The influence of serious games and educational robotics on computational thinking to promote reading ability and reading motivation in children with dyslexia

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Abstract

Digital technologies such as serious games (SG) and educational robotics (ER) are increasingly being used to support children with learning difficulties, such as dyslexia, with the aim of improving their reading ability, reading motivation, and computational thinking (CT). In this study we examined the effectiveness of SG and ER as educational interventions in twenty-seven dyslexic primary school children, who were assigned to either an SG or ER group. Before and after the intervention, a CT-test, a reading ability test, a questionnaire about reading motivation and an interview about reading motivation were administered. The findings indicated that both interventions led to improvements in CT, with the largest increase observed in the ER group, although the difference between groups was not statistically significant. Reading ability also improved: SG had a greater effect on reading existing words, while ER contributed more to reading pseudowords. The progress within both groups was significant, but no significant difference between the two groups was found. Neither intervention had a significant effect on reading motivation. However, CT was found to be positively correlated with reading motivation, but not with reading ability, and emerged as a unique predictor of reading motivation, without a direct link to reading ability. These findings highlight the potential of digital interventions to enhance reading ability and emphasize the importance of integrating CT into education to partially mitigate the negative impact of dyslexia on reading. While the findings already offer valuable insights, further research is needed.

Keywords

Computational thinking, dyslexia, serious games, educational robotics, reading ability, reading motivation.

1. Introduction

Reading is an important cognitive skill that originates in formal education [1]. However, recent findings from the Progress in International Reading Literacy Study (PIRLS) shows declining reading skills among Dutch children, influenced by reduced reading habits, lower socioeconomic status and

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whether the Dutch language is spoken at home [2]. Existing research indicates that children from socioeconomically privileged families and Dutch-speaking households generally achieve better school results [2]. The emphasis placed on reading skills at school also plays an important role. In addition, neurobiological factors, particularly dyslexia, have a further impact on reading results. Research shows that dyslexia affects 3–10% of Dutch primary school children and is the most common learning disorder [3, 4]. Dyslexia refers to persistent reading and spelling difficulties despite normal intelligence and education [5]. As a consequence, dyslexic children have difficulty recognizing letters and sounds, deciphering words, and reading words [6], which often leads to reduced self-confidence and motivation [7].

1.1. Reading ability and reading motivation in dyslexic children

Reading can be an effortful activity, and it requires motivation to do it [5]. For children with dyslexia, the reading and spelling process can even be more challenging. In addition to problems with reading and spelling, dyslexic children also tend to be less motivated to engage in reading-oriented activities [7]. They show more negative self-perceptions as a result of their reading difficulties, and demonstrate a higher frequency of avoidance behavior towards reading activities in comparison to their neurotypical counterparts [7].

To facilitate reading ability and reading motivation, specialized treatments use structured methods and psychoeducation to support reading and emotional well-being [8]. Furthermore, digital tools, such as serious games (SG) and educational robotics (ER), have been shown to be effective in supporting reading development in children with dyslexia [9, 10]. Such technologies also foster Computational Thinking (CT).

1.2. Computational thinking

CT - problem-solving in a computer-compatible way - can significantly enhance the learning process across multiple academic subjects, including reading ability [11]. CT encompasses more than just problem solving based on concepts derived from the world of computer science (CS). It provides a conceptual framework for analyzing and interpreting both natural and social phenomena by viewing the world as a system of information processes [12].

CT was first introduced by Papert in 1980 [12]. He encouraged children to create algorithms and computer programs from a constructionist perspective on education. His idea was that through this process, children would develop cognitive skills that would enhance their problem-solving abilities [13].

After CT was relegated to the background, the concept was reintroduced by Wing in 2006 [14]. Wing (2006) defined CT as the cognitive process and skillset that leverages information and tools from computer science to address problems, devise system designs and understand human behavior [14]. Subsequently, Selby and Woollard (2013) delineated five fundamental components of CT, drawing from Wing's definition [15]. These components include problem decomposition (decomposing complex problems into more manageable subcomponents), generalization (leveraging established problem-solving methodologies to address analogous or emergent challenges), abstraction (reducing complexity to facilitate problem resolution), evaluation (identifying the appropriate methodology for problem resolution), and algorithmic thinking (a strategy of determining the steps needed for problem resolution) [15]. Furthermore, the 3D framework developed by Brennan and Resnick (2012) categorizes CT into three dimensions: (a) computational concepts, (b) computational practices, and (c) computational, perspectives [16].

At present, there are several definitions of the concept of CT. However, a unified definition does not yet exist [17]. Nevertheless, scholars agree that CT skills encompass algorithmic thinking, navigating various levels of abstraction, breaking down problems into manageable parts, and representing data through models [18].

