Developmentally appropriate apps to promote Computational Thinking, Fluency and coding skills for young students

Dr. Papadakis Stamatios
Department of Preschool Education,
University of Crete, Greece

Agenda

Topic One:

- Touchscreen technology on young children's learning
- Educational apps
- The landscape of educational apps

Topic Two:

- Computational Thinking or Computational Fluency?
- Developmentally appropriate apps to promote Computational Thinking, Fluency and coding skills for young students
- ScratchJr

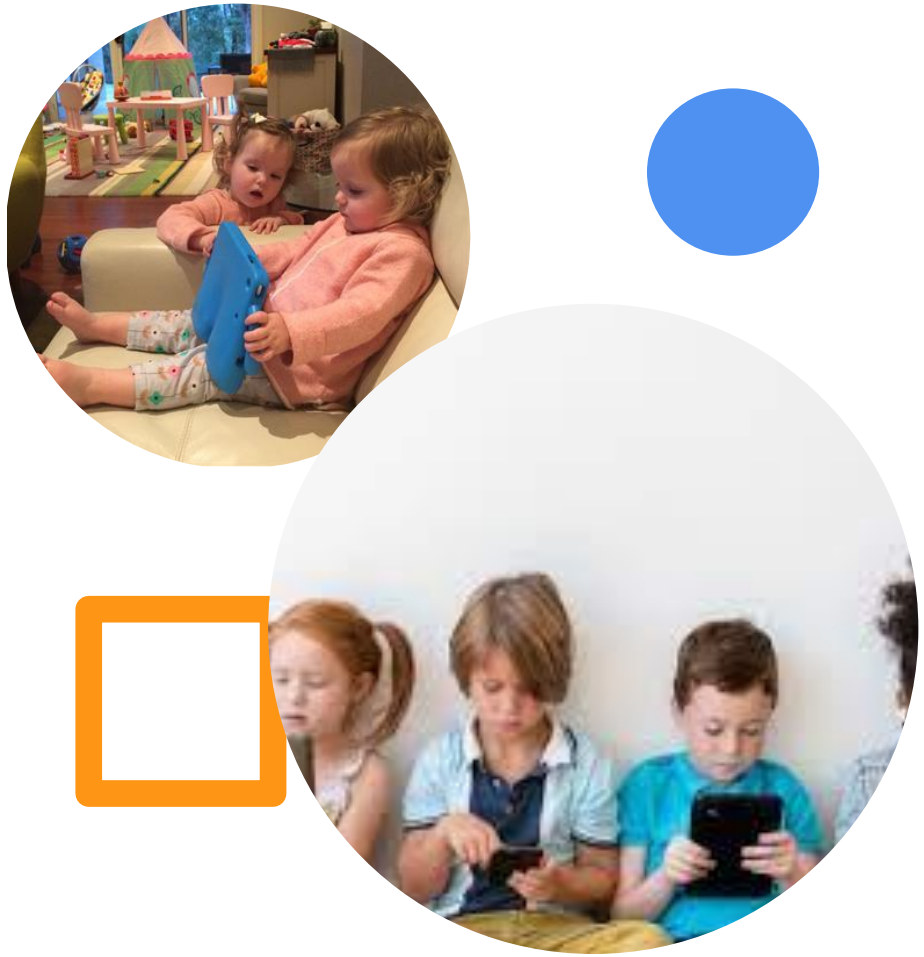
Topic one

- Touchscreen technology on young children's learning
- Educational apps
- The landscape of educational apps

Touchscreen technology on young children's learning

Technological advancements in the 21st century have created a remarkable shift in learning experiences for young children (Kim et al., 2021; Kucirkova et al., 2019).

The ubiquity of technologies in our daily lives has exposed children to a wide array of digital devices from an early age (Papadakis, 2022).



Touchscreen technology on young children's learning

According to a nationwide survey conducted in the U.S. in 2017:

- 98% of children aged 0-8 years had access to mobile devices in their home environment, and
- 42% of them owned their personal tablets.

According to the survey of EU Kids Online children between 3-6 years prefer using tablet devices using internet weekly (Ólafsson, Livingstone & Haddon, 2013).

These rates indicate the high popularity of digital devices, especially touchscreen devices, among young children (Papadakis & Kalogiannakis, 2022).

Touchscreen technology on young children's learning

A wide range of applications with supposedly educational benefits are available with a purpose to help young children prepare for the demands posed by the schooling system.

- Most of the parents are convinced that their child can benefit from using digital devices (Rideout & Robb, 2020).
- Although the American Academy of Pediatrics does not suggest more than 1 hour use of media for children above 2 years (Hill et al., 2016), children between 5 and 8 years spend approximately daily three hours with screen media, such as watching television or using touchscreen devices (Rideout & Robb, 2020).

Currently, the most popular applications available on Google Play are labelled as educational, and in 60% of the cases the target group of these applications are preschoolers (Shuler, Levine & Ree, 2012).

- One of the best exemplars are electronic storybook applications, that use multimedia elements and interactive features to adapt traditional storytelling for touchscreen devices.

Touchscreen characteristics

- Lightweight design
- Tactile-based digital interface:
  - allow even very young children to interactively engage with the digital content
- Potentials to facilitate:
  - personalized, flexible,
  - mobile learning experiences,
  - individualized assessment and
  - rich communication

Have led to the introduction of these devices into school and informal settings for educational purposes (McLean, 2016).

Touchscreen technology on young children's learning

The increasing uptake of touchscreens by young children both in:

- formal and
- informal settings

highlights the importance of giving special consideration to the effects of these technologies on young children learning.

