangrijke nieuwe technologieën die relevant zijn bij het ontwerpen van een leeractiviteit door FoLA^2 [post-test] te gebruiken
	Ik speel vaak met de technologie bij het ontwerpen van een leeractiviteit [pre-test] Ik speel vaak met de technologie bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [pre-test]
	Ik ken veel verschillende technologieën voor het ontwerpen van een leeractiviteit [pre-test] Het gebruik van FoLA^2 heeft me geholpen om mijn kennis over verschillende technologieën voor het ontwerpen van een leeractiviteit te vergroten [post-test]
	Ik heb de technische vaardigheden die ik nodig heb om technologie te gebruiken bij het ontwerpen van een leeractiviteit [pre-test] Ik heb de technische vaardigheden die ik nodig heb om technologie te gebruiken bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
PEDAGOGISCH-INHOUDELIJKE KENNIS	Ik weet hoe ik effectieve onderwijsbenaderingen moet selecteren om studenten te begeleiden bij het ontwerpen van een leeractiviteit [pre-test] Ik weet hoe ik effectieve onderwijsbenaderingen kan selecteren om studenten te begeleiden bij het ontwerpen van een leeractiviteit door FoLA^2 te gebruiken [post-test]

	Ik weet hoe ik de juiste taken moet ontwikkelen om studenten te bevorderen bij het complexe denken over de ontworpen leeractiviteit [pre-test] Ik weet hoe ik de juiste taken kan ontwikkelen om studenten te bevorderen bij het complexe denken over de ontworpen leeractiviteit door FoLA^2 te gebruiken [post-test]
	Ik weet hoe ik oefeningen moet ontwikkelen waarmee studenten hun kennis kunnen consolideren (d.w.z. behouden) bij het ontwerpen van een leeractiviteit [pre-test] Ik weet hoe ik oefeningen kan ontwikkelen waarmee studenten hun kennis kunnen consolideren (d.w.z. behouden) bij het ontwerpen van een leeractiviteit door FoLA^2 te gebruiken [post-test]
	Ik weet hoe ik de prestaties van studenten moet evalueren bij het ontwerpen van een leeractiviteit [pre-test] Ik weet hoe ik de prestaties van studenten moet evalueren bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
TECHNOLOGISCH-PEDAGOGISCHE KENNIS	Ik kan technologieën kiezen die de onderwijsbenaderingen verbeteren bij het ontwerpen van een leeractiviteit [pre-test] Ik kan technologieën kiezen die de onderwijsbenaderingen verbeteren bij het ontwerpen van een leeractiviteit door FoLA^2 te gebruiken [post-test]
	Ik kan technologieën kiezen die het leren van studenten verbeteren bij het ontwerpen van een leeractiviteit [pre-test] Ik kan technologieën kiezen die het leren van studenten verbeteren bij het ontwerpen van een leeractiviteit door FoLA^2 te gebruiken [post-test]

	Ik kan het gebruik van de technologieën waarover ik leer aanpassen aan de leeractiviteit die moet worden ontworpen [pre-test] Ik kan het gebruik van de technologieën waarover ik leer aanpassen aan de leeractiviteit die moet worden ontworpen met behulp van FoLA^2 [post-test]
	Ik denk kritisch na over het gebruik van technologie bij het ontwerpen van een leeractiviteit [pre-test] Ik denk kritisch na over het gebruik van technologie bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
TECHNOLOGISCH-INHOUDELIJKE KENNIS	Ik weet hoe technologische ontwikkelingen de leerinhoud van mijn ontworpen onderwijsactiviteit [pre-test] hebben veranderd Ik weet hoe technologische ontwikkelingen de leerinhoud van mijn ontworpen onderwijsactiviteit hebben veranderd door FoLA^2 te gebruiken [post-test]
	Ik kan uitleggen welke technologieën zijn gebruikt in onderzoek in relatie tot de leerinhoud bij het ontwerpen van een leeractiviteit [pre-test] Ik kan uitleggen welke technologieën zijn gebruikt in onderzoek in relatie tot de leerinhoud bij het ontwerpen van een leeractiviteit door gebruik te maken van FoLA^2 [post-test]
	Ik weet welke nieuwe technologieën momenteel worden ontwikkeld in relatie tot de leerinhoud bij het ontwerpen van een leeractiviteit [pre-test] Ik weet welke nieuwe technologieën momenteel worden ontwikkeld in relatie tot de leerinhoud bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]