CT can be stimulated by means of plugged-in environments and unplugged environments. The primary feature of unplugged programming is that it involves activities conducted without the use of ICT, like board games, use of paper or experiences with one's own body [19, 20]. Unplugged programming environments appear to hold significant promise in influencing CT [21]. Research indicates, for instance, that unplugged activities lead to lower cognitive load, as the focus is on CT concepts rather than on (new) digital technologies [22].

In contrast to unplugged environments, plugged-in environments use computer-based tools and programming environments via, for instance, computers, tablets or tangible technologies (such as robots) to introduce children to the concepts of CT [21]. Using robots, children can create and program a sequence of instructions by, for example, scanning codes or pressing buttons [23]. Tactile programming of robotic systems teaches children logical thinking and simple programming concepts, such as sequences, loops, and patterns [24, 19]. These tactile technologies also stimulate children's interest in learning [25].

1.3. Serious games

SG are defined as a mental contest played with a computer, according to specific rules, that use entertainment to enhance learning objectives [26]. The primary objective of this tool is educational, with the playful aspect of the activity being secondary. SG are designed to facilitate the acquisition of competencies and skills [27, 28]. They are proven to be effective educational tools and not only motivate but also support the development of hard-to-teach skills. SG allows teachers to simulate real-world tasks, encouraging learning through doing or playing, risk-taking, and diverse learning approaches with minimal consequences for failure. They provide immediate feedback, aiding reflection [29].

SG also engages children cognitively, motivationally, behaviorally, and socially, improving learning outcomes, such as reading and spelling skills in children with dyslexia [30, 31]. Research also indicates that SG can have a positive impact on phonological awareness, and consequently letter recognition and motivation in dyslexic children [31, 32]. Phonological awareness is a skill that is crucial for learning to read, because it helps children understand how sounds correspond to letters and letter combinations in written language [3, 4].

Although serious games differ from traditional learning environments, their interactive and problem-solving nature incorporates elements that closely align with the core components of CT, such as problem decomposition, generalization, abstraction, evaluation, and algorithmic thinking [15, 19, 20, 21]. This makes SG potentially valuable tools not only for domain-specific learning but also for supporting CT development [44].

1.4. Educational robotics

ER emerges as a specialized section within social robotics, a subfield within robotics. It is, among other things, dedicated to examining how robotic engagement can enhance and facilitate learning processes in humans [10]. Research indicates that ER has a significant impact on academic achievements by making subjects more concrete, allowing children to play an active role in the learning process, and stimulating interest, attention, and motivation in children [33].

ER also holds significant potential to improve learning in children with dyslexia [34]. It can support dyslexic children in educational challenges, providing direct feedback [34]. Furthermore, a meta-analysis on selected papers reporting ER activities with children diagnosed with neurodevelopmental disorders (including dyslexia), where children had the opportunity to program robots, has shown that the majority of these studies demonstrated enhancements in performance, in terms of learning objectives, in children' engagement, and in interaction with peers [10].

Similar to SG, ER enables children to engage in CT-activities, such as problem solving, and decomposition [11, 19]. Despite their differing design philosophies, both environments therefore hold potential for supporting CT development, albeit in different ways [11, 19, 44].

Given their potential to stimulate reading ability and reading motivation via the impact of CT, SG and ER may offer promising interventions for dyslexic children. Although the two environments differ in nature (with SG often being designed primarily as games and ER as structured learning tools), this variety offers an opportunity to explore whether different types of environments can facilitate CT development through different pathways. However, research - especially in Dutch contexts and in this combination -is limited. This study aims to investigate how CT, via SG or ER, can enhance reading ability and motivation in children with dyslexia.

2. Methodology

This study focused on children aged 9–13 with a formal diagnosis of dyslexia, enrolled in grades 5–8 of Dutch primary education. Among the participants were also children who had been referred to *BCO Onderwijsadvies en ondersteuning* (BCO) for dyslexia assessment or treatment. Given the possibility of comorbid conditions [3], children with other learning or neurological developmental disorders were not excluded. Participants were assigned on a quasi-experimental basis to one of two research groups: Asgaard Saga (SG) or Ozobot (ER). Group allocation was not random but based on predefined criteria. Children registered at BCO were assigned to the SG group, as the SG is part of the organization's treatment materials and is only available in that setting. Children recruited through schools were assigned to the ER group. It is important to note that children registered at BCO also attend schools in the same region as children of the ER group. This allocation procedure was chosen to ensure the practical feasibility of implementing the intervention within the available timeframe and the accessibility of materials across settings.