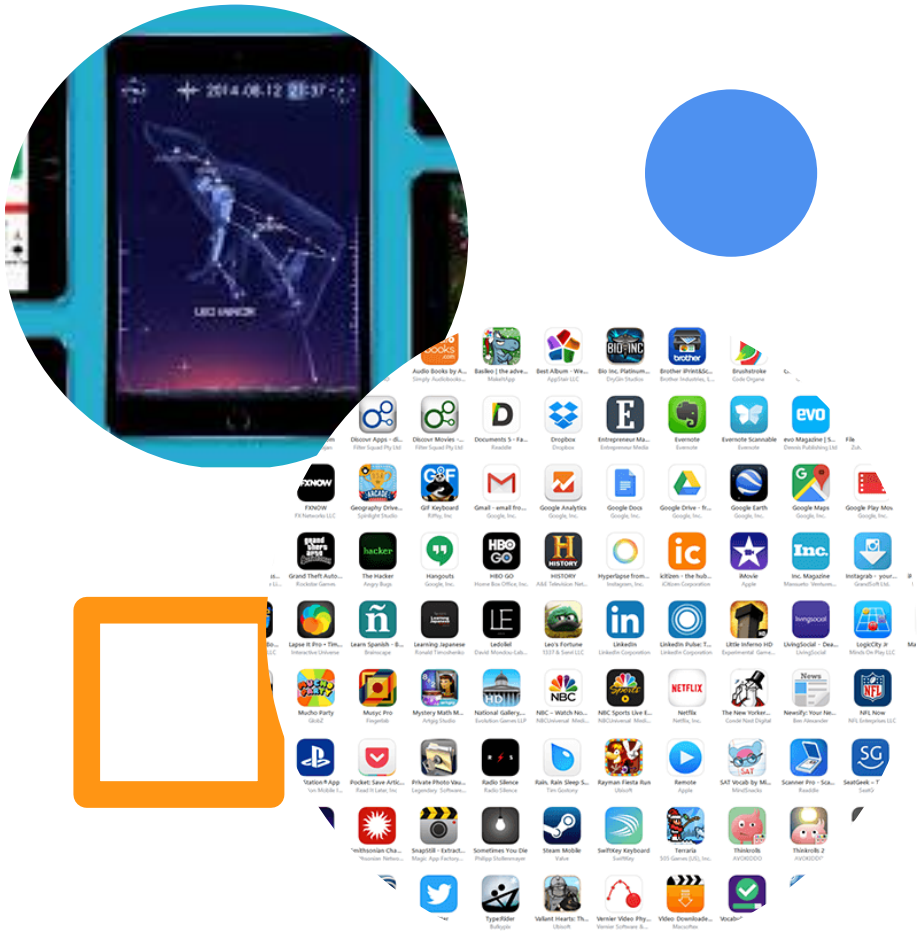
The American Academy of Pediatrics (2009) has warned about the exposure of young children to violent content through digital technologies and their consequences, such as: "aggressive behaviour, desensitization to violence, nightmares, and fear of being harmed" (p. 1495).

As acknowledged by OECD (2019),
"active interaction with touchscreens can generate dynamic stimulation, and, if used appropriately, may be just as engaging and cognitively stimulating as traditional toys or books" (p. 45).

Educational apps

Children are in the midst of a vast, unplanned experiment, surrounded by digital technologies that were not available but 10-15 years ago.

- At the apex of this boom is the introduction of applications (“apps”) for tablets and smartphones.

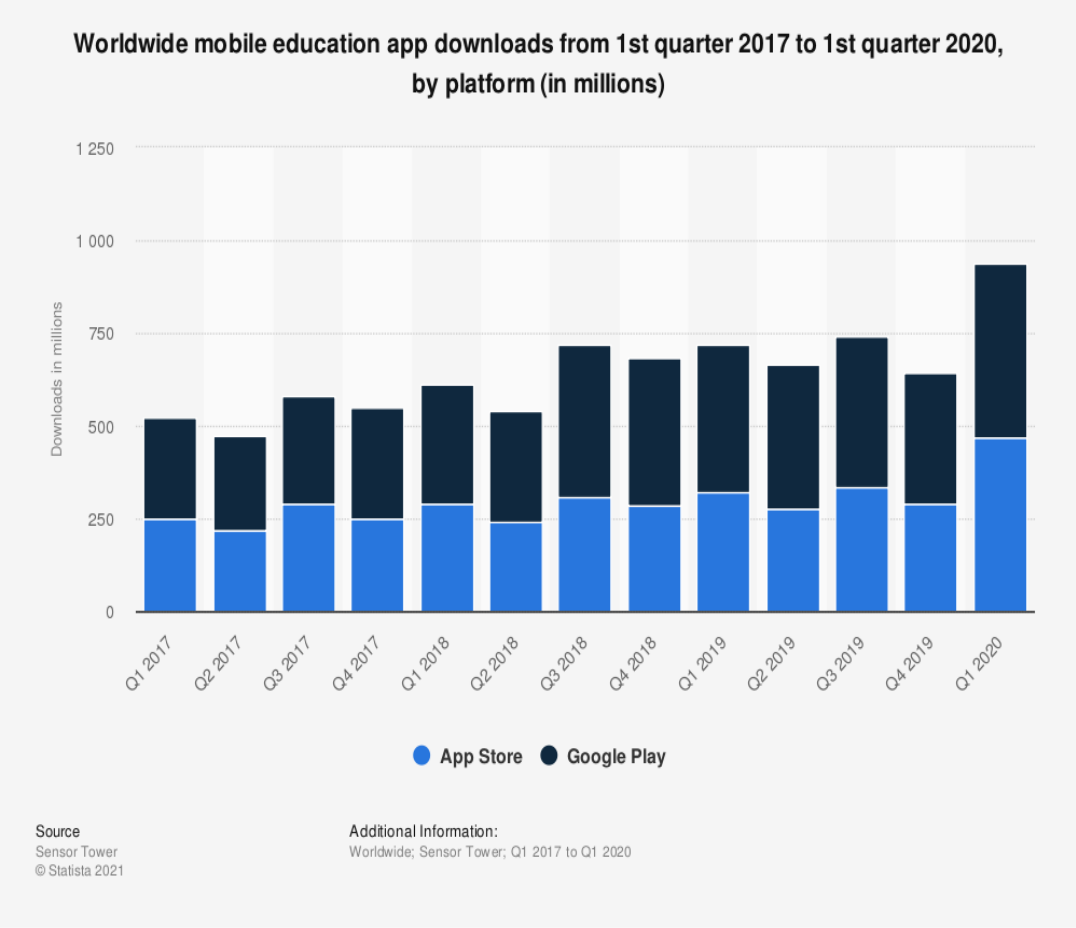


Educational apps

The numbers tell the story.

Apps are not just ubiquitous, but also big business:

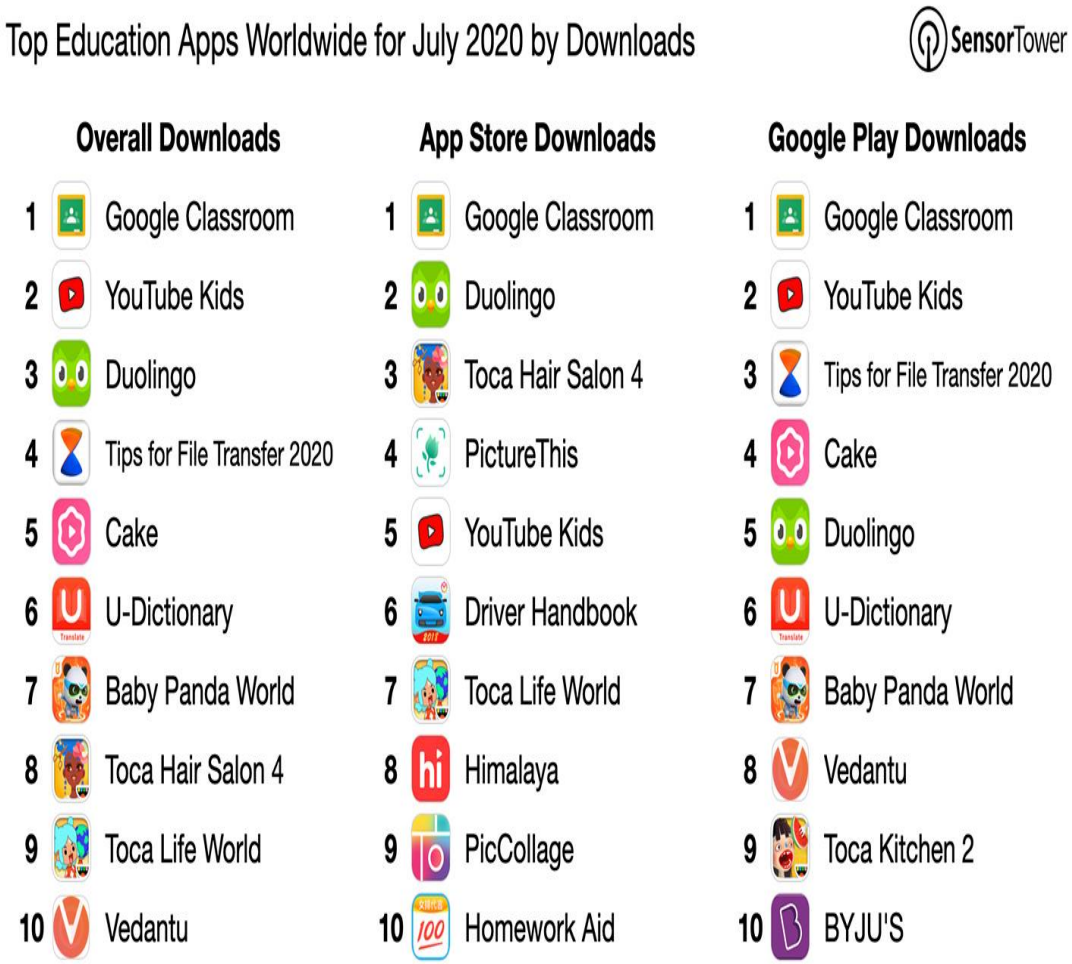
- Over $10 billion was spent in the App Store in 2013 (Apple, 2014).
- By 2015, revenue from apps was tripled to $38 billion (Statista, 2016).
- By 2020, in the latest reported quarter, the Apple App Store had 470 million educational app downloads, In comparison, users downloaded 466 million educational apps via Google Play.



Educational apps

While this sweeping change has had significant effects on the daily lives of adults, its ultimate impact may be even more significant for the children for whom apps are designed and marketed:

- Over 80,000 apps were classified as education- and learning based (Apple, 2015).
- In 2018, 78% of parents in the United States reported that they had downloaded apps for their children (Common Sense Media, 2018).
- Indeed, the Preschool/primary category is the most popular category of apps in the App Store, accounting for 72% of the top paid apps (Statista, 2022).
- The near-instantaneous delivery of new apps prevents scientists from evaluating specific apps as they are introduced into the marketplace.



Educational apps

We have to concentrate on the use of apps by this age bracket for 4 reasons:

1. Intuitive interactions afforded by touch-screen devices make app content potentially accessible to very young prereaders—even babies.

   Indeed, there are so many apps targeted toward young children that parents and educators do not know how to navigate the marketplace of possibilities (Guernsey, 2014; Rideout, 2014).

2. A large number of schools worldwide have integrated the use of tablets into their curriculum, despite the absence of research to support this change.

Educational apps

3. Less than 20% of a child's waking time is spent in school (LIFE Center: Learning in Informal and Formal Environments, 2005).
   - The amount of time that children spend with digital media and the surge in educational apps' popularity suggest that at least some apps are being used in an attempt to supplement learning outside of school.
   - Apps present a significant opportunity for out-of-school, informal learning when designed in educationally appropriate ways.
4. School readiness is predictive of later achievement (Duncan et al., 2007).
   - If apps can improve young children's skills, school readiness, or executive-function capabilities, then early learning with apps might have long-term impacts (Goldin et al., 2014).

Educational apps

Research suggests that children learn best when they are cognitively active and engaged, when learning experiences are meaningful and socially interactive, and when learning is guided by a specific goal.

- This should not suggest that learning cannot take place outside of these conditions, only that the research literature suggests that these conditions often set the stage for effective learning.
- Therefore, apps that recruit some or all of these pillars within a learning context are more likely to result in effective learning than those that do not.

Educational apps

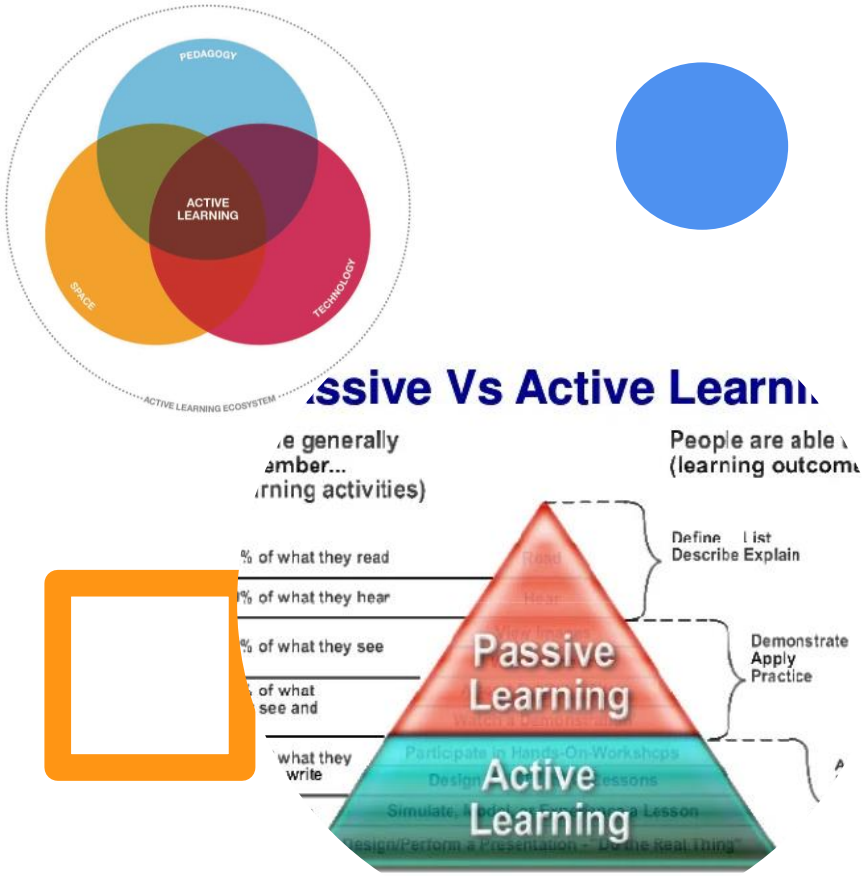
It is important to clarify what is meant by:

- "active,"
- "engaged,"
- "meaningful,"
- "socially interactive," and
- "in the service of a learning goal."