	Ik weet hoe ik technologieën moet gebruiken om deel te nemen aan de wetenschappelijke gesprekken met betrekking tot de leerinhoud bij het ontwerpen van een leeractiviteit [pre-test] Ik weet hoe ik technologieën moet gebruiken om deel te nemen aan de wetenschappelijke gesprekken met betrekking tot de leerinhoud bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
TECHNOLOGISCH-PEDAGOGISCH-INHOUDELIJKE KENNIS	Ik kan strategieën gebruiken die de leerinhoud, technologieën en onderwijsbenaderingen combineren bij het ontwerpen van een leeractiviteit [pre-test] Ik kan strategieën gebruiken die de leerinhoud, technologieën en onderwijsbenaderingen combineren bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik kan technologieën kiezen die de inhoud van de ontworpen leeractiviteit verbeteren [pre-test] Ik kan technologieën kiezen die de inhoud van de ontworpen leeractiviteit verbeteren door FoLA^2 te gebruiken [post-test]
	Ik kan technologieën selecteren bij het ontwerpen van een leeractiviteit die verbeteren wat ik lesgeef, hoe ik lesgeef en wat studenten leren [pre-test] Ik kan technologieën selecteren bij het ontwerpen van een leeractiviteit die verbeteren wat ik lesgeef, hoe ik lesgeef en wat studenten leren door FoLA^2 te gebruiken [post-test]
	Ik kan een leeractiviteit ontwerpen die de leerinhoud, technologieën en onderwijsbenaderingen op de juiste manier combineert [pre-test]

	Ik kan een leeractiviteit ontwerpen die de leerinhoud, technologieën en onderwijsbenaderingen op de juiste manier combineert met behulp van FoLA^2 [post-test]

Appendix B

B. Intrinsic Motivation Inventory (IMI)

Response categories: 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = agree, and 7 = strongly agree

The items in this study pertain to the design of a learning activity. The pre-test items are identical for both groups, while the post-test questions differ between the experimental and control groups. The distinction lies in the inclusion of 'by using FoLA²' in the post-test questions for the experimental group, whereas the control group does not have this addition.

	IMI ITEMS FOR TEACHERS
INTEREST	When designing a learning activity, I think about how much I enjoy it [pre-test] While I was designing a learning activity by using FoLA², I was thinking about how much I enjoyed it [post-test]
	I find designing a learning activity interesting [pre-test] I found designing a learning activity by using FoLA² very interesting [post-test]
	Designing a learning activity is fun [post-test] Designing a learning activity by using FoLA² was fun [post-test]
	I enjoy designing a learning activity very much [pre-test] I enjoyed designing a learning activity by using FoLA² very much [post-test]
	I think designing a learning activity is very boring [pre-test] I thought designing a learning activity by using FoLA² was very boring [post-test]

	I think designing a learning activity is very interesting [pre-test] I thought designing a learning activity by using FoLA² was very interesting [post-test]
	I will describe design a learning activity as very enjoyable [pre-test] I would describe design a learning activity by using FoLA² as very enjoyable [post-test]
PERCEIVED COMPETENCE	I think I am pretty good at designing a learning activity [pre-test] I think I am pretty good at designing a learning activity by using FoLA² [post-test]
	I think I do pretty well at designing a learning activity, compared to other colleagues [pre-test] I think I did pretty well at designing a learning activity by using FoLA², compared to other colleagues [post-test]
	I am satisfied with my performance at designing a learning activity [pre-test] I am satisfied with my performance at designing a learning activity by using FoLA² [post-test]
	I feel pretty skilled at designing a learning activity [pre-test] I felt pretty skilled at designing a learning activity by using FoLA² [post-test]
	When designing a learning activity for a while, I feel pretty competent [pre-test] After designing a learning activity by using FoLA² for a while, I felt pretty competent [post-test]
PERCEIVED CHOICE	I feel that it is my choice to designing a learning activity [pre-test] I felt that it was my choice to designing a learning activity by using FoLA² [post-test]
	I do not really have a choice about designing a learning activity [pre-test]

