# Tools, Languages, and Environments Used in Primary and Secondary Computing Education


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# Thanks!


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# Introduction

- Tools, Languages, and Environments (TLEs) for teaching programming have been a hot-button long-debated topic in computing education for decades
- Teaching computing in K-12 has brought the same problem into those classrooms, i.e. what is “best”?, what should I use?

# Research Question

What tools, languages, and environments (TLEs) used to teach computing to primary and secondary students and teachers are most frequently studied by researchers and reported on in practice via experience reports?

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# Background

- Grover & Pea (2013) - Comprehensive review of CT in K-12 included tools used to support
  - CSTA Standards, College Board Advanced Placement (AP) Exams, CSforAll, Code.org
- ITiCSE Working Group (2018) - TLEs for introductory programming
- Census of Australian University use of TLEs (2001, 2003, 2010, 2013, 2016)

# Methodology

- Definition of TLE?
- Scratch?
- Physical Manipulatives?

Working definition: Formal materials that have been studied in research studies or mentioned in experience reports as part of the overall student experience

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# Methodology

Dataset: Articles in csedresearch.org from years 2012-2018 inclusive

Count and percentage were computed for TLEs used:

- in informal and formal learning environments across the entire dataset
- in professional development (PD) studies
- in studies of students (total), those used in research studies of students, and those used in experience reports of teaching students
- across the countries where students were located

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# Most reported TLEs in research and experience reports

Article count

(includes students & teachers as learners)?

| TLE | # | % |
|---|---|---|
| Scratch | 85 | 14.0% |
| Java | 25 | 4.1% |
| Python, AppInventor | 24 | 4.0% |
| Alice, Arduino (non-Lilypad) | 22 | 3.6% |
| CS Unplugged, Lego | 21 | 3.5% |
| Lego Mindstorms | 19 | 3.1% |
| Pololu 3PIs | 12 | 2.0% |
| Greenfoot | 11 | 1.8% |
| C#, HTML, Alice, Lego NXT, Processing | 8 | 1.3% |
| AgentCubes, CSS, Snap!, Logo | 7 | 1.2% |

N=605

Number of learners

(includes students & teachers as learners)?

| TLE | # | % |
|---|---|---|
| Scratch | 116,723 | 55.9% |
| AgentSheets | 11,064 | 5.3% |
| AgentCubes | 10,413 | 5.0% |
| Alice | 7,393 | 3.5% |
| Java | 6,751 | 3.2% |
| CSS | 6,673 | 3.2% |
| Python | 6,354 | 3.0% |
| Arduino (Not LilyPad) | 6,163 | 3.0% |
| Bebras Challenge | 6,081 | 2.9% |
| Greenfoot | 6,001 | 2.9% |

N=208,806

# Most reported TLEs in research and experience reports

Article count

Primary & Secondary Students Only

| TLE | # | % |
|---|---|---|
| Scratch | 77 | 14.4% |
| Java | 24 | 4.5% |
| AppInventor | 21 | 3.9% |
| Arduino (not LilyPad), Python | 20 | 3.7% |
| Alice, CS Unplugged | 17 | 3.2% |
| Lego Mindstorms | 15 | 2.8% |
| Greenfoot, Pololu 3PIs | 10 | 1.9% |
| C#, Processing, HTML, Alice 2.2 | 8 | 1.5% |
| CSS, Logo, Lego NXT, AgentCubes, Snap! | 7 | 1.3% |
| EarSketch, JavaScript, LilyPad Arduino | 6 | 1.1% |

N=535

Number of learners

Primary & Secondary Students Only

| TLE | # | % |
|---|---|---|
| Scratch | 116,723 | 55.9% |
| AgentSheets | 11,064 | 5.3% |
| AgentCubes | 10,413 | 5.0% |
| Alice | 7,393 | 3.5% |
| Java | 6,751 | 3.2% |
| CSS | 6,673 | 3.2% |
| Python | 6,354 | 3.0% |
| Arduino (Not LilyPad) | 6,163 | 3.0% |
| Bebras Challenge | 6,081 | 2.9% |
| Greenfoot | 6,001 | 2.9% |

N=208,071

# Most reported TLEs in research studies

Article count

Primary & Secondary Students Only

| TLE | # | % |
|---|---|---|
| Scratch | 45 | 18.5% |
| AppInventor, CS Unplugged | 12 | 4.9% |
| Alice | 10 | 4.1% |
| CS Unplugged, Lego Mindstorms, Python | 7 | 2.9% |
| C# | 5 | 2.1% |
| CSS, Logo, Snap!, Lego NXT, Kodu | 4 | 1.6% |

N=243

Number of learners

Primary & Secondary Students Only

| TLE | # | % |
|---|---|---|
| Scratch | 13,953 | 18.6% |
| AgentCubes, AgentSheets | 10,