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Research paper

Understanding the role of fun in learning to code

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ABSTRACT

There are growing efforts amongst educators and especially researchers in gamification and maker spaces to ensure that learning environments are fun and enjoyable. Accordingly, efforts to evaluate whether students enjoyed a certain learning activity are often an important aspect of innovations. However, the role of fun in learning in the aforementioned fields is not well understood not least due to a lack of a common theoretical framework for defining the concept of fun and for supporting its measurement. This study set out to investigate the role that fun plays in students' learning to code and its impact on their attitude towards the topic. We designed a two-hour-long playful coding workshop and measured the experienced fun using FunQ, a theoretically motivated and empirically grounded inventory for measuring fun in learning activities. Eighty-six children (N = 86) with ages between 9 and 12 participated in the study. For the analysis, we used structural equation modeling and mediation analysis. Our results support efforts of educational researchers and practitioners who try to make learning activities more fun for students. While fun was not shown to have a direct effect on learning assessed through a self-report measure, it had a significant and positive indirect effect on perceived learning through student's attitude towards coding. Future research should examine whether this empirical finding extends to learning activities beyond coding and different age groups.

1. Introduction

One of the primary aims of educators is to get and keep learners motivated, which can improve learning effectiveness (Long, 2007). Accordingly, substantial research effort has been invested in making learning enjoyable. Gamification of learning is a popular approach (Long, 2007) which is founded upon a commonly accepted belief that games can make learning fun. However, as Iten and Petko note, "*it is less clear what fun in serious games actually means and how is it related to cognitive, emotional and behavioral engagement*" (p. 154). Additionally, they argued that despite that this belief is widely held, there is a lack of empirical evidence regarding the relationship between the experienced fun while learning and learning with serious games. Nevertheless, it is quite common for creators of such games to evaluate them based on whether learners experience fun (e.g. Read, 2008; Sim, MacFarlane, & Read, 2006) or they even consider fun as a direct user benefit (Schepers, Dreessen, & Zaman, 2018).

Another approach to making learning enjoyable is to develop learning environments that foster intrinsic motivation and engagement by triggering the learners' curiosity. Such learning environments can be found in informal and non-formal learning spaces such as science museums, maker spaces or coding clubs. Accordingly, non-formal learning can be described by the following properties: it takes place outside of the formal learning environment, it is structured and guided or teacher-led, it might follow a syllabus and participation in the learning activity is usually voluntary (Tisza, Papavlasopoulou, Christidou, Voulgari, Iivari, Giannakos, Kinnula, & Markopoulos, 2019). On the other hand, informal learning can be defined by taking place anywhere, being unstructured and spontaneous, not following a syllabus and participation in the learning activity is always voluntary (Tisza et al., 2019). A recent Europe-wide study on STEM-related (Science Technology Engineering and Mathematics) informal and non-formal learning activities reported that approximately two-thirds of the investigated activities intended to be playful, and more than one-third of the investigated activities aimed to engage their participants with scientific topics (Tisza et al., 2019). These findings reflect a worldwide pursuit of increasing children's interest in STEM fields by making learning fun (Girls Who Code, 2019) and particularly in computer science given that programming is frequently seen as the literacy skill of the 21st century (Papavlasopoulou, Sharma, & Giannakos, 2018).

From previous research we know that students' success in computer science courses and their career choices can be affected by their attitudes towards programming (Cetin & Ozden, 2015). Earlier studies also indicated that children's attitude towards programming is positively affected by interacting with

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visual programming environments (such as Scratch) (Gunbatar & Karalar, 2018; Sáez-López, Román-González, & Vázquez-Cano, 2016). In a field study, Long (Long, 2007) found that the most common motivation (87.5% of their participants) for participating in a game-based coding experience was to have fun, and her study results suggested that having fun while learning results in a higher learning effort to be committed. Other studies described – either based on observations, or data collected with a 6-item unidimensional enjoyment scale – the coding activity in terms of students having fun, and reported an improvement in their attitudes towards programming and positive change in learning outcomes (Papavlasopoulou et al., 2018; Sáez-López et al., 2016), without however investigating the link between those. An important reason for this limitation in this body of research is that despite the apparent importance of fun during learning, there is a lack of measurement instruments to assess fun, and especially so in adolescents.

A recently developed measurement tool for the assessment of the experienced fun is FunQ (Tisza & Markopoulos, 2021). FunQ is based on the theoretically motivated conception of fun, and as just mentioned, the instrument is specifically developed for adolescents (age 11–18) both in design and methodology. FunQ defines the following dimensions for measuring fun: *Autonomy* measures the experienced control over the activity and one's participation in the activity; *Challenge* assesses the experienced challenge; *Delight* measures the positive emotions during the activity and the related desires; *Immersion* monitors the loss of time and space; *Loss of Social Barriers* measures social connectivity; *Stress* (a contradictive factor) assesses the negative emotions experienced during the activity.

In order to investigate how fun affects learning to program, we report on a study where a playful learning to code activity is evaluated in three primary school classes. In this context we investigated how the experienced fun, measured by the FunQ, influences students' learning to code, taking into account students' attitude about the subject. The activity was presented in the form of a 2 hours-long workshop and aimed to introduce programming for primary school children with the use of micro:bits (pocket-sized programmable microcomputers). Before and after the session students filled in a questionnaire on their attitude towards coding. Additionally, after the workshop students were asked to evaluate the activity with the use of the FunQ and report on their perceived learning.

The current study is the first to assess the direct and indirect effects of fun on learning to code while taking into account students' attitude about the topic. In the following sections, we introduce earlier research and related theories and provide our theoretical framework. Then, we present our method, the data collected and the data analysis and results, followed by the discussion of research findings, limitations, future research and conclusion.

2. Related work and background theory

2.1. Learning, attitudes and emotions

Traditionally, the aim of learning has been knowledge acquisition. Based on the work of Schunk (2012), learning assessment can be supported by (a) direct observations, (b) written responses, (c) oral responses, (d) rating by others and (e) self-reports. Under self-reports, Schunk includes questionnaires, interviews, stimulated recall, think-aloud and dialog. We adopt the definition of Schunk and understand the self-report measure as "people assessments of and statements about themselves" (Schunk, 2012, p. 16). Several design research studies in education include informal assessments of fun and learning, which, however, do not allow quantifying the relationship between them (e.g. Grosshandler & Niswander Grosshandler, 2000). Therefore, in the herein introduced study we assessed students' knowledge by a self-report measure, which we adopted from previous research (Papavlasopoulou et al., 2018; Tisza, Markopoulos, & Bekker, 2020).

Studies on the influence of attitudes on learning carried out as early as the 1950s (e.g. Fedon, 1958), suggested an association between attitudes and academic achievement. Recent studies on the association between attitudes towards learning different subjects and the learning outcomes (a.k.a. academic achievement) (Bakar, Tarmizi, Mahyuddin, Elias, Luan, & Ayub, 2010; Bidin, Jusoff, Aziz, Salleh, & Tajudin, 2009; Narmadha & Chamundeswari, 2013) suggested that a positive attitude towards learning or an academic subject is associated with an inclination to learn. However, others found no direct relationship between the attitude about school and academic achievement (Erkman, Caner, Hande Sart, Börkan, & Şahan, 2010; Jackson & Getzels, 1959; Jackson & Lahaderne, 1967; Lee, 2016; Yilmaz, 2014). Lee (2016) investigating the PISA (Programme for International Student Assessment) 2003, 2009 and 2012 data sets – involving nearly a half a million students from 65 countries – found no significant correlation between mathematics and reading achievement and students' general attitude towards school. Thus, the question of the role of attitude on learning appears to be controversial.