These characteristics are warranted by the literature and deserves to be further refined through additional empirical research.

Educational apps

- Active Learning examines whether an app is "minds-on," requiring thinking and intellectual effort, rather than simply engaging in cause-and-effect interactions with the app.
  - Does the app activities involve the child generating responses and ideas, versus simply reacting to on-screen stimuli?

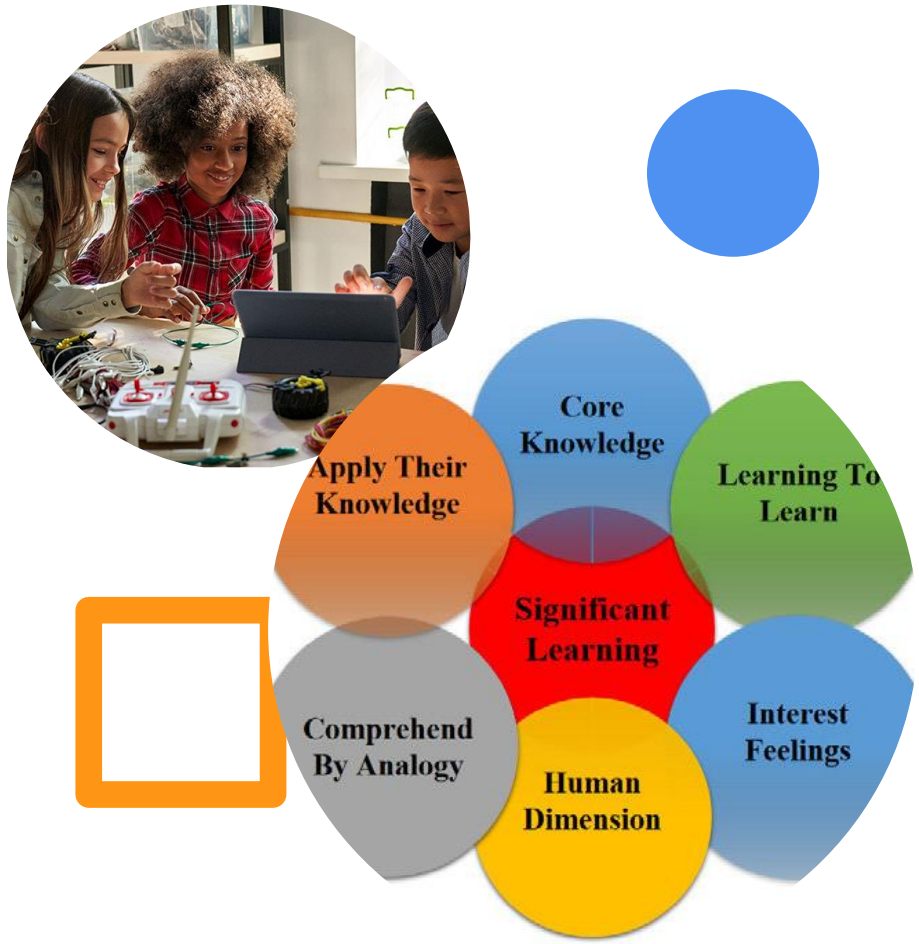


Educational apps

- Engagement in the Learning Process assesses the interactive enhancements of an app;
  - examines whether these features serve to engage the user in app activities versus distract the user, as occurs with interactive hotspots, excessive visual or sound effects, or disruptive advertisements.
- Does the interactive and gamified qualities of the app support engagement with the app's learning objectives, or potentially distract the user?

Educational apps

- Meaningful Learning examines whether the content of the app is meaningful to children's everyday experiences and is taught in a manner that can be contextualized within existing knowledge.
  - Does the presentation of the educational curriculum promote transfer of meaningful information or instructed skills to the child's life context?



Educational apps

- Social Interaction assesses the degree to which children can interact meaningfully with characters through the app interface or with caregivers around the app.
- Does the level of social interactivity promote in gameplay?
  - Social interactions may occur through co-playing with another person, or through development of parasocial relationships with characters.
  - Parasocial relationships are one-sided, emotionally charged connections with a media character which have been found to improve children's learning.

The landscape of educational apps market

Only a handful of apps are designed with an eye toward how children actually learn.

A small number of developers at both small start-ups and bigger toy/media companies have used research-based approaches with preliminary results of research.

The landscape of educational apps market

The majority of apps in today's marketplace can be considered part of the "first wave" of the digital revolution.

In this wave, apps are simply:

- digital worksheets,
- games, and
- puzzles

that have been reproduced in an e-format without any explicit consideration of how children learn or how the unique affordances of electronic media can be harnessed to support learning.