	I did not really have a choice about designing a learning activity by using FoLA² [post-test]
	I feel like I am doing what I want to do while I am designing a learning activity [pre-test] I felt like I was doing what I wanted to do while I was designing a learning activity by using FoLA² [post-test]
	I feel like I have to design a learning activity [pre-test] I felt like I had to design a learning activity by using FoLA² [post-test]
	I design a learning activity because I have no choice [post-test] I designed a learning activity by using FoLA² because I had no choice [post-test]
PRESSURE	I do not feel at all nervous about designing a learning activity [pre-test] I did not feel at all nervous about designing a learning activity by using FoLA² [post-test]
	I feel tense while designing a learning activity [pre-test] I felt tense while designing a learning activity by using FoLA² [post-test]
	I feel relaxed while designing a learning activity [pre-test] I felt relaxed while designing a learning activity by using FoLA² [post-test]
	I am anxious while designing a learning activity [pre-test] I was anxious while designing a learning activity by using FoLA² [post-test]
	I feel pressured while designing a learning activity [pre-test] I felt pressured while designing a learning activity by using FoLA² [post-test]

Antwoordcategorieën: 1 = sterk oneens, 2 = oneens, 3 = enigszins oneens, 4 = neutraal, 5 = enigszins mee eens, 6 = eens en 7 = sterk mee eens

	IMI ITEMS VOOR PRIMAIR ONDERWIJS (PO) LERAREN
INTERESSE	Bij het ontwerpen van een leeractiviteit denk ik na over hoeveel ik ervan geniet [pre-test] Terwijl ik een leeractiviteit aan het ontwerpen was met behulp van FoLA^2, dacht ik na over hoeveel ik ervan genoot [post-test]
	Ik vind het ontwerpen van een leeractiviteit interessant [pre-test] Ik vond het ontwerpen van een leeractiviteit met behulp van FoLA^2 erg interessant [post-test]
	Designing a learning activity is fun [post-test] Designing a learning activity by using FoLA^2 was fun [post-test]
	Ik vind het erg leuk om een leeractiviteit te ontwerpen [pre-test] Ik vond het erg leuk om een leeractiviteit te ontwerpen met behulp van FoLA^2 [post- test]
	Ik denk dat het ontwerpen van een leeractiviteit erg saai is [pre-test] Ik vond het ontwerpen van een leeractiviteit met behulp van FoLA^2 erg saai [post-test]
	Ik denk dat het ontwerpen van een leeractiviteit erg interessant is [pre-test] Ik vond het ontwerpen van een leeractiviteit met behulp van FoLA^2 erg interessant [post-test]
	Ik zal het ontwerpen van een leeractiviteit beschrijven als zeer plezierig [pre-test]

	Ik zou het ontwerpen van een leeractiviteit met behulp van FoLA^2 beschrijven als zeer plezierig [post-test]
WAARGENOMEN COMPETENTIE	Ik denk dat ik redelijk goed ben in het ontwerpen van een leeractiviteit [pre-test] Ik denk dat ik redelijk goed ben in het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik denk dat ik het redelijk goed doe in het ontwerpen van een leeractiviteit, vergeleken met andere collega's [pre-test] Ik denk dat ik het redelijk goed heb gedaan bij het ontwerpen van een leeractiviteit met behulp van FoLA^2, in vergelijking met andere collega's [post-test]
	Ik ben tevreden over mijn prestaties bij het ontwerpen van een leeractiviteit [pre-test] Ik ben tevreden over mijn prestaties bij het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik voel me behoorlijk bedreven in het ontwerpen van een leeractiviteit [pre-test] Ik voelde me behoorlijk bedreven in het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Bij het ontwerpen van een leeractiviteit voor een tijdje, voel ik me behoorlijk competent [pre-test] Na het ontwerpen van een leeractiviteit door een tijdje FoLA 2 te gebruiken, voelde ik me behoorlijk competent [post-test]
WAARGENOMEN KEUZE	Ik heb het gevoel dat het mijn keuze is om een leeractiviteit te ontwerpen [pre-test]