Hascher (2010) stated that "there is rarely any learning process without emotions. (…) Despite the obvious connection between learning and emotion, still very little is known about it." (Hascher, 2010, p. 13). Although enjoyment has traditionally been more extensively investigated than fun, we need to note that the notion of fun and the importance of the fun experience is getting widely acknowledged (McManus & Furnham, 2010). Accordingly, fun is often an evaluation criteria for example for learning games (e.g. Read, 2008; Sim et al., 2006) or even considered as a direct user benefit (Schepers et al., 2018). Nevertheless, the concept of fun has been hugely neglected in the field of psychology which is reflected in the fact that "no psychology textbook has fun in its index" (McManus & Furnham, 2010, p. 160). Accordingly, fun is often used interchangeably with other positive emotions such as enjoyment. In a recent literature review, investigating emotions and learning in the technology-based learning environment in the past 50 years, Loderer, Pekrun and Lester (Loderer, Pekrun, & Lester, 2018) found that enjoyment was the second most frequently investigated academic emotion, accounting for approximately a quarter (24.1%) of all reviewed papers. They found a positive association between enjoyment and control and positive valuation (i.e. attitude) of learning/technology, engagement, strategy use, curiosity/interest and the learning outcomes.

Addressing the relationship between emotions and learning from the perspective of cognitive psychology and neuroscience, Willis claimed that "when classroom activities are pleasurable, the brain releases dopamine, a neurotransmitter that stimulates the memory centers and promotes the release of acetylcholine, which increases focused attention." (Willis, 2007, p. 3). Hence, "superior learning takes place when classroom experiences are enjoyable and relevant to students lives, interests, and experiences." (p. 1).

2.2. Conceptualizing fun and its assessment

Whatever we do, we have to make it fun has become a modern cliché, especially in the United States, applied to several fields of life starting from playing sports, throughout teaching children modern languages or encouraging people to eat more fruit and vegetables (McManus & Furnham, 2010). Yet, as stated by various authors (Bisson & Luckner, 1996; Chu, Angello, Saenz, & Quek, 2017; Dismore & Bailey, 2011; Iten & Petko, 2016; Mellecker, Lyons, & Baranowski, 2013), defining fun is neither easy nor straightforward and accordingly, its measurement is complicated (Sim et al., 2006). As a result, it is only occasionally defined in the academic literature, pinpointing the lack of underlying conceptual framework — and raising concerns about the clarity of measurements and unity of previous research (Garn & Cothran, 2006; McManus & Furnham, 2010; Tisza & Markopoulos, 2021). This problem is well introduced in the work of McManus and Furnham (2010) who present a huge variety of related concepts that are frequently used interchangeably with fun in academic literature, while they also note that "only in a very occasional set of studies is there a direct confrontation with the nature of fun and its definition" (p. 160) and accordingly, there is a "lack of conceptual clarity in the literature concerning the nature of fun" (p. 160). As already noted above, in academic literature, enjoyment is frequently used interchangeably with and as a synonym to fun (Elton-Chalcraft & Mills, 2015; Fowler; Iten & Petko, 2016; Long, 2007; McManus & Furnham, 2010; Mellecker et al., 2013; Romero, 2014). However, other researchers (Dismore & Bailey, 2011; Tisza & Markopoulos, 2021) argue that meanwhile the two concepts are related, they are not the same as fun has a more nuanced interpretation.

For the conceptualization of fun we adopt the work of Tisza and Markopoulos (2021), who after investigating the meaning of fun for adolescents conclude that fun is a positive emotional experience during which the level of challenge meets the level of skills, one feels in control, loses the perception of time and space, lets go of social inhibitions, and is intrinsically motivated for the participation in the experience. Based on this definition an instrument called FunQ is designed, with five contributing dimensions that are necessary for the fun experience: Autonomy, Challenge, Delight, Immersion, Loss of Social Barriers and Stress as a contraindicative factor. While there are clear links between the FunQ and Self-Determination Theory (SDT) and the Intrinsic Motivation Inventory (IMI) as noted by Grosshandler and Grosshandler (Grosshandler & Niswander Grosshandler, 2000, p. 228) "self-determination is a crucial factor in the construction of fun and learning", however, we argue that they are not the same. The two questionnaires measure along different dimensions according to their underlying theories, and FunQ targets adolescents while IMI is designed for adults. The comparison of the dimensions of the FunQ and some frequently used measurement tools for closely related concepts are displayed in Table 1. In the herein introduced study for the assessment of fun we used the FunQ (the questionnaire is described in detail in Section 3.4 below and the descriptive statistics of the items are presented in Appendix).

2.3. Fun in relation to attitudes and learning

Most research on the relation between fun, attitudes and learning is found in the field of digital game-based learning, however, earlier research appears to be controversial.

Chan, Wan, and Ko (2019) investigated whether fun has a moderating role in the relationship between interactivity, active collaborative learning and university students' learning performance while using personal response systems. Their findings indicated that fun students experience while using personal response systems could promote collaborative learning and learning performance. However, they did not measure learning as such but rather students' self-efficacy in using personal response systems, which included items such as *I have mastered the use of PRSs*.

Iten and Petko (2016) investigated empirically the relationship between enjoyment and willingness to play, as well as between the learning gains and knowledge assessment test results in children 10–13 playing serious games. Their results indicated that the experienced fun had a significant effect on the motivation to learn and to engage again with the learning game. However, they did not find a significant association between neither the self-reported nor the measured learning and the experienced fun.

In accordance with these results, Sim et al. (2006) found no significant correlation between the observed- or the reported fun and the learning in 7 and 8 years-old-children using educational software. However, they find that the software children selected as the most fun was the one they would like to use again.

In contrast with the aforementioned findings, several previous studies (Chan et al., 2019; Lucardie, 2014; Rambli, Matcha, & Sulaiman, 2013; Tews, Michel, & Noe, 2017; Vieira & da Silva, 2017; Willis, 2007) suggested that fun somehow has a positive effect on learning, but this effect is rarely quantified or measured directly, which is very likely to be due to the lack of reliable measurement tools and the lack of a common theoretical framework for fun.

2.4. Fun in coding activities

Coding is frequently seen as the literacy of the 21st century (Papavlasopoulou et al., 2018), and accordingly, there is a worldwide pursuit to increasing children's interest by making learning fun (Girls Who Code, 2019).

Long in her field study with adults on programming games for educational purposes found that having fun while learning was a significant contributor to the learning effort (Long, 2007). She examined across a survey whether the game promoted self-motivated learning and self-reported learning effectiveness. (Cetin & Ozden, 2015) found in their large-scale study with university students that students' success in computer science courses – and their career choices – could be affected by their attitudes towards programming. Other studies focusing on younger students indicated that children's attitude towards programming is positively affected by interacting with visual programming environments (such as Scratch) (Gunbatar & Karalar, 2018; Sáez-López et al., 2016). Additionally, further studies described the coding activity in terms of students having fun, and reported an improvement in their attitudes towards programming and positive change in learning outcomes (Papavlasopoulou et al., 2018; Sáez-López et al., 2016), without however investigating the link between those. Despite the aforementioned studies suggest that fun has some kind of influence on learning to code, based on our best knowledge no systematic examination exists on the relationship of those, nor a theoretical framework exists yet that would focus especially on the role fun plays on learning to program.

2.5. Hypotheses

Accordingly, based on the aforementioned studies, with special regards to previous research done in the field of learning to program, we set up the following hypotheses:

H1: The experienced fun has a direct and positive effect on students' learning to code.