Topic Two

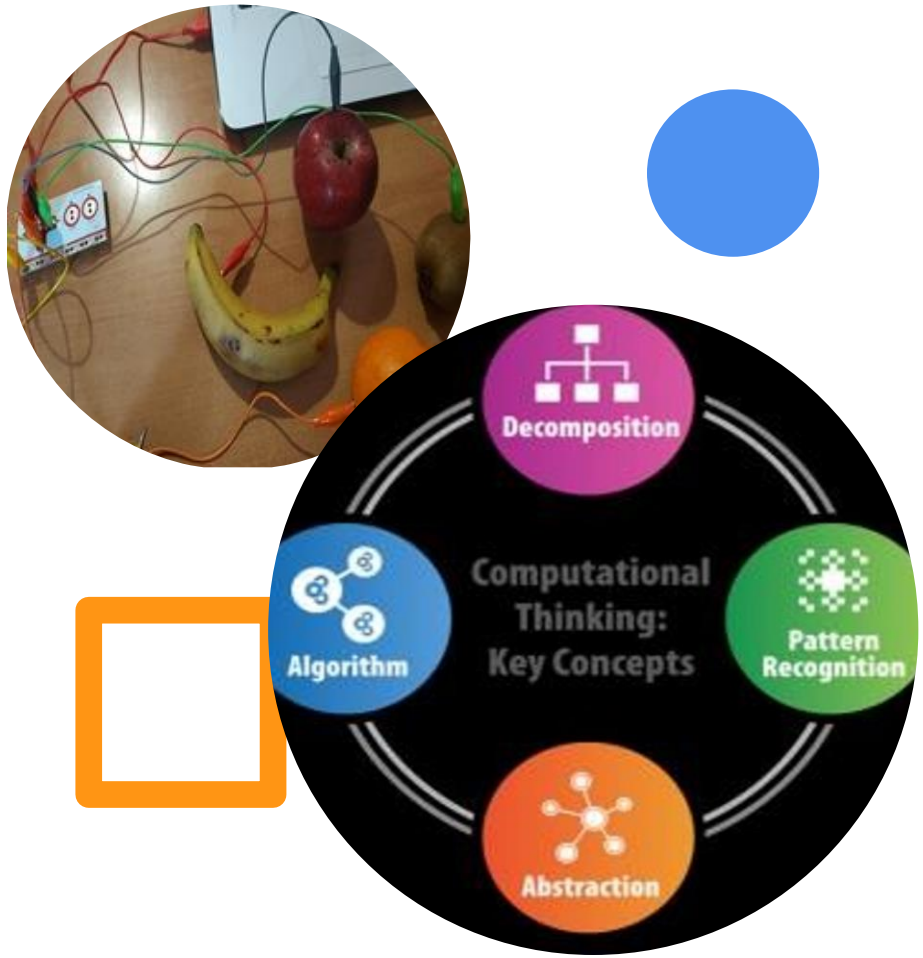
Computational Thinking or
Computational Fluency?

ScratchJr

Computational Thinking

The development of Computational Thinking (CT) skills for young children attract increasing attention (Strawhacker, Lee & Bers, 2018) as a new literacy for the twenty-first century (Bers, 2020).

- It is considered an effective way to build thinkers and innovators, engaging children in skills that translate across the disciplines and undoubtedly need them at some point in their lives (Kazakoff, 2014).



Computational Thinking

CT can be considered a general problem-solving framework involving knowledge, skills, or solving problems approaches and coding to support these concepts and tasks (Bers, 2019; Brennan & Resnick, 2012; Ching et al., 2018; Rose, 2019).

These include

- sequences,
- conditionals,
- operators, and
- variables and
- an understanding of triggers, events, and parallelism (Falloon, 2016; Nouri, Zhang, Mannila & Norén, 2020).

CT and programming's relationship can be described as follows:

- 'programming supports CT's development

while

- CT provides to programming a new upgraded role' (Tikva & Tambouris, 2020, p.7).

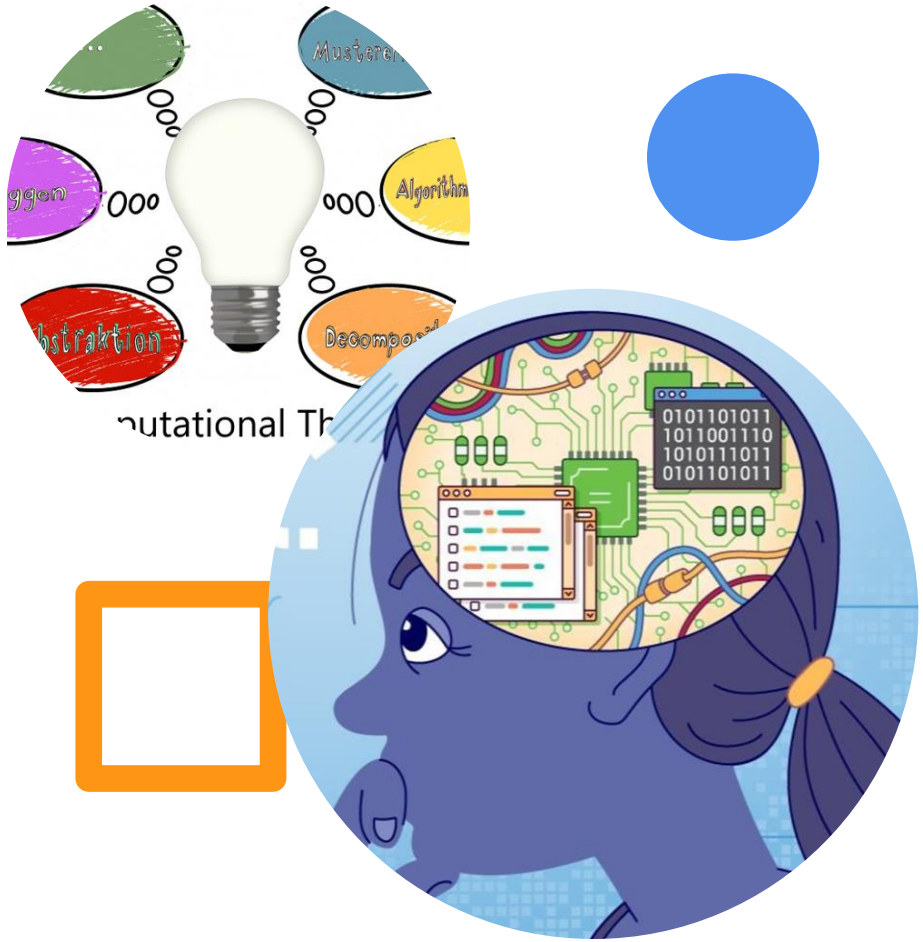
Computational Fluency

Many researchers also claim that coding in early childhood should not consider a set of technical skills but a new type of literacy and self-expression:

- which students need to function effectively in the 21st century;
- a new way for people to organize, share their ideas and express themselves (Resnick, 2017).

Seymour Papert's computational thinking involved

- problem-solving and
- the notion of expression (Bers, 2020).



Computational Fluency

Individuals become technologically fluent when they can use technology to:

- express themselves creatively in a fluent way,
- effortlessly, and
- smoothly, as one does with language (Bers, 2020).

For the reasons mentioned, researchers such as Resnick (2017) and Bers (2020) state that it is better to focus on computational fluency than computational thinking.

For Resnick, computational fluency involves:

- understanding computational concepts and
- problem-solving strategies and
- creating and expressing oneself with digital technologies.

Computational Fluency

Mitchel Resnick states (Kamenetz, 2015):

- *If you present just logic puzzles, it is like teaching them writing by only teaching grammar and punctuation.*
- *In terms of textual literacy, it would be like only giving children crossword puzzles to solve and expecting them to become fluent writers.'*

Thus, if computational thinking is to be defined as a process of problem-solving, expression, and creation, we need to provide tools that enable creating an external artifact (Bers, 2020).

The problem…

In many introductory coding activities, students are asked to code step by step the movements to navigate a virtual character through a maze toward a goal.