During both the pre-test and post-test, all children were presented with a number of questionnaires and tests. First, a 'Reading motivation questionnaire' (*Vragenlijst leesmotivatie*) was administered. This questionnaire contains 14 multiple-choice questions about intrinsic and extrinsic reading motivation, reading behavior at home and at school, and asks children to rate their answers from very positive to very negative [35]. Depending on their age, the children also completed either the *Beginners Computational Thinking Test* (BCTt) (aimed at children aged 5-9) [36] or the *Computational Thinking Test* (CTt) (aimed at children aged 10-16) [37]. The BCTt and CTt are questionnaires in which children have to solve a number of pictorial problems based on Brennan & Resnick's 3D framework [38], with an emphasis on computational concepts, computational perspectives, and computational practices [37]. In addition, the One Minute Test (EMT) and Klepel-R were administered to all children. Both tests are reading tests but focus on different aspects of the reading process. The EMT focuses on word recognition using real words, while the Klepel-R uses pseudowords to assess decoding skills—the ability to convert written text into spoken language [39, 40]. Finally, the study concluded with an interview with each child about reading motivation, covering motivation, reading preferences, reading environment, and reading ability. The combined duration of the questionnaires and tests for both the pretest and posttest was 120 minutes.

During the experiment, the children in the ER-group received six weekly lessons of 30–45 minutes at school, during which they played a custom-designed board game with Ozobot - a programmable educational robot that responds to color codes or Scratch programming language (https://ozobot-benelux.nl/). Using code stickers, children guided Ozobot to collect cards with reading and spelling assignments from the SG Asgaard Saga (figure 1). A rotation schedule ensured equal playtime. Each session lasted between 30 and 45 minutes and was supervised by the researcher. During the first session, children were divided into groups of four and received a 5-minute introduction to the use of the Ozobot. In addition, each following session began with a 5-minute instruction period related to the specific board game used in that session. Children from the SG group played Asgaard Saga individually for 30–45 minutes each week (figure 2). This SG for the treatment of dyslexia integrates phonological training, letter-sound mapping, spelling rules, and reading fluency, grounded in scientific and psychological principles [40, 41, 42]. Players complete challenges as warrior avatars and earn rewards to help in-game villagers (https://asgaard-saga.nl). Sessions were supervised by the child's therapist. During the first session, the children received a short instruction of 5 minutes on how to use the game.

Figure 1: Boardgame using Ozobot.

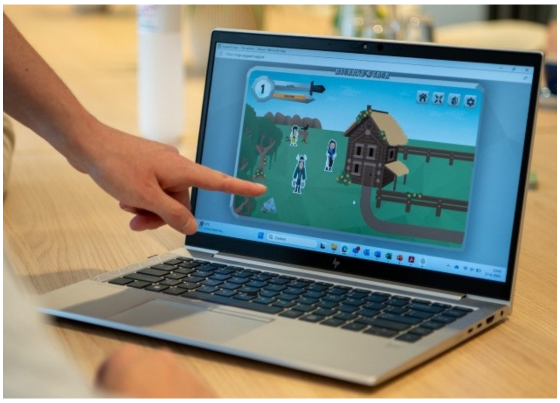

Figure 2: Asgaard Saga (photo by Petra Lenssen).

3. Main findings

All analyses were performed with SPSS, version 30. Data from children who missed taking either the pretest or post-test, or could not fully participate in the various interventions, were not included in the analysis. The results of the pre- and post-test on the BCTt or CTt, the 'Vragenlijst leesmotivatie' and the EMT and Klepel-R were entered into SPSS for quantitative data analysis. To investigate whether two plugged-in interventions (SG and ER) could potentially promote reading ability and reading motivation influenced by the impact of CT, the means of pre- and post-test scores on the CT tests, EMT, Klepel-R, and the reading motivation questionnaire were calculated for each experimental group, and subsequently compared. Due to the limited number of participants per test, the BCTt and CTt could not be analysed separately. Consequently, it was not possible to conduct direct comparisons between the subcategories of both questionnaires. Instead, a combined total score based on both tests was calculated. To facilitate comparability across measures, total scores on CT, EMT, and Klepel-R were converted to percentages prior to analysis. Also, multiple two way mixed ANOVA's were performed, in which both interventions served as independent variables. The post-measurements on CT, reading and reading motivation were used as independent variables.

Data obtained from the reading motivation interviews were explored and coded based on recurring themes. After transcription, participant responses were manually grouped based on thematic similarity. This process led to the identification of recurring themes, which were categorized accordingly. Within each theme, the frequency of specific types of responses was counted to provide insight into the prevalence of different perspectives. These frequencies formed the basis for a quantitative interpretation of the qualitative findings, allowing underlying patterns and distinctions between participants to emerge.