H2: The experienced fun has a direct and positive effect on students' attitude about coding.

H3: Students' attitude about coding has a direct and positive effect on their learning to code.

H4: The experienced fun has an indirect and positive effect on students' learning to code.

The hypothesized relationships between fun, attitude and learning to code are depicted in Fig. 1.

Table 1
Related measurement tools and the dimensions they investigate compared with the FunQ dimensions.

Instrument	Dimensions						Target age
FunQ (Tisza & Markopoulos, 2021)	*Autonomy*	*Challenge*	*Delight*	*Immersion*	*Loss of Social Barriers*	*Stress*	Adolescents
IMI (Ryan & Deci, 2000)	Perceived choice	–	Interest / Enjoyment	–	Relatedness	Pressure/Tension	Adults
PENS (Johnson, Gardner, & Perry, 2018; Ryan, Rigby, & Przybylski, 2006)	Autonomy	–	–	Presence/Immersion	Relatedness	–	Adults
Flow state scale (Jackson & Marsh, 1996)	Sense of control	Challenge-skill	Autotelic experience	Loss of self-consciousness & Transformation of time	–	–	Adults
EGame Flow (Fu, Su, & Yu, 2009)	Autonomy	Challenge	–	Immersion	Social interaction	–	Adults
GEQ (Johnson et al., 2018; Poels, de Kort, & IJsselsteijn, 2007)	–	Challenge	Positive affect	Flow	–	Negative affect & Tension	Adults

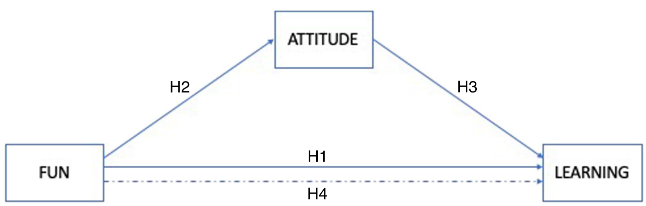

Fig. 1. The role of fun on learning: hypothesized model. Dashed line indicates indirect effect.

3. Methods

3.1. The activity

To test our hypotheses, we collected data from children before and after three creative coding workshops. The main aim of the workshop was to introduce programming to children in a playful way. The workshop was designed as a non-formal learning activity, during which no specific learning goals were declared. Nevertheless, as it is frequent during such activities, it followed a learning-by-doing approach. The workshop lasted two-hours and was given to 9 to 12 years old primary school students during school hours, however, as an extracurricular activity. It was based on interactive instructional videos that introduce the basics of programming, defining and explaining terms, giving tasks to children, and providing instructions on the steps to take. We used the *Inventing with Microbit* video series of SkillsDojo,[1] from which we selected three specific videos to play during each workshop. Accordingly, during the workshop children learned about basic programming terms (e.g. microcomputer, editor) and wrote code to display their names (first video), made a stone-paper-scissors game (second video; see Fig. 2) or created microPets that react to kinetic stimuli (third video).

Playfulness was by nature inherent to the workshop as it was a non-formal activity, which built on children's voluntary participation, used digital technology and followed a learning-by-doing approach (Kangas, Siklander, Randolph, & Ruokamo, 2017). Children were invited to follow the video guide, in which the playfulness was reflected in the design, the tone and the introduction of the tasks. Additionally, children were encouraged to use their creativity to solve the programming tasks and to make the created artifacts unique to their liking. Once the artifacts were created, children could play with those alone or together with others. According to (Huizinga, 1949), the basic motivation to play is to experience the pleasure it grants. Hence, we assumed that a playful activity is a fun experience for children.

[1] www.skillsdojo.nl

3.2. Procedures

Each child was provided with a laptop or Chromebook, on which they could follow the video guide in their own pace. Additionally, each child was provided with a BBC micro:bit. Micro:bits are pocket-sized, powerful computers, with which one can easily learn to program and create electronics projects. It has a programmable LED display, buttons, sensors, and several input and output features allowing various ways for user interaction. Furthermore, children were also allowed to use paper, pencils, scissors etc. to dress up their microPets.

The workshop had the following structure:
(1) Introduction of the topic and the structure of the workshop (∼5 min)
(2) Pre-activity data collection (∼10 min)
(3) Creative coding (∼90 min)
(4) Post-activity data collection (∼10 min).
During the workshop, children were allowed to move around freely, to work alone or to interact with each other, which for no specific instructions or rules were given. When it was needed, the researcher provided children with further cues and helped when they asked for it. Thus, the role of the researcher was to help children troubleshoot eventual problems and was responsible for keeping the structure of the workshop, while the class teacher was present as an observer. During the workshop children used their creativity to solve the problems and the overall approach was playful throughout the introduction, exploration and outcome phases.

Although the data were collected from three workshops, the structure of the workshop and the collected data were similar (see the comparison in Section 4.1).

3.3. Participants

Primary school teachers could voluntarily sign up their classes for the workshops, which were held in June 2019 in The Netherlands. The specific activity was not part of the curriculum, though the workshops were held in a classroom during school hours. Accordingly, students' participation in the workshop was compulsory as it took place during school hours, but their participation in the study (i.e. responding the questionnaires) was voluntary. Nevertheless, all children filled in the questionnaires. Given the students' age, informed consent was obtained from their parents across the schools, and the data was collected accordingly. The herein introduced results are based on the collected data from three creative coding workshop which were given in three Dutch primary schools. We collected data in total from 86 children (45 boys, 37 girls, 4 missing) between age 9 and 12 (mean = 10.35,

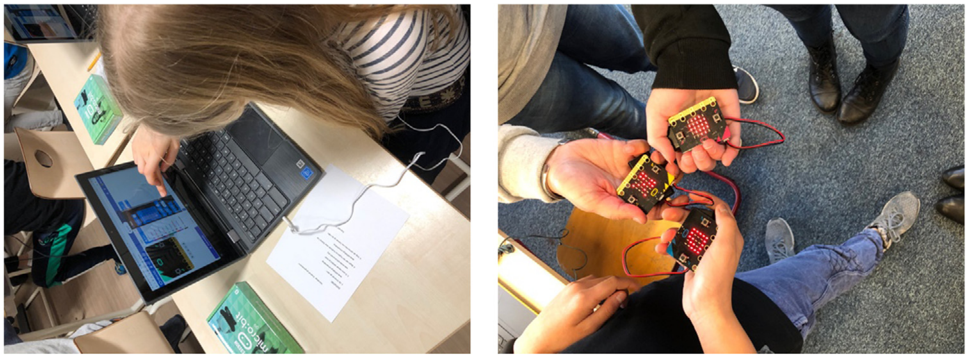

Fig. 2. Children during the workshop. *Left*: interaction with the programming interface. *Right*: group play with the created stone-paper-scissors game.

SD = 0.743). Before the workshop students reported on their previous experience with programming across a 5-step Likert-type question: 'Do you have any idea about programming?'. The frequency of the responses given to the question is displayed in Table 2. The mean of the responses is 2.48, which translates to knowing a bit. In other words, children were mainly novices in the field of programming.