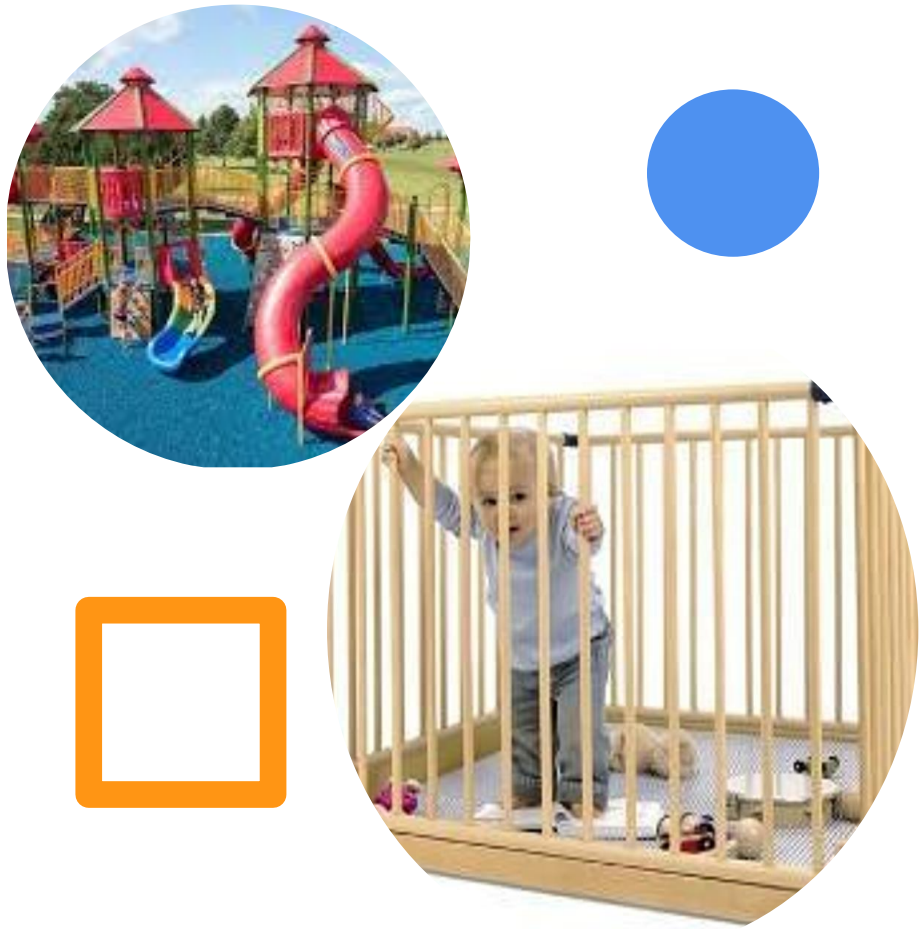
This approach is designed

- to help students learn basic science concepts,

but

- it does not allow them to:
- express themselves creatively,
- developing imagination, curiosity, and
- a long-term engagement with coding (Resnick & Siegel, 2015).

Well-designed coding apps must provide an interface that enables users to think creatively, promote problem-solving, and often work collaboratively to create or improve their projects (Hutchison, Nadolny, & Estapa, 2015).



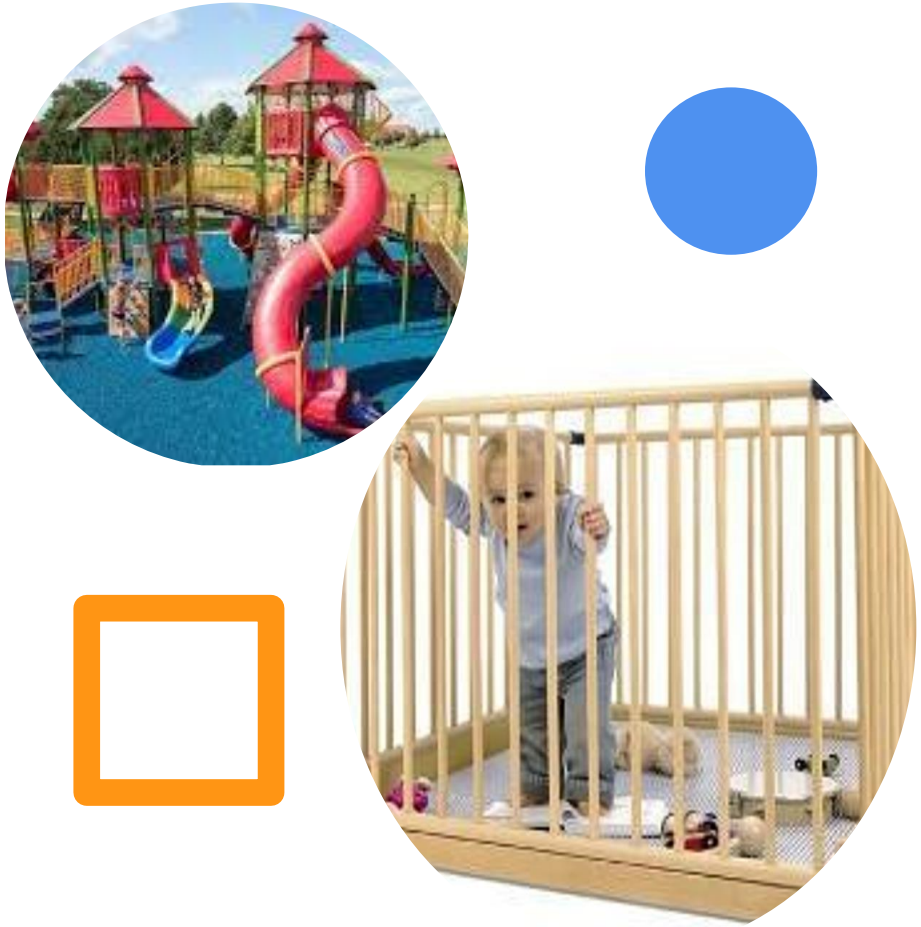
The problem…

Resnick (2003) states that computer science is well-suited for young children education as it provides a positive and effective learning environment where young children can "play to learn while learning to play" (Resnick, 2003, p.1), promoting a coding playground and not a coding playpen (Bers, González-González, & Armas-Torres, 2019).

A playpen is an environment that:

- provides children with limited opportunities to explore (Resnick, 2017).

- The coding playground promotes:
  - open-ended exploration opportunities,
  - creating personally meaningful projects,
  - imagination,
  - problem-solving,
  - conflict resolution, and
  - collaboration.