Both interventions led to improvements in CT, with the largest increase observed in the ER group (Ozobot: 2.00% increase; Asgaard Saga: 1.81% increase), although the difference between groups was not statistically significant ($F(1, 25) = .001$, $p = .974$, partial $\eta 2 = .000$). Reading skills also improved: SG had a greater effect on reading existing words (Asgaard Saga: 5.17% increase; Ozobot: 3.05% increase), while ER contributed more to reading pseudowords (Asgaard Saga: 2.40% increase; Ozobot: 2.98% increase). Progress within both groups was significant (EMT: $F(1, 25) = .227,886$, $p .< .001$, partial $\eta 2 = .602$; Klepel-R: $F(1, 25) = 20.709$, $p .< .001$, partial $\eta 2 = .453$) but no significant difference was found between them (table 1).

Table 1

Differences in computational thinking (CT), reading ability, and reading motivation

Variable	Asgaard Saga (SG)			Ozobot (ER)		
	M	SD	Range	*M*	SD	Range
Pre-test: CT: BCTt (25 items) / CTt (28 items) (percentage correctly solved tasks)	71.05	18.82	21.43 – 96.00	54.82	24.80	7.14 – 96.00
Post test: CT: BCTt (25 items) / CTt (28 items) (percentage correctly solved tasks)	72.86	22.10	28.57 – 96.00	56.82	23.40	17.86 – 88.00
Pre-test: EMT words read correctly (Percentage of 116 items)	31.22	11.74	13.79 – 50.86	39.72	12.30	18.97 – 61.21
Post test: EMT words read correctly (Percentage of 116 items)	36.39	9.99	19.83 – 49.14	42.77	12.73	22.41 – 69.83
Pre-test: Klepel-R words read correctly (Percentage of 116 items)	15.15	3.46	9.48 – 20.69	15.72	7.42	6.03 – 31.90
Post test: Klepel-R words read correctly (Percentage of 116 items)	17.55	4.51	12.07 – 27.59	18.70	8.34	6.03 – 37.07
Pre-test: Reading motivation questionnaire total (maximum score is 50)	31.79	5.35	20.00 – 38.00	31.77	5.50	21.00 – 43.00
Post test: Reading motivation questionnaire total (maximum score is 50)	31.00	5.97	21.00 – 41.00	31.31	7.75	17.00 – 41.00

M = average, SD = standard deviation, range = spread in measurement

Neither intervention had a significant effect on reading motivation ($F(1, 25) = .042$, $p = .840$, partial $\eta 2 = .002$). However, CT was positively associated with reading motivation (pre: $r(23) = .460$, $p = .016$; post: $r(23) = .513$, $p = .006$), but not with reading ability, and emerged as a unique predictor of reading motivation ($F(1, 25) = 8.94$, $p = .006$, $R^2 = .263$), without a direct link to reading skills (table 2).

Table 2

Regression analysis

	Predictor			
	CT			
Dependent variable	R^2	β	*t*	*p*
EMT (existing words)	.018	−.136	−0.69	.500
Klepel-R (pseudo words)	.005	−.068	−0.34	.737
Reading motivation questionnaire	.263	.513	2.99	.006*
Reading motivation questionnaire with EMT	.318	.545	3.20	.004*
Reading motivation questionnaire with Klepel-R	.277	.521	2.99	.006*

R^2 = explained variance; β = standardized regression coefficient (beta); *t* = t-value regression analysis; *p* = p-value regression analysis; * = statistical significance.

Further qualitative research into the differences in experience reported by children with regard to their reading ability and motivation to read showed that the proportion of children, who indicated in the SG intervention that they disliked reading, decreased.