3.4. Measures

For the measurement of the elements in the model, we used a variety of tools (see summary in Table 3). When selecting the tools, we carefully considered a number of aspects, keeping in mind the level of cognitive development of the responding children. According to both Piaget (1964) and Erikson (1950), there is a cognitive and psychological developmental shift at the edge of adolescence, approximately at the age of 11–12. Children develop during this stage the ability of thinking about abstract objects. Before this age, their thinking processes are based on mental representations that relate to concrete events, objects, or experiences. Nevertheless, we know that children are able to share detailed knowledge about their experiences from an early age on (Romero, 2014). Accordingly, we found it important to relate the measurement as much as possible to the activity by collecting their responses in the same environment where the activity took place, with the equipment still in front of them. This way making it easy for them to think back on the concrete event and to report on their related experiences. Additionally, the selected questionnaire for the assessment of fun was specifically developed for adolescents, taking into account children's attention span (length of the survey, Davis, 2009; Goss Lucas & Bernstein, 2005; McKeachie & Svinicki, 2006; Wolvin, 1983), age-dependent reading comprehension (short items, simple wording, Flesch, 1948; Kincaid, Fishburne, Rogers, & Chissom, 1975), questionnaire design preferences (font type and size; items with alternating highlight, Bernard, Mills, Talissa, & McKown, 2001) and response format (referring to frequency of behavior/thoughts and not agreement, de Leeuw, 2011; Mellor & Moore, 2014). While visual scales exists for the measurement of the preference of a product, they are either targeting young children (aged 2–7; Yusoff, Ruthven, & Landoni, 2011; Zaman, Abeele, & De Grooff, 2013) or measuring enjoyment with a single item (Hall, Hume, & Tazzyman, 2016; Read, 2008). Scales that are designed for adults not necessarily suitable for young adolescents (Fu et al., 2009; O'Brien, Cairns, & Hall, 2018; Poels et al., 2007; Ryan et al., 2006). Regarding the measures used for the assessment of children's attitude about coding, we used a Smiley-face scale, and for the assessment of learning we labeled the scale steps in an age-appropriate way (de Leeuw, 2011; Mellor & Moore, 2014). Additionally, we took into account the country of data collection, as Dutch children are in general encouraged from an early age on to express their opinion and are familiar with self-reported measures.

For assessing the experienced fun, we recorded the FunQ (Tisza & Markopoulos, 2021) with the students at the end of the activity. FunQ is a recently developed and validated scale, and as just mentioned, specifically designed for adolescents for the assessment of the experienced fun. The authors report on good psychometric properties (Tisza & Markopoulos, 2021), including internal consistency ($\omega_{\text{overall}} = 0.875$; $\omega > 0.6$ is regarded as acceptable Hair, Black, Babin, & Anderson, 2014; Tasci & Ko, 2016) and reliability measures (RMSEA = 0.052; SRMR = 0.072; RMSEA < 0.06 or lower indicate good model fit, Hu & Bentler, 1999; SRMR < 0.08 or lower indicate good model fit, Hu & Bentler, 1999). The questionnaire consists of eighteen 5-step Likert-type items along six dimensions as follows. *Autonomy* measures whether one feels control over his/her participation and the activity itself. *Challenge* monitors the experienced challenge. *Delight* measures the positive emotions and related desires. *Immersion* assesses the loss of time and space. *Loss of Social Barriers* measures social connectivity. Finally, *Stress* monitors negative emotions and is a contra-indicative factor. We present the items in Appendix along with the related factors and descriptive statistics. We also used a single-item measure to cross-check the validity of the FunQ questionnaire "During the activity I had fun".

For addressing students' attitude towards the topic, students were asked to rate their agreement with the statement: "I think that programming is my thing" (Bakar et al., 2010 not at all – (Bisson & Luckner, 1996) absolutely). This single-item measure was adopted from earlier research (Tisza et al., 2020) (see Fig. 3). While some multi-dimensional scales exist for the measurement of primary school students' interest in programming (e.g. Kong, Chiu, & Lai, 2018; Mason & Rich, 2020), they focus on various aspects (e.g. self-efficacy, utility, interest in programming). However, in this study, we aimed to measure attitude about programming as a global construct while keeping the length of the survey at a minimum for the sake of data quality taking into account children's attention span. Given that previous research (Bergkvist & Rossiter, 2007) found that single-item measures are equally suitable for the measurement of concrete attributes as multiple-item measures, and using single-item measures for investigating attitudes about learning to program are not unusual (Papavlasopoulou et al., 2018), we favored the single-item measure. The same argument applies to the measurement of learning.

To measure learning we adopted the self-report measure from previous research (Papavlasopoulou et al., 2018), and asked students to answer on a 5-point Likert-type scale for the question 'Have you learned something new today about programming?'.

3.5. Data analysis

For the development of our model on the role of fun on learning, we used structural equation modeling (SEM) and mediation analysis (Kline, 2015). Mediation analysis was performed to

Table 2
The frequency of the responses for 'Do you have any idea about programming?'.

Missing	(1) Not at all	(2) I know a bit	(3) I know something	(4) I know much	(5) I am a pro
3 (3.5%)	15 (17.4%)	27 (31.4%)	24 (27.9%)	13 (15.1%)	4 (4.7%)

Table 3
The model components, their operational definition and their respective measures.

Component	Operational definition	Measure
Fun	The degree to which students experienced fun during the activity.	FunQ and 'During the activity I had fun' ((1) Never – (5) All the time)
Attitude	The degree to which students indicate their attitude towards the subject.	'I think programming is my thing' ((1) Not at all – (5) Absolutely)
Learning	The degree to which students indicate their learning during the activity.	'Have you learned something new today about programming?' ((1) Not at all – (5) A whole lot)

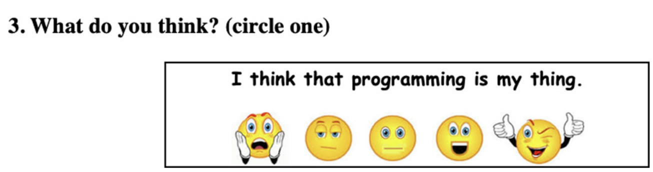

Fig. 3. Questionnaire item assessing children attitude about programming.

assess whether fun indirectly influences learning across its effect on students' attitude on the subject. For the data analysis the RStudio 1.1.453 (RStudio Team, 2016) software, for modeling the lavaan (Rosseel, 2012) and psych (Revelle, 2018) packages were used.

4. Research findings

4.1. Descriptive results

To start with, we compared the data of the three workshops along the main elements of the hypothesized model: the experienced fun, the attitude and the reported learning. The descriptives are displayed in Table 4. One-way ANOVA analysis indicates no statistical difference in the data coming from the three workshops ($p_{fun} = 0.985$; $p_{attitude} = 0.737$; $p_{learning} = 0.285$) hence, analyzing them all together is justified.

For calculating the FunQ scores, after reversing the scores of the *Stress* factor, we summed the values, resulting in an average score of 69.75 (SD = 8.283) from the possible range of 18–90. The internal consistency of the FunQ questionnaire appeared to be sufficient at both the first- and the second-order level ($\omega_{first\text{-}order} = 0.721$; $\omega_{second\text{-}order} = 0.778$; $\omega > 0.6$ is regarded as acceptable (Hair et al., 2014; Tasci & Ko, 2016); for further statistics on the FunQ items, see Appendix). Further, to safeguard the validity of the FunQ scores we calculated the correlation between those and the single-item measure 'During the activity I had fun.' (mean = 4.56, SD = 0.859). The correlation coefficient indicates a positive and significant relationship ($r = 0.422$, $p < 0.01$), strengthening further our assumption about the reliability of the FunQ questionnaire and the measured values. Based on the aforementioned, we assume that students had fun during the workshops.

The reported average score for students' attitude towards programming measured after the activity is 3.96 (SD = 0.974) on a 5-point scale. The frequency of the responses is shown in Table 5.

Students self-rated their learning on average 4.02 (SD = 0.908) on a 5-point scale, which translates to having learned 'much'. The frequency of the responses is shown in Table 6.