Another problem…

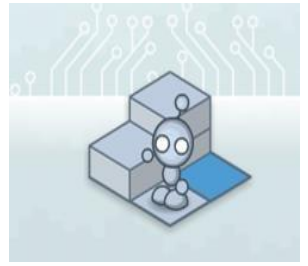
All coding apps available in the two biggest app stores claim that they have value as educational tools, but their value is undetermined.

- To date, there has been little empirical research on the effectiveness of these apps in introducing CT and CF in young children (Sheehan et al., 2019).
- Many of these apps have never been evaluated in young children, so their claims cannot be confirmed (Giannakoulas & Xinogalos, 2018; Terzopoulos, Satratzemi, & Tsompanoudi, 2019).

Appropriate apps for CT, CF, coding skills

Based on a recent research findings (Papadakis, 2022) four apps positively affect the development of Computational Thinking of young age students.

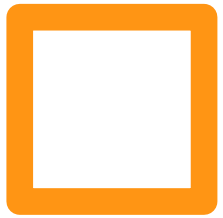
- All apps can teach young children foundational coding skills while providing a fun and enjoyable platform for practicing these skills.

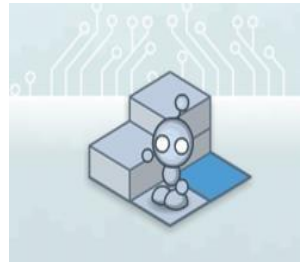


Appropriate apps for CT, CF, coding skills

Concepts		Kodable	Lightbot	Daisy the Dinosaur	ScratchJr
Abstraction and generalization	Understanding of the grid and character movement	a	a	a	a
Algorithms and procedures	Sequencing instructions to create algorithms	a	a	a	a
Data collection, analysis, and representation	The counting movement is needed using the grid	a	a	a	a
Decomposition	Breaking down and solving levels in parts	a	a	a	a
Parallelism	Blocks of instructions are executed in parallel	b	b	b	a
Debugging, testing, and analysis	Programs can be re-run to check for errors	a	a	a	a
Control structures	Conditional	a	a	b	b
	Loops	a	a	a	a

[a]*Supported concept,* -
[b]*not supported concept.*

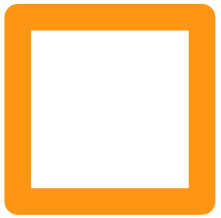


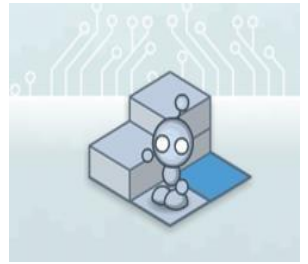


Appropriate apps for CT, CF, coding skills

Principles		Kodable	Lightbot	Daisy the Dinosaur	ScratchJr
Projects	Provide children with opportunities to work on meaningful projects (not just puzzle-solving activities)	b	b	b	a
Peers	Encourage collaboration and sharing, and help children learn to build on the work of others. Coding should not be a solitary activity	b	b	b	b
Passion	Allow children to work on projects connected to their interests. They will work longer and harder – and learn more in the process	a	a	a	a
Play	Encourage children to experiment playfully – try new things, take risks, test the boundaries, learn from failures	a	a	a	a

[a]*supported principle.*
[b]*not supported principle.*





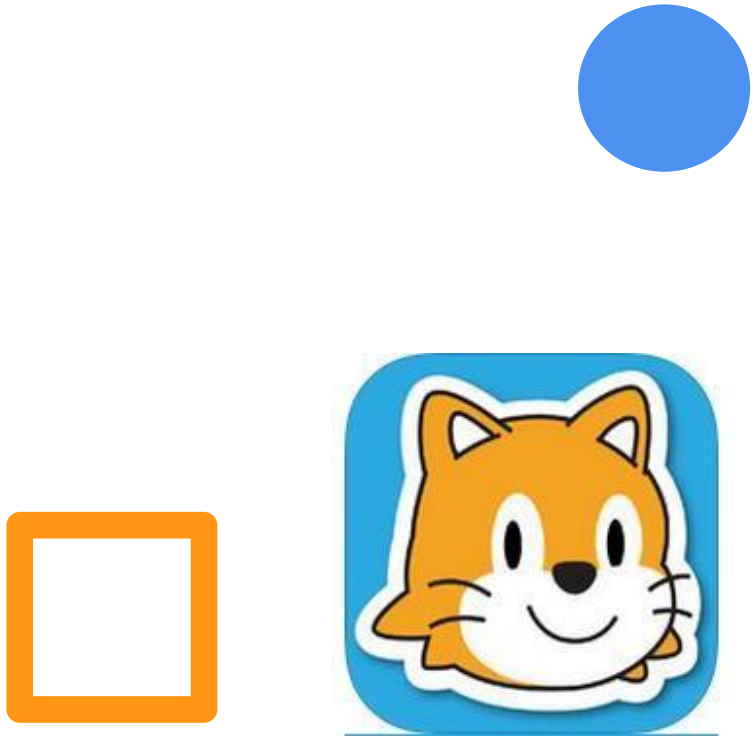
ScratchJr

ScratchJr is led by:

- Prof. Marina Umaschi Bers (Tufts University)
- Prof. Mitch Resnick (Lifelong Kindergarten Group at MIT)
- DevTech Research Group (Tufts University)

The software is also designed by:

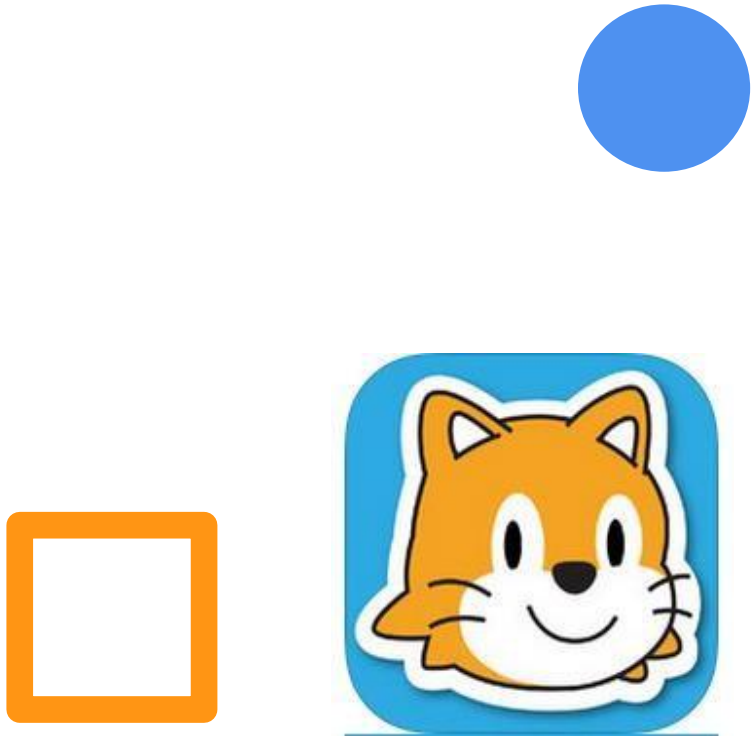
- Lifelong Kindergarten Group at MIT
- Playful Invention Company Enter what you learned here



ScratchJr

For young children:

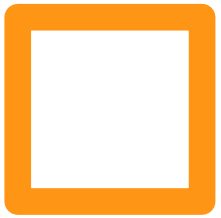
- to gain a better understanding of mathematics and literacy.
- to become familiar with classifications of various computer software and mathematical components.
- to build foundational knowledge structures across domains.
- to become better problem- solvers and thinkers, as well as gain
- a better understanding of science and software development.