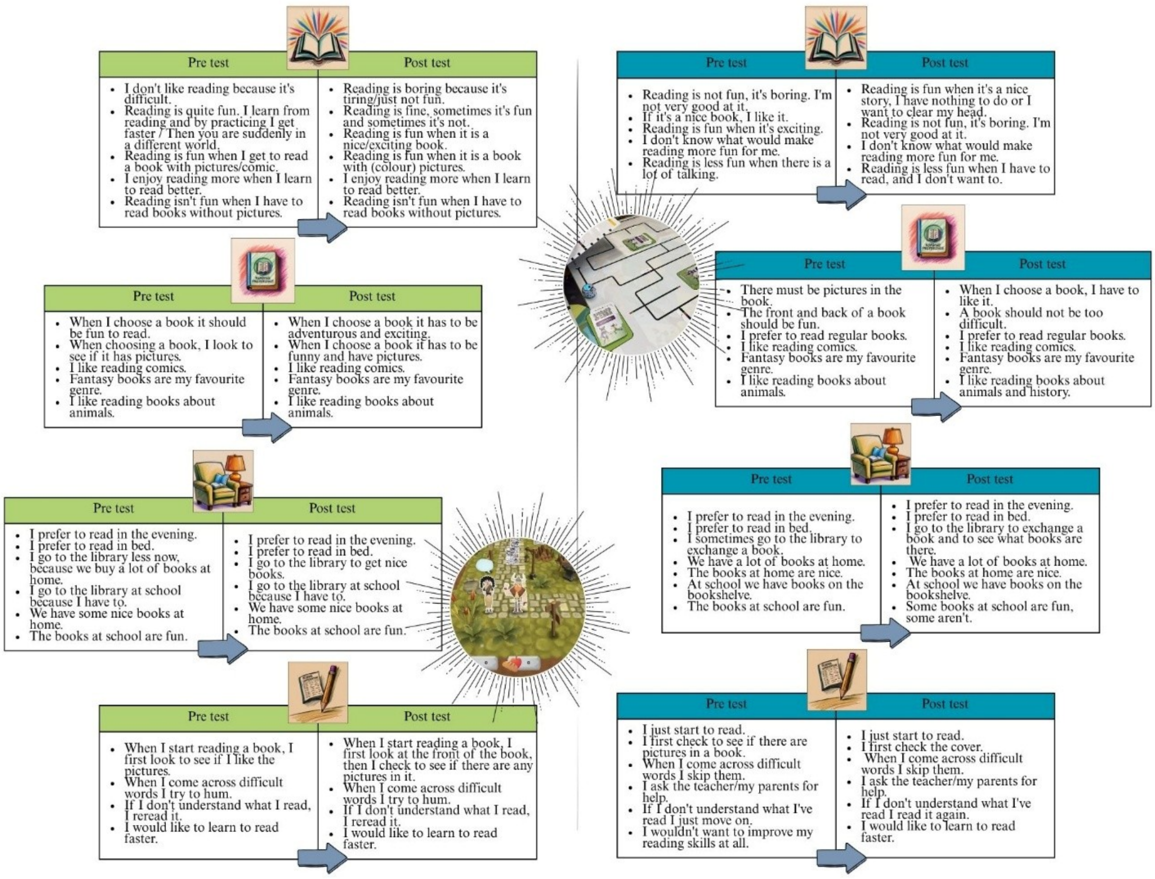

Figure 3: Selection of most common answers of the Asgaard Saga group (left) and Ozobot group (right) on the reading motivation interview on categories ‘reading motivation’, ‘reading preference’, ‘reading environment’, and ‘reading ability.

Children gave responses such as: “*Reading is fun when it’s exciting*” and “*Reading becomes more enjoyable as I improve*”. Children’s reading motivation in the ER intervention, remained relatively stable over time. Reading preferences, in both groups relatively remained the same. Children indicated for instance that: “*The book should not be too difficult*” and “*A book should have pictures*” (figure 3).

4. Discussion & limitations

This study found modest but non-significant improvements in CT after implementing SG and ER. Similar results reported by Hong [43] are often linked to limited duration, intensity, and explicit instruction. While other studies that used targeted programming or robotics interventions did find significant CT gains [11, 19], our study did not yield comparable results. Although few studies have specifically examined the impact of SG on CT, recent meta-analyses report increasingly positive effects when SG are explicitly designed to develop CT [20, 44]. Such targeted interventions typically yield to significant growth in CT. In contrast, the SG in our study focused primarily on reading rather than CT, which likely explains the absence of significant CT effects.

The development of CT also appears to be gradual and requires structured, reflective practice [45]. Without explicit guidance, learning remains superficial [46]. No significant effects on reading ability or motivation were found in children with dyslexia, probably due to their greater learning needs and the short intervention period. Although not significant, an improvement in reading skills could nevertheless be observed within groups and between groups (SG: EMT: 5.17%; Klepel-R: 2.4%; ER: EMT: 3.05%, Klepel-R: 2.98%). Furthermore, CT correlated positively with reading motivation, suggesting that CT leverages the typical strengths of dyslexic learners—such as visualization, spatial awareness, creativity, and lateral thinking—which can improve competence, self-image, and intrinsic motivation [42, 47, 48]. The reduced linguistic demands of visual programming may further promote positive engagement with reading [3, 47, 48].