The descriptive statistics and the test of normality values for the model elements – fun, attitude, and learning – are displayed in Table 7.

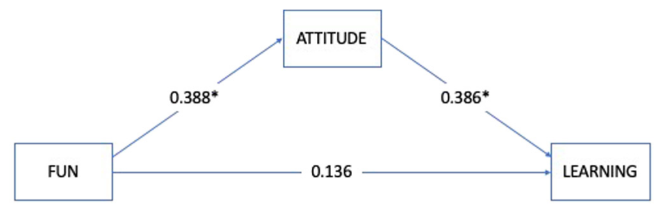

Fig. 4. Path analysis: direct relationship between the components of the model (*p < 0.05).

Table 8
Correlation matrix of the model components.

	Fun	Attitude	Learning
Fun	–	0.388**	0.286*
Attitude	–	–	0.439**
Learning	–	–	–

*p-value = 0.022.
**p-value < 0.01.

For assessing the strength of the relationship between the main elements of the model, we calculated the correlation coefficients. Table 8 displays the pairwise correlations among the experienced fun (measured by FunQ), the attitude and the reported learning. We conclude that all pairwise correlations are positive and significant.

4.2. Path analysis

We applied path analysis to test the direct effects between the three main components of our model. The analysis revealed that the experienced fun, measured by FunQ, has no direct influence on the reported learning ($p = 0.203$, $\beta_{std} = 0.136$). Further, fun influences positively and significantly students' attitude about the subject ($p < 0.001$, $\beta_{std} = 0.388$). Regarding the effect of students' attitude about coding on the reported learning, our findings indicate a significant, positive relationship ($p < 0.001$, $\beta_{std} = 0.386$). The direct effects are displayed in Fig. 4.

4.3. Mediation analysis

To assess a possible indirect effect of fun on learning, we used mediation analysis. The analysis revealed that both the indirect effect of fun on learning across the attitude ($\beta_{std} = 0.150$, $p < 0.001$), and the total effect of fun on learning (i.e. indirect plus direct effect; $\beta_{std} = 0.286$, $p = 0.008$) are significant (see Fig. 5). The model explains the 20.8% of the variance ($R^2 = 0.208$; $p < 0.01$).

5. Discussion

The relationship between motivation and learning has been researched extensively since the 1980s, but the identification of

Table 4
Comparison of the three workshops along the model components. No statistical difference is found.

	Workshop1	Workshop2	Workshop3	Total sample
Fun	70.06 (SD = 10.18)	69.62 (SD = 6.587)	69.68 (SD = 9.280)	69.75 (SD = 8.283)
Attitude	3.96 (SD = 1.107)	3.87 (SD = 0.957)	4.07 (SD = 0.900)	3.96 (SD = 0.974)
Learning	4.05 (SD = 0.899)	3.84 (SD = 0.898)	4.21 (SD = 0.917)	4.02 (SD = 0.908)

Table 5
The frequency of the responses for 'Programming is my thing'.

Missing	(1) not at all	(2) a bit	(3) moderately	(4) much	(5) absolutely
4 (4.7%)	2 (2.3%)	3 (3.5%)	19 (22.1%)	30 (34.9%)	28 (32.6%)

Table 6
The frequency of the responses for 'Have you learned something new today about programming?'.

Missing	(1) nothing at all	(2) a bit	(3) something	(4) much	(5) a whole lot
5 (5.8%)	0 (0.0%)	6 (7.0%)	14 (16.3%)	33 (38.4%)	28 (32.6%)

Table 7
Descriptive statistics and test of normality of the elements of the model.

	Mean	Min.	Max.	Standard deviation	Skewness	Kurtosis	Shapiro–Wilk test of normality
Fun	69.75	44	84	8.283	−0.568	0.361	0.049
Attitude	3.96	1	5	0.974	−0.829	0.538	<0.001
Learning	4.02	2	5	0.908	−0.666	−0.309	<0.001

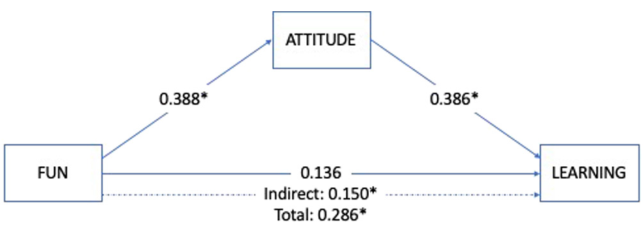

Fig. 5. Mediation analysis: indirect relationship between fun and learning across attitude (*p < 0.05).

key emotions on learning is still at an early stage (Hascher, 2010). Studies on the effect of attitudes on learning appear to be controversial (Lee, 2016), and the role of the concept of fun on learning is still premature (e.g. Iten & Petko, 2016; Papavlasopoulou et al., 2018; Sáez-López et al., 2016; Sim et al., 2006).

Adopting FunQ (Tisza & Markopoulos, 2021) as a theoretical and measurement framework for fun during learning, our study has examined if and how fun influences students' learning to code. Our results showed that fun has a clear, positive, but indirect effect on the reported learning.

The herein introduced activity was playful by its nature as it was a non-formal learning activity using digital technology, following a learning-by-doing approach and building on children's voluntary participation (Kangas et al., 2017). During the workshops, children were invited to follow the video guide, which included playful elements regarding the design, the tone and the introduction of the tasks. Additionally, children were encouraged to use their creativity to solve the programming tasks, make the created artifacts unique and to play with those alone or together.

Evaluating the activities in general, we conclude that students experienced fun during the playful coding workshops, while the activities were meaningful in terms of learning, as students report on having learned much. Additionally, at the end of the workshop students expressed a positive attitude about programming as well.

Our study contributes to understanding the relationship between fun and learning, for which earlier research studies diverge. Some authors have found no significant correlation between fun and learning (Iten & Petko, 2016; Sim et al., 2006), while others (Papavlasopoulou et al., 2018; Sáez-López et al., 2016) observe students having fun and learning without though directly investigating the relationship between the two.

In this study we hypothesized that (i) fun has a positive direct effect on learning to code, (ii) fun has a positive effect on students' attitude about coding, (iii) students' attitude about coding has a positive effect on their learning, and (iv) fun has a positive and indirect effect on learning to code as well.

Our hypotheses have been partially confirmed as we have not found a significant direct relationship between fun and learning to code. However, while previous work on the effect of attitude on learning is inconclusive (Lee, 2016), our results indicate a clear positive effect.

Regarding the final hypothesis, we found that fun has a significant and positive indirect effect on learning across attitude and that the total effect (indirect plus direct effect) of fun on learning to code is also significant. Our findings may explain why earlier studies (Iten & Petko, 2016; Sim et al., 2006) have found no significant relationship between fun and learning, while they still report increased learning when students were observed having fun (Papavlasopoulou et al., 2018; Sáez-López et al., 2016). The absence of a direct effect of fun on learning aligns with Sim et al. (2006) who did not find a significant correlation between neither the observed- nor the measured fun and learning, though they did find that children were more inclined to play again with educational software when they had more fun. We also concur with Iten and Petko (2016) who found that the experienced fun while learning has a significant effect on motivation to learn and engage again with the learning game, but not on the reported- nor the measured learning. Our results extend those of the previous studies which only examined the direct relationship between fun and learning, despite having indications of a key intermediate element, namely the attitude. Further, our finding that fun does have a positive and indirect effect on learning is supported by previous work (Papavlasopoulou et al., 2018; Sáez-López et al., 2016), which observe students having fun and an increased learning. In those previous studies, however, the relationship between fun and learning was not investigated in depth.