	Ik voelde dat het mijn keuze was om een leeractiviteit te ontwerpen met behulp van FoLA^2 [post-test]
	Ik heb niet echt een keuze over het ontwerpen van een leeractiviteit [pre-test] Ik had niet echt een keuze over het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik heb het gevoel dat ik doe wat ik wil doen terwijl ik een leeractiviteit ontwerp [pre-test] Ik had het gevoel dat ik deed wat ik wilde doen terwijl ik een leeractiviteit ontwierp met behulp van FoLA^2 [post-test]
	Ik heb het gevoel dat ik een leeractiviteit moet ontwerpen [pre-test] Ik had het gevoel dat ik een leeractiviteit moest ontwerpen met behulp van FoLA^2 [post-test]
	Ik ontwerp een leeractiviteit omdat ik geen keuze heb [na de test] Ik heb een leeractiviteit ontworpen met behulp van FoLA^2 omdat ik geen keuze had [na de test]
DRUK	Ik voel me helemaal niet nerveus over het ontwerpen van een leeractiviteit [pre-test] Ik voelde me helemaal niet nerveus over het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik voel me gespannen tijdens het ontwerpen van een leeractiviteit [pre-test] Ik voelde me gespannen tijdens het ontwerpen van een leeractiviteit met behulp van FoLA^2 [post-test]
	Ik voel me ontspannen tijdens het ontwerpen van een leeractiviteit [pre-test]

	Ik voelde me ontspannen tijdens het ontwerpen van een leeractiviteit met behulp van FoLA² [post-test]
	Ik ben angstig tijdens het ontwerpen van een leeractiviteit [pre-test] Ik was angstig tijdens het ontwerpen van een leeractiviteit met behulp van FoLA² [post-test]
	Ik voel me onder druk gezet tijdens het ontwerpen van een leeractiviteit [pre-test] Ik voelde me onder druk gezet tijdens het ontwerpen van een leeractiviteit met behulp van FoLA² [post-test]

Appendix C

C. E-Learner Satisfaction (ELS)

Response categories: 1 = strongly agree, 2 = agree, 3 = somewhat agree, 4 = neutral, 5 = somewhat disagree, 6 = disagree, and 7 = strongly disagree

The items in this study pertain to the design of a learning activity. The pre-test items are identical for both groups, while the post-test questions differ between the experimental and control groups. The distinction lies in the inclusion of 'by using FoLA²' in the post-test questions for the experimental group, whereas the control group does not have this addition.

	ELS ITEMS FOR PE TEACHERS
	I like the idea of designing a learning activity [pre-test] I liked the idea of designing a learning activity by using FoLA^2 [post-test]
	Designing a learning activity is a good idea [pre-test] Designing a learning activity by using FoLA^2 was a good idea [post-test]
	Designing a learning activity is a positive experience [pre-test] Designing a learning activity by using FoLA^2 was a positive experience [post-test]
	Overall, designing a learning activity is satisfying [pre-test] Overall, I am satisfied with designing a learning activity by using FoLA^2 [post-test]
	Designing a learning activity is pleasing [pre-test] Designing a learning activity by using FoLA^2 was pleasant [post-test]
	Designing a learning activity is enjoyable [pre-test]

	Designing a learning activity by using FoLA² was enjoyable [post-test]
	As a whole, designing a learning activity is effective [pre-test] As a whole, designing a learning activity by using FoLA² was effective [post-test]

Antwoordcategorieën: 1 = sterk mee eens, 2 = eens, 3 = enigszins mee eens, 4 = neutraal, 5 = enigszins oneens, 6 = oneens en 7 = sterk oneens

	ELS ITEMS VOOR PRIMAIR ONDERWIJS (PO) LERAREN
	Ik vind het ontwerpen van een leeractiviteit een goed idee [pre-test] Ik vond het een goed idee om een leeractiviteit te ontwerpen met behulp van FoLA² [post-test]
	Het ontwerpen van een leeractiviteit is een goed idee [pre-test] Het ontwerpen van een leeractiviteit met behulp van FoLA² was een goed idee [post-test]
	Het ontwerpen van een leeractiviteit is een positieve ervaring [pre-test] Het ontwerpen van een leeractiviteit met behulp van FoLA² was een positieve ervaring [post-test]
	Over het algemeen is het ontwerpen van een leeractiviteit bevredigend [pre-test] Over het algemeen ben ik tevreden met het ontwerpen van een leeractiviteit met behulp van FoLA² [post-test]
	Het ontwerpen van een leeractiviteit is aangenaam [pre-test] Het ontwerpen van een leeractiviteit met behulp van FoLA² was aangenaam [post-test]

	Het ontwerpen van een leeractiviteit is leuk [pre-test] Het ontwerpen van een leeractiviteit met behulp van FoLA^2 was leuk [post-test]
	Als geheel is het ontwerpen van een leeractiviteit effectief [pre-test] Als geheel was het ontwerpen van een leeractiviteit met behulp van FoLA^2 effectief [post-test]