Although this study was carefully designed, several limitations should be considered when interpreting the results. The term 'reading ability' was deliberately defined broadly to encompass various skills such as fluency, vocabulary, and decoding, but its interpretation can still vary [49, 50]. All participants had been diagnosed with dyslexia and received support at school, although the nature and quality of that support differed between schools [3]. In addition, external influences such as practicing at home and the regular school curriculum, may have impacted the outcomes. The limited geographic and educational scope of the study restricts the generalizability of the findings. The use of a quasi-experimental design without randomization or a control group affects internal validity, and the six-week intervention period may have been too short to observe lasting effects. Differences in intervention formats and repeated testing may also have led to bias. Furthermore, CT was assessed using age-specific instruments with different subcategories, making direct comparisons challenging. Finally, reading outcomes are influenced by many factors beyond CT, including the language spoken at home and the emphasis schools place on reading performance [2].

5. Future work

Our research findings contribute to the development of interventions that can enhance reading ability and reading motivation. The results obtained underscore the importance of integrating CT into current school curricula, thereby partially overcoming the impact of dyslexia on reading performance.

6. Conclusion

This research showed that the use of SG or ER led to small improvements in CT and reading ability. There appeared to be no clear advantage of one intervention over the other. Also, no significant effects were found on reading motivation for either intervention, despite this being a stated objective. However, CT was found positively associated with reading motivation and emerged to be a unique predictor of reading motivation. This suggests that both forms of technology are potentially valuable in the treatment of children with dyslexia. The findings of our study contribute to the development of tailored interventions that can enhance reading ability and reading motivation in dyslexic children. The results not only reveal implications for further research but also underscore the importance of integrating CT into current school curricula, thereby partially overcoming the impact of dyslexia on reading performance.

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Compliance with ethical standards

The Ethical Research Board (cETO) of the Open University of the Netherlands has assessed the proposed research and concluded that this research is in line with the rules and regulations and the ethical codes for research in human subjects (reference: Ceto_RP1010/U202500935). Informed consent was obtained.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

References

[1] S. Bertoni, S. Franceschini, G. Puccio, M. Mancarella, S. Gori, and A. Facoetti, “Action Video Games Enhance Attentional Control and Phonological Decoding in Children with Developmental Dyslexia”, Brain Sciences 11. 2 (2021): 171. doi: 10.3390/brainsci11020171.

[2] Swart, Gubbels, In ‘T Zandt, Wolbers, en Segers, “PIRLS-2021: Trends in leesprestaties, leesattitude en leesgedrag van tienjarigen uit Nederland”, Expertisecentrum Nederlands, 2023.

[3] Scheltinga, Tijms, Zeguers, Rolak, and De Bree, Brede vakinhoudelijke richtlijn dyslexie. Nederlands instituut van psychologen (NIP), Nederlandse vereniging van pedagogen en onderwijskundigen (NVO), Nederlands kwaliteitsinstituut dyslexie (NKD) en Landelijke beroepsvereniging remedial teachers (LBRT)., 2020.

[4] Blomert, Dyslexie in Nederland: Theorie, praktijk en beleid. Nieuwezijds, 2003.

[5] M. Soriano-Ferrer, M. R. Morte-Soriano, J. Begeny, en E. Piedra-Martínez, “Psychoeducational Challenges in Spanish Children With Dyslexia and Their Parents’ Stress During the COVID-19 Pandemic”, Frontiers in Psychology, 12 (2021): doi: 10.3389/fpsyg.2021.648000.

[6] H. Yaacob, N. Z. Zakariya, and S. M. M. Rashid, “Technology-based Interventions for Dyslexic Children: A Systematic Literature Review (SLR)”, International Journal Of Academic Research in Business And Social Sciences 14. 2 (2024): doi: 10.6007/ijarbss/v14-i2/20826.

[7] R. Gibby-Leversuch, B. K. Hartwell, and S. Wright, “Dyslexia, Literacy Difficulties and the Self-Perceptions of Children and Young People: a Systematic Review”, Current Psychology, 40.11 (2019): 5595–5612. doi: 10.1007/s12144-019-00444-1.

[8] E. Toffalini, D. Giofrè, M. Pastore, B. Carretti, F. Fraccadori, and D. Szűcs, “Dyslexia treatment studies: A systematic review and suggestions on testing treatment efficacy with small effects and small samples”, Behavior Research Methods 53.5 (2021): 1954–1972. doi: 10.3758/s13428-021-01549-x.