In the herein introduced study we used self-reported measures with children at the edge of the formal operational Piagetian stage (Piaget, 1964). In child–computer interaction research – according to the theory of Piaget – age 11–12 is often considered as a strong border for using verbal questionnaires with children due to their state of cognitive development. However, in clinical psychology, the use of questionnaires with younger children is often difficult to avoid as those are used for assessment (Mellor & Moore, 2014). The study of Mellor and More (Mellor & Moore, 2014) found that even young children are capable of giving reliable responses to Likert-type scales when certain criteria are met (e.g. scale labels reflect frequency of behavior/thoughts and not agreement; scale items refer to concrete situations/bodily feelings and not to abstract ones etc.). These findings are also supported by other studies on children as respondents in survey research (Borgers, 2003; Borgers, de Leeuw, & Hox, 2000; de Leeuw, 2011). While several design research studies in education include informal assessments of fun and learning, they do not allow quantifying the relationship between them (e.g. Grosshandler & Niswander Grosshandler, 2000). Therefore, in the herein introduced study we designed a survey with adhering to the above detailed criteria, and assessed students' attitude, knowledge and the fun they have experienced while learning by a self-report measure. We argue that the validity of the responses were not hindered by the format of the investigation (i.e. using self-reported measures), however, they allowed us to quantify the relationship between fun, attitude and learning, which would not have been possible with informal assessment methods (e.g. observation, qualitative measurements etc.).

Our results support efforts of educational researchers and practitioners who try to make learning activities more fun for students. On the other hand, endorse the efforts of informal and non-formal learning environments – such as science museums, maker spaces and coding clubs – for making learning fun in order to engage students more and facilitate their learning process, as we see that when children are having fun while learning to code, then it has a significant effect not only on their attitude about coding but their learning as well. As an explanation, we propose that while fun has a positive effect on attitude, it serves as an enhancer for the willingness for learning about programming as well. In Glasser's words, fun "is like a catalyst that makes anything we do better and worth doing again and again" (Glasser, 1986, p. 28). This, we find especially important as programming is considered as the literacy skill of the 21st century (Papavlasopoulou et al., 2018), hence it should be in the interest of both educationalists and educational researchers to support the learning process of coding. Moreover, given that from previous research we know that students' success in computer science courses and their career choices can be affected by their attitudes towards programming (Cetin & Ozden, 2015), we find applying fun elements during learning to code crucial. Therefore, we strongly encourage both researchers and practitioners to utilize this property of fun especially when teaching or introducing to children such an important subject as programming.

6. Limitations and future work

In the herein introduced study we tested the role of fun on the reported learning, however, this bears with some limitations. To start with, we need to recognize that the assessment of learning is complicated. Accordingly, we cannot be sure what type of learning students considered when responding to the question (e.g. knowledge acquisition, learning new skills etc.), and the time constraint of the workshop could have played a role in the depth and extent of learning. The use of single-item measures, we believe, did not hinder the predictive validity given that both items measured concrete and simple constructs, nevertheless, in a future study more aspects of programming-related attitudes could be investigated with multi-item and multidimensional tools. Furthermore, we propose future research focusing on the eventual differences between the reported and the measured learning and the test of the herein introduced model's validity for the measured learning (a.k.a. knowledge acquisition) and other goals of learning (e.g. learning new skills) as well, including the investigation of learning during longer activities.

Another limitation of our research is that we did not investigate the effect of collaboration, which in future research could be an interesting angle to study.

Given that most of the participants were novices in the field of programming, novelty effect might have played a role in the magnitude of investigated aspects, but we believe it did not affect the relationships between those. Nevertheless, future research could investigate the effect of fun on learning in other scenarios where novelty effect is not present.

At last, investigating non-linear relationships between the components, including bi-directional effects in the future would contribute to a better understanding of the role that fun plays on learning to program.

7. Conclusion

In this paper, we have examined the relationship between fun, attitude and learning to code. Our results extend and explain earlier research suggesting that there is no direct relationship between the experienced fun and learning, as we found a positive indirect effect on learning across the attitude about programming and that the total effect (indirect plus direct effect) of fun on learning to code is also significant. This finding explains apparent contradictions in earlier studies where students were observed having fun and were found to learn more, while no significant association could be between fun and learning. Our results support efforts of educational researchers and practitioners who try to make learning activities more fun for students in the belief that making education – and especially learning to code – fun enhances students' learning. Therefore, this encourages us to work further in this direction to deepen our understanding of how fun influences not only the self-reported but the actual (or measured) learning, to extend our research findings to different topics and age groups, with a special interest towards the different goals of learning and non-linear relationships.

8. Selection and participation

Primary school teachers could voluntarily sign up their classes for the workshops and the study. The specific activity was not part of the curriculum, though the workshops were held in a classroom during school hours. Accordingly, students' participation in the workshop was compulsory as it took place during school hours, but their participation in the study (i.e. responding the questionnaires) was voluntary. Given the students' age, informed consent was obtained from their parents across the schools, and the data was collected accordingly.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Descriptive statistics of FunQ items (N=86).

Item	Mean[a]	Standard deviation	Factor	Standardized loading
During the activity…				
I knew what to do	4.22	0.918	Autonomy	0.342
I felt I was good at this activity.	3.97	0.960	Challenge	0.393
I did something new	4.00	1.184	Challenge	0.277
I was curious.	3.48	1.447	Challenge	0.284
I had fun.	4.56	0.859	Delight	0.298
I was happy.	4.51	0.714	Delight	0.445
I felt that time flew.	4.32	1.141	Immersion	0.333
I forgot about school.	2.82	1.615	Immersion	0.271
I felt good	4.59	0.689	Immersion	0.704
I made new friends.	1.82	1.412	Loss of Social Barriers	0.597
I talked to others easier than usual.	3.19	1.406	Loss of Social Barriers	0.362
I felt closer to others more than usual.	2.33	1.408	Loss of Social Barriers	0.334
I felt bad. (R)	1.27	0.812	Stress	0.502
I felt angry. (R)	1.14	0.476	Stress	0.842
I felt sad. (R)	1.14	0.687	Stress	0.554
I did this activity because I had to. (R)	2.14	1.402	Autonomy	0.464
I did this activity because I wanted to.	4.04	1.178	Autonomy	0.885
I want to do something like this again.	4.25	0.808	Delight	0.673

[a] 1 = never, 5 = all the time.

References

Bakar, K. A., Tarmizi, R. A., Mahyuddin, R., Elias, H., Luan, W. S., & Ayub, A. F. M. (2010). Relationships between university students' achievement motivation, attitude and academic performance in Malaysia. *Procedia - Social and Behavioral Sciences*, *2*(2), 4906–4910. http://dx.doi.org/10.1016/j.sbspro.2010.03.793.

Bergkvist, L., & Rossiter, J. R. (2007). The predictive validity of multiple-item versus single-item measures of the same constructs. *Journal of Marketing Research*, *44*(2), 175–184. http://dx.doi.org/10.1509/jmkr.44.2.175.

Bernard, M., Mills, M., Talissa, F., & McKown, J. (2001). Which fonts do children prefer to read online? *Usability News*, *3*(1).

Bidin, S., Jusoff, K., Aziz, N. A., Salleh, M. M., & Tajudin, T. (2009). Motivation and attitude in learning english among UiTM students in the northern region of Malaysia. *English Language Teaching*, *2*(2), 16–20. http://dx.doi.org/10.5539/elt.v2n2p16.