ScratchJr vs Scratch

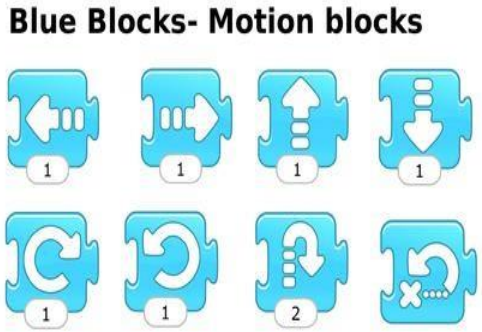
ScratchJr has many noticeable similarities to Scratch but many different features, too, at the same time:

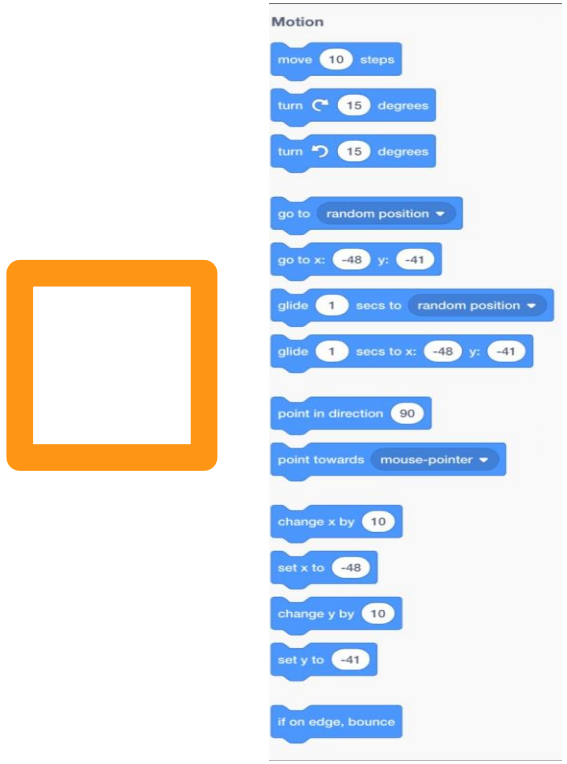
- The program is optimized for mobile devices as opposed to Scratch (v 3.0?) which is built for computers.
- The program is designed for children, thus being simpler than the Scratch program.



ScratchJr vs Scratch

- Blocks, instead of stacking top-to-bottom stack left-to-right in Scratch Jr.
- They have more similar dimensions in width and height unlike Scratch's blocks.
- Looping blocks such as "repeat" loop above and over the blocks placed within the loop.
- There are six total categories of blocks, the majority of them being present in Scratch.
- Scratch contains a larger variety of blocks as well as better control flow and usage of variables and mathematics.





SCRATCH JR
Cat

SCRATCH JR
Cat
Butterfly
Daisy
Daisy

2
4
4
4

Summary

- Young children have become keen users of mobile digital devices.
- Appropriately designed apps for young age children have the potential to teach early school CT, CF and coding skills.
- Selecting high quality educational apps for young age children is challenging.
- The children's app marketplace is currently unregulated.

References

- Papadakis, S., (2022). Can Preschoolers Learn Computational Thinking and Coding Skills with ScratchJr? A Systematic Literature Review. International Journal of Educational Reform, 1056787922107607 7.
- Papadakis, S. (2021). The impact of coding apps on young children Computational Thinking and coding skills. A literature review. Frontiers in Education, 6, 657895. https://doi.org/10.3389/feduc.2021.657895
- Papadakis, S. (2021). Tools for evaluating educational apps for young children: a systematic review of the literature. Interactive Technology and Smart Education, 18(1), 18-49. https://doi.org/10.1108/ITSE-08-2020-0127
- Papadakis, S. (2020). Apps to Promote Computational Thinking Concepts and Coding Skills in Children of Preschool and Pre-Primary School Age. In Mobile Learning Applications in Early Childhood Education (pp. 101-121). IGI Global.
- Papadakis, S., & Kalogiannakis, M. (2020). A research synthesis of the real value of self-proclaimed mobile educational applications for young children. Mobile learning applications in early childhood education, 1-19.

References

- Common Sense Media (2020) App reviews. Retrieved July 2022 from https://www.commonsensemedia.org/reviews/age/2/age/3/age/4/category/app/genre/education-58/genre/educational-games-60?sort=field_stars_rating&order=desc
- Department for Education (2020). Early years apps approved to help families kick start learning at home. Retrieved July 2022 from https://www.gov.uk/government/news/early-years-apps-approved-to-help-families-kick-start-learning-at-home
- Griffith, S. F., Hagan, M. B., Heymann, P., Heflin, B. H., & Bagner, D. M. (2020). Apps as learning tools: a systematic review. *Pediatrics*, *145*(1).
- Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in 'educational' apps: Lessons from the science of learning. *Psychological Science in the Public Interest, 16*, 3–34
- Kolak, J., Norgate, S. H., Monaghan, P., & Taylor, G. (2021). Developing evaluation tools for assessing the educational potential of apps for preschool children in the UK. *Journal of Children and Media*, *15*(3), 410-430.
- Meyer, M., Zosh, J. M., McLaren, C., Robb, M., McCaffery, H., Golinkoff, R. M., ... & Radesky, J. (2021). How educational are "educational" apps for young children? App store content analysis using the Four Pillars of Learning framework. Journal of Children and Media, 1-23.

Thank you

Dr. Papadakis Stamatios

Email: stpapadakis@uoc.gr

Online identities:

- ResearchGate: https://www.researchgate.net/profile/Stamatios_Papadakis
- Google Scholar: https://scholar.google.gr/citations?user=e3vLZegAAAAJ&hl=en
- ORCID: https://orcid.org/0000-0003-3184-1147
- Scopus: https://www.scopus.com/authid/detail.uri?authorId=57038471800