[9] S. Franceschini, S. Bertoni, L. Ronconi, M. Molteni, S. Gori, en A. Facoetti, "'Shall We Play a Game?': Improving Reading Through Action Video Games in Developmental Dyslexia", Current Developmental Disorders Reports 2. 4 (2015): 318–329. doi: 10.1007/s40474-015-0064-4.
[10] M. Pivetti, S. Di Battista, F. Agatolio, B. Simaku, M. Moro, and E. Menegatti, "Educational Robotics for children with neurodevelopmental disorders: A systematic review", Heliyon 6. 10 (2020): e05160. doi: 10.1016/j.heliyon.2020.e05160.
[11] S. Van Bergen and N. Fanchamps, "The Impact of Robotic Programming Environments on Computational Thinking with an Effect on Word Reading Fluency and Decoding", Lecture notes in computer science (2024): 182–188. doi: 10.1007/978-3-031-72312-4_25.
[12] P. J. Denning and M. Tedre, Computational thinking. 2019. doi: 10.7551/mitpress/11740.001.0001.
[13] S. Papert, Mindstorms: children, computers, and powerful ideas. 1980.
[14] J. M. Wing, "Computational thinking," Communications of the ACM 49. 3 (2006): 33–35. doi: 10.1145/1118178.1118215.
[15] C.C. Selby, "Computational Thinking: the developing definition", 2013. URL: https://eprints.soton.ac.uk/346937/1/Selby_an_for_eprints.pdf
[16] Brennan, K., & Resnick, M. (2012, April 13-17). New frameworks for studying and assessing the development of computational thinking. Proceedings of the 2012 Annual Meeting of the American Educational Research Association, Vancouver, Canada.
[17] S. Grover and R. Pea, "Computational thinking: a competency whose time has come", Computer Science Education, 2018. doi: 10.5040/9781350057142.ch-003.
[18] S. R. Jacob and M. Warschauer, "Computational thinking and literacy," Journal of Computer Science Integration 1.1 (2018). 10.26716/jcsi.2018.01.1.1.
[19] N. L. J. A. Fanchamps, L. Slangen, M. Specht, and P. Hennissen, "The Impact of SRA-Programming on Computational Thinking in a Visual Oriented Programming Environment", Education And Information Technologies 26. 5 (2021): 6479–6498. doi: 10.1007/s10639-021-10578-0.
[20] A. Giannakoulas and S. Xinogalos, "Studying the effects of educational games on cultivating computational thinking skills to primary school students: a systematic literature review", Journal Of Computers in Education 11. 4 (2023): 1283–1325. doi: 10.1007/s40692-023-00300-z.
[21] N. Fanchamps, E. Van Gool, L. Slangen, and P. Hennissen, "The effect on computational thinking and identified learning aspects: Comparing unplugged smartGames with SRA-Programming with tangible or On-screen output," Education and Information Technologies 29. 3 (2023): 2999–3024. doi: 10.1007/s10639-023-11956-6.
[22] D. Kotsopoulos et al., "A pedagogical framework for computational thinking," Digital Experiences in Mathematics Education 3. 2 (2017): 154–171. doi: 10.1007/s40751-017-0031-2.
[23] C. F. Ferrada, D. D. Levicoy, N. S. Orellana, and R. Parraguez, "Propuesta de actividades STEM con Bee-bot en matemática," Edma 0-6 Educación Matemática En La Infancia 8. 1 (2021): 33–43. doi: 10.24197/edmain.1.2019.33-43.
[24] M. U. Bers, A. Strawhacker, and A. Sullivan, "The state of the field of computational thinking in early childhood education," OECD Education Working Papers, 2022, doi: 10.1787/3354387a-en.
[25] A. Gerosa, V. Koleszar, G. Tejera, L. Gómez-Sena, and A. Carboni, "Educational Robotics Intervention to Foster Computational thinking in preschoolers: Effects of Children's Task Engagement," Frontiers in Psychology 13 (2022): 904761. doi: 10.3389/fpsyg.2022.904761.
[26] M. Zyda, "From visual simulation to virtual reality to games," Computer 38. 9 (2005): 25–32. doi: 10.1109/mc.2005.297.
[27] J. Y. A. Lopez, R. N. N. Huaycho, F. I. Y. Santos, F. T.- Mendoza, and F. H. R. Paucar, "The Impact of Serious Games on Learning in Primary Education: A Systematic literature review," International Journal of Learning Teaching and Educational Research 22. 3 (2023): 379–395. doi: 10.26803/ijlter.22.3.23.

[28] C. V. Marinelli et al., “The Effectiveness of Serious Games for Enhancing Literacy Skills in Children with Learning Disabilities or Difficulties: A Systematic Review,” Applied Sciences 13. 7 (2023): 4512. doi: 10.3390/app13074512.

[29] O. Amiri et al., “Virtual Reality Serious Game with the TABAN Robot Avatar for Educational Rehabilitation of Dyslexic Children,” Lecture notes in computer science (2023): 161–170. doi: 10.1007/978-981-99-8715-3_14.