Bisson, C., & Luckner, J. (1996). Fun in learning: The pedagogical role of fun in adventure education. *The Journal of Experiential Education*, *19*(2), 108–112. http://dx.doi.org/10.1177/105382599601900208.

Borgers, N. (2003). Response quality in survey research with children and adolescents: The effect of labeled response options and vague quantifiers. *International Journal of Public Opinion Research*, *15*(1), 83–94. http://dx.doi.org/10.1093/ijpor/15.1.83.

Borgers, N., de Leeuw, E., & Hox, J. (2000). Children as respondents in survey research: Cognitive development and response quality 1. *Bulletin of Sociological Methodology* (Bulletin de Méthodologie Sociologique) *66*(1), 60–75. http://dx.doi.org/10.1177/075910630006600106.

Cetin, I., & Ozden, M. Y. (2015). Development of computer programming attitude scale for university students. *Computer Applications in Engineering Education*, *23*(5), 667–672. http://dx.doi.org/10.1002/cae.21639.

Chan, S. C. H., Wan, J. C. L., & Ko, S. (2019). Interactivity, active collaborative learning, and learning performance: The moderating role of perceived fun by using personal response systems. *International Journal of Management Education*, *17*(1), 94–102. http://dx.doi.org/10.1016/j.ijme.2018.12.004.

Chu, S. L., Angello, G., Saenz, M., & Quek, F. (2017). Fun in making: Understanding the experience of fun and learning through curriculum-based making in the elementary school classroom. *Entertainment Computing*, *18*(2017), 31–40. http://dx.doi.org/10.1016/j.entcom.2016.08.007.

Davis, B. G. (2009). *Tools for teaching*. Jossey-Bass.

Dismore, H., & Bailey, R. (2011). Fun and enjoyment in physical education: Young people's attitudes. *Research Papers in Education*, *26*(4), 499–516. http://dx.doi.org/10.1080/02671522.2010.484866.

Elton-Chalcraft, S., & Mills, K. (2015). Measuring challenge, fun and sterility on a 'phunometre' scale: Evaluating creative teaching and learning with children and their student teachers in the primary school. *Education*, *43*(5), 482–497. http://dx.doi.org/10.1080/03004279.2013.822904.3-13.

Erikson, E. H. (1950). *Childhood and society*. Norton & Company.

Erkman, F., Caner, A., Hande Sart, Z., Börkan, B., & Şahan, K. (2010). Influence of perceived teacher acceptance, self-concept, and school attitude on the academic achievement of school-age children in Turkey. *Cross-Cultural Research*, *44*(3), 295–309. http://dx.doi.org/10.1177/1069397110366670.

Fedon, J. P. (1958). The role of attitude in learning arithmetic. *The Arithmetic Teacher*, *5*(6), 304–310.

Flesch, R. (1948). A new readability yardstick. *Journal of Applied Psychology*, *32*(3), 221–233.

Fowler, A. (2013). Measuring learning and fun in video games for young children: A proposed method. In *Proceedings of the 12th international conference on interaction design and children* (pp. 639). New York, New York, USA.

Fu, F. L., Su, R. C., & Yu, S. C. (2009). EGameFlow: A scale to measure learners' enjoyment of e-learning games. *Computers and Education*, *52*(1), 101–112. http://dx.doi.org/10.1016/j.compedu.2008.07.004.

Garn, A. C., & Cothran, D. J. (2006). The fun factor in physical education. *Journal of Teaching in Physical Education*, *25*(3), 281–297.

Girls Who Code (2019). *Advocacy report 2019 - The state of girls in K-12 computer science classrooms: Making the case for gender-specific education policies.*

Glasser, W. (1986). *Control theory in the classroom*. Perennial Library/Harper & Row Publishers.

Goss Lucas, S., & Bernstein, D. A. (2005). *Teaching psychology: A step by step guide*. Lawrence Erlbaum Associates.

Grosshandler, D. J., & Niswander Grosshandler, E. N. (2000). Constructing fun: Self-determination and learning at an afterschool design lab. *Computers in Human Behaviour*, *16*(3), 227–240. http://dx.doi.org/10.1016/S0747-5632(00)00003-0.

Gunbatar, M. S., & Karalar, H. (2018). Gender differences in middle school students' attitudes and self-efficacy perceptions towards MBlock programming. *European Journal of Educational Research*, *7*(4), 925–933. http://dx.doi.org/10.12973/eu-jer.7.4.923.

Hair, J. F., Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis*. Pearson Education Limited.

Hall, L., Hume, C., & Tazzyman, S. (2016). Five degrees of happiness: Effective smiley face likert scales for evaluating with children. In *Proceedings of the the 15th international conference on interaction design and children* (pp. 311–321). http://dx.doi.org/10.1145/2930674.2930719.

Hascher, T. (2010). Learning and emotion: Perspectives for theory and research. *European Educational Research Journal*, *9*(1), 13–28. http://dx.doi.org/10.2304/eerj.2010.9.1.13.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55. http://dx.doi.org/10.1080/10705519909540118.

Huizinga, J. (1949). *Homo ludens*. Routledge & Kegan Paul.

Iten, N., & Petko, D. (2016). Learning with serious games: Is fun playing the game a predictor of learning success? *British Journal of Educational Technology*, *47*(1), 151–163. http://dx.doi.org/10.1111/bjet.12226.

Jackson, P. W., & Getzels, J. W. (1959). Psychological health and classroom functioning: A study of dissatisfaction with school among adolescents. *Journal of Educational Psychology*, *50*(6), 295–300. http://dx.doi.org/10.1037/h0039656.

Jackson, P. W., & Lahaderne, H. M. (1967). Scholastic success and attitude toward school in a population of sixth graders. *Journal of Educational Psychology*, *58*(1), 15–18. http://dx.doi.org/10.1037/h0024233.

Jackson, S. A., & Marsh, H. W. (1996). Development and validation of a scale to measure optimal experience: The flow state scale. *Journal of Sport and Exercise Psychology*, *18*(1), 17–35. http://dx.doi.org/10.1123/jsep.18.1.17.

Johnson, D., Gardner, M. J., & Perry, R. (2018). Validation of two game experience scales: The player experience of need satisfaction (PENS) and game experience questionnaire (GEQ). *International Journal of Human Computer Studies*, *118*(2018), 38–46. http://dx.doi.org/10.1016/j.ijhcs.2018.05.003.

Kangas, M., Siklander, P., Randolph, J., & Ruokamo, H. (2017). Teachers' engagement and students' satisfaction with a playful learning environment. *Teaching and Teacher Education*, *63*(2017), 274–284. http://dx.doi.org/10.1016/j.tate.2016.12.018.

Kincaid, J. P., Fishburne, R. P., Jr., Rogers, R. L., & Chissom, B. S. (1975). *Derivation of new readability formulas (automated readability index, fog count and flesch reading ease formula) for navy enlisted personnel*. http://dx.doi.org/10.21236/ADA006655.

Kline, R. B. (2015). *Principles and practice of structural equation modeling*. The Guilford Press.

Kong, S. C., Chiu, M. M., & Lai, M. (2018). A study of primary school students' interest, collaboration attitude, and programming empowerment in computational thinking education. *Computers and Education*, *127*, 178–189. http://dx.doi.org/10.1016/j.compedu.2018.08.026.

Lee, J. (2016). Attitude toward school does not predict academic achievement. *Learning and Individual Differences*, *52*(2016), 1–9. http://dx.doi.org/10.1016/j.lindif.2016.09.009.

de Leeuw, E. D. (2011). *Improving data quality when surveying children and adolescents: Cognitive and social development and its role in questionnaire construction and pretesting*.