Appendix D

D. Demographic questionnaire

Background information:

- Please provide your email address. Your email address will only be used to link the data from the pre-test with the post-test. Once the data has been successfully linked, the email addresses will be promptly deleted: _____
- Age: _____ years old
- Gender: male – female – non
- Years of teaching experience:

0-5	
5-10	
> 10	

- Active in grade:

1, 2	
3 tot en met 8	
Non	

Learning Design:

- On a scale of 'no knowledge' [1] to 'extensive knowledge' [5], please indicate your level of knowledge with Learning Design

1	2	3	4	5

- Are you comfortable in the use of Learning Design: yes / no
- Do you have experience in Learning Design: yes / no

  If you have answered "yes," please provide an explanation.

Learning Analytics:

- On a scale of ‘no knowledge’ [1] to ‘extensive knowledge’ [5], please indicate your level of knowledge with Learning Analytics

1	2	3	4	5

- Are you comfortable in the use of Learning Analytics: yes / no
- Do you have experience in Learning Analytics: yes / no

  If you have answered "yes," please provide an explanation.

Background information:

- Geef uw e-mailadres op. Uw e-mailadres wordt alleen gebruikt om de gegevens van de pre-test te koppelen aan de post-test. Zodra de gegevens met succes zijn gekoppeld, worden de e-mailadressen onmiddellijk verwijderd:

  _____
- Leeftijd: _____ jaar oud
- Geslacht: man – vrouw – niet

- Aantal jaar onderwijservaring:

0-5	
5-10	
> 10	

- Actief in leerjaar:

1, 2	
3 tot en met 8	
Non	

Learning Design (leerontwerp):

- Geef op een schaal van 'geen kennis' [1] tot 'uitgebreide kennis' [5] uw kennisniveau aan met Learning Design:

1	2	3	4	5

- Bent u comfortabel in het gebruik van Learning Design: ja / nee
- Heeft u ervaring met Learning Design: ja / nee

  Als u 'ja' hebt geantwoord, geef dan een toelichting.

_____

_____

_____

_____

Learning Analytics (leeranalyses):

- Geef op een schaal van 'geen kennis' [1] tot 'uitgebreide kennis' [5] uw kennisniveau aan met Learning Analytics

1	2	3	4	5

- Bent u comfortabel in het gebruik van Learning Analytics: ja / nee
- Heeft u ervaring in Learning Analytics: yes / no

  Als u ‘ja’ hebt geantwoord, geef dan een toelichting.

  _____

  _____

  _____

  _____

Appendix E

E. Current format control group

Current format of groups one and two (age four to five) for preparing a theme:

Thema:

Thema en inhouden:

Betekenissen van de kinderen:

Bedoelingen - gebruik hiervoor de cirkel van Basisontwikkeling:

Basiskenmerken binnenste cirkel; voorwaarden om te komen tot ontwikkeling:

Startactiviteiten

- Activiteit met voorwerpen:
- Activiteit met illustraties en boeken:
- Activiteit met een video of tv-fragment:
- Activiteit over een eigen ervaring:
- Activiteit de wereld in:
- Activiteit onderzoeken met je zintuigen:
- Activiteit probleemstelling oproepen:

Spelactiviteiten:

- Gymlessen/buitenspel met materiaal
- Manipulerend spel en rollenspel:

Hoeken – themahoek, huishoek, bouwhoek, rekenhoek, taalhoek:

Doelen voor alle leerlingen - specificeer de bedoelingen van de cirkel:

Zorgleerlingen:

Onderzoeksactiviteiten/ uitstapjes/gast in de klas:

Constructie en beeldende activiteiten:

Gesprek- en kringactiviteiten – liedjes, versjes, kring:

Lees en schrijfactiviteiten - denk aan de verschillende tekstvormen: functionele teksten, ervaringsteksten, expressieve teksten en teksten om te leren – lettermuur en schrijven:

Reken en wiskunde activiteiten:

De speel-leeromgeving:

Current format of groups five to eight (age eight to eleven) for preparing a theme:

Thema:

Algemeen:

- Weekopening:
- Tussenactiviteiten:
- Weeksluiting:
- Creatief:
- Werkstuk:

Specifiek voor week 1, 2, 3, 4 en 5:

- Lezen met begrip:
- Woordenschat:
- Leesplezier:

.