[30] S. Politi-Georgousi and A. Drigas, “Mobile Applications, an Emerging Powerful Tool for Dyslexia screening and intervention: A systematic literature review,” International Journal of Interactive Mobile Technologies (iJIM) 14. 18 (2020): 4. doi: 10.3991/ijim.v14i18.15315.

[31] A. Brennan, T. McDonagh, M. Dempsey, and J. McAvoy, “Cosmic Sounds: a game to support phonological awareness skills for children with dyslexia,” IEEE Transactions on Learning Technologies 15. 3 (2022): 301–310. doi: 10.1109/tlt.2022.3170231.

[32] A. Khaleghi, Z. Aghaei, and M. Behnamghader, “Developing two game-based interventions for dyslexia therapeutic interventions using gamification and serious games approaches entertainment computing journal,” Entertainment Computing 42 (2022): 100482. doi: 10.1016/j.entcom.2022.100482.

[33] T. Talan, “The Effect of educational robotic applications on Academic Achievement: A Meta-Analysis study,” International Journal of Technology in Education and Science 5. 4 (2021): 512 –526,. doi: 10.46328/ijtes.242.

[34] M. Shahab et al., “A Tablet-Based Lexicon Application for Robot-Aided Educational Interaction of Children with Dyslexia,” Lecture notes in computer science (2023): 344–354. doi: 10.1007/978-981-99-8718-4_30.

[35] Van Elsäcker, Vragenlijst Leesmotivatie. Expertisecentrum Nederlands, 2002.

[36] Zapata-Cáceres, M., Martín-Barroso, E., and Román-González, M. (2020). Computational thinking test for beginners: Design and content validation. Paper presented at the 2020 IEEE Global Engineering Education Conference (EDUCON), Porto, Portugal.

[37] M. Román-González, J.-C. Pérez-González, and C. Jiménez-Fernández, “Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test”. Computers in Human Behavior 72 (2016): 678–691. doi: 10.1016/j.chb.2016.08.047.

[38] Brennan and Resnick, New frameworks for studying and assessing the development of computational thinking. Vancouver, Canada, 2012.

[39] Van Den Bos, De Groot, and De Vries, Klepel-R. Een test voor de leesvaardigheid van pseudowoorden. Pearson, 2019.

[40] Nederlands Kwaliteitsinstituut Dyslexie, “Protocol dyslexie diagnostiek en behandelingversie 3.0”, 2021. URL: https://www.nkd.nl/app/uploads/2021/09/Protocol-Dyslexie-Diagnostiek-en-Behandeling-3.0-versie-0.99.pdf

[41] Serrarens en Hulsen, Asgaard Saga: Theoretische onderbouwing. Berkel-B, 2023.

[42] R. M. Ryan en E. L. Deci, “Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions”, Contemporary Educational Psychology 61 (2020): 101860. doi: 10.1016/j.cedpsych.2020.101860.

[43] L. Hong, “The impact of educational robots on students' computational thinking: A meta-analysis of K-12”, Education And Information Technologies 29. 11 (2023): 13813–13838. doi: 10.1007/s10639-023-12415-y.

[44] S. W. Gundersen and G. Lampropoulos, “Using Serious Games and Digital Games to Improve Students' Computational Thinking and Programming Skills in K-12 Education: A Systematic Literature Review”, Technologies 13. 3 (2025), doi: 10.3390/technologies13030113.

[45] J. Denner, L. Werner, and E. Ortiz, “Computer games created by middle school girls: Can they be used to measure understanding of computer science concepts?”, Computers & Education 58. 1 (2011): 240–249. doi: 10.1016/j.compedu.2011.08.006.

[46] S. Papavlasopoulou, M. N. Giannakos, and L. Jaccheri, “Empirical studies on the Maker Movement, a promising approach to learning: A literature review”, Entertainment Computing 18 (2016): 57–78. doi: 10.1016/j.entcom.2016.09.002.

[47] J. Asbell-Clarke e.a., “Including neurodiversity in computational thinking”, Frontiers in Education 9 (2024) doi: 10.3389/feduc.2024.1358492.
[48] N. Powell, D. Moore, J. Gray, J. Finlay, and J. Reaney, “Dyslexia and learning computer programming”, Innovation in Teaching And Learning in Information And Computer Sciences 3. 2 (2004): 1–12. doi: 10.11120/ital.2004.03020005.
[49] P. Afflerbach, P. D. Pearson, and S. G. Paris, “Clarifying Differences Between Reading Skills and Reading Strategies”, The Reading Teacher 61. 5 (2008): 364–373. doi: 10.1598/rt.61.5.1.
[50] F. Liu, “Reading Abilities and Strategies: A Short Introduction”, International Education Studies 3. 3 (2010) doi: 10.5539/ies.v3n3p153.