Loderer, K., Pekrun, R., & Lester, J. C. (2018). Beyond cold technology: A systematic review and meta-analysis on emotions in technology-based learning environments. *Learning and Instruction*, (2018), 1–15. http://dx.doi.org/10.1016/j.learninstruc.2018.08.002.

Long, J. (2007). Just for fun: Using programming games in software programming training and education - A field study of IBM robocode community. *Journal of Information Technology Education*, *6*(2007), 279–290. http://dx.doi.org/10.28945/216.

Lucardie, D. (2014). The impact of fun and enjoyment on adult's learning. *Procedia - Social and Behavioral Sciences*, *142*(2014), 439–446. http://dx.doi.org/10.1016/j.sbspro.2014.07.696.

Mason, S. L., & Rich, P. J. (2020). Development and analysis of the elementary student coding attitudes survey. *Computers and Education*, *153*(2019), Article 103898. http://dx.doi.org/10.1016/j.compedu.2020.103898.

McKeachie, W. J., & Svinicki, M. (2006). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers*. Houghton-Mifflin.

McManus, I. C., & Furnham, A. (2010). Fun, fun, fun: Types of fun, attitudes to fun, and their relation to personality and biographical factors. *Psychology*, *1*, 159–168. http://dx.doi.org/10.4236/psych.2010.13021.

Mellecker, R., Lyons, E. J., & Baranowski, T. (2013). Disentangling fun and enjoyment in exergames using an expanded design, play, experience framework: A narrative review. *Games for Health Journal*, *2*(3), 142–149. http://dx.doi.org/10.1089/g4h.2013.0022.

Mellor, D., & Moore, K. A. (2014). The use of likert scales with children. *Journal of Pediatric Psychology*, *39*(3), 369–379. http://dx.doi.org/10.1093/jpepsy/jst079.

Narmadha, U., & Chamundeswari, S. (2013). Attitude towards learning of science and academic achievement in science among students at the secondary level. *Journal of Sociological Research*, *4*(2), 114–124. http://dx.doi.org/10.5296/jsr.v4i2.3910.

O'Brien, H., Cairns, P., & Hall, M. (2018). A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human - Computer Studies*, *112*(2018), 28–39. http://dx.doi.org/10.1016/j.ijhcs.2018.01.004.

Papavlasopoulou, S., Sharma, K., & Giannakos, M. N. (2018). How do you feel about learning to code? Investigating the effect of children's attitudes towards coding using eye-tracking. *International Journal of Child-Computer Interaction*, *17*, 50–60. http://dx.doi.org/10.1016/j.ijcci.2018.01.004.

Piaget, J. (1964). Part I: Cognitive development in children: Development and learning. *Journal of Research in Science Teaching*, *2*(3), 176–186. http://dx.doi.org/10.1002/tea.3660020306.

Poels, K., de Kort, Y. A. W., & IJsselsteijn, W. A. (2007). *D3.3: Game experience questionnaire: Development of a self-report measure to assess the psychological impact of digital games*.

Rambli, D. R. A., Matcha, W., & Sulaiman, S. (2013). Fun learning with AR alphabet book for preschool children. *Procedia Computer Science*, *25*, 211–219. http://dx.doi.org/10.1016/j.procs.2013.11.026.

Read, J. C. (2008). Validating the fun toolkit: An instrument for measuring children's opinions of technology. *Cognition, Technology & Work*, *10*(2), 119–128. http://dx.doi.org/10.1007/s10111-007-0069-9.

Revelle, W. (2018). *Psych: Procedures for personality and psychological research*. Northwestern University.

Romero, V. (2014). Children's experiences: Enjoyment and fun as additional encouragement for walking to school. *Journal of Transport and Health*, *2*(2), 230–237. http://dx.doi.org/10.1016/j.jth.2015.01.002.

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36.

RStudio Team (2016). *RStudio: Integrated development environment for R*.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation. *American Psychologist*, *55*(1), 68–78. http://dx.doi.org/10.1037/0003-066X.55.1.68.

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion*, *30*(4), 347–363. http://dx.doi.org/10.1007/s11031-006-9051-8.

Sáez-López, J. M., Román-González, M., & Vázquez-Cano, E. (2016). Visual programming languages integrated across the curriculum in elementary school: A two year case study using scratch in five schools. *Computers and Education*, *97*(2016), 129–141. http://dx.doi.org/10.1016/j.compedu.2016.03.003.

Schepers, S., Dreessen, K., & Zaman, B. (2018). Fun as a user gain in participatory design processes involving children: A case study. In *IDC 2018 - Proceedings of the 2018 ACM conference on interaction design and children* (pp. 396–404). http://dx.doi.org/10.1145/3202185.3202763.

Schunk, D. H. (2012). *Learning theories - An educational perspective*. Pearson.

Sim, G., MacFarlane, S., & Read, J. C. (2006). All work and no play: Measuring fun, usability, and learning in software for children. *Computers & Education*, *46*(3), 235–248. http://dx.doi.org/10.1016/j.compedu.2005.11.021.

Tasci, A. D. A., & Ko, Y. J. (2016). A FUN-SCALE for understanding the hedonic value of a product: The destination context. *Journal of Travel and Tourism Marketing*, *33*(2), 162–183. http://dx.doi.org/10.1080/10548408.2015.1038421.

Tews, M. J., Michel, J. W., & Noe, R. A. (2017). Does fun promote learning? The relationship between fun in the workplace and informal learning. *Journal of Vocational Behavior*, *98*, 46–55. http://dx.doi.org/10.1016/j.jvb.2016.09.006.

Tisza, G., & Markopoulos, P. (2021). FunQ: Measuring the fun experience of a learning activity with adolescents. *Current Psychology*, http://dx.doi.org/10.1007/s12144-021-01484-2.

Tisza, G., Markopoulos, P., & Bekker, T. M. (2020). *Learning to code: Interplay of attitude, emotions and fun*. Manuscript submitted for publication.

Tisza, G., Papavlasopoulou, S., Christidou, D., Voulgari, I., Iivari, N., Giannakos, M. N., Kinnula, M., & Markopoulos (2019). The role of age and gender on implementing informal and non-formal science learning activities for children. In *ACM international conference proceeding series*, http://dx.doi.org/10.1145/3335055.3335065.

Vieira, L. C., & da Silva, F. S. C. (2017). Assessment of fun in interactive systems: A survey. *Cognitive Systems Research*, *41*(2017), 130–143. http://dx.doi.org/10.1016/j.cogsys.2016.09.007.

Willis, J. (2007). The neuroscience of joyful education. *Educational Leadership*, *64*(2007), 1–4.

Wolvin, A. D. (1983). Improving listening skills. In R. B. Rubin (Ed.), *New directions for college learning as- sistance, Improving speaking and listening skills*. Jossey-Bass.

Yilmaz, E. (2014). Analiys ıs of students' success in the exam for transition to futher education through some of the variables. *International Journal of Academic Research*, *6*(1), 57–63. http://dx.doi.org/10.7813/2075-4124.2014/6-1/B.8.

Yusoff, Y. M., Ruthven, I., & Landoni, M. (2011). The fun semantic differential scales. In *Proceedings of the 10th international conference on interaction design and children* (pp. 221–224).

Zaman, B., Abeele, V. Vanden, & De Grooff, D. (2013). Measuring product liking in preschool children: An evaluation of the smileyometer and this or that methods. *International Journal of Child-Computer Interaction*, *1*(2), 61–70. http://dx.doi.org/10.1016/j.ijcci.2012.12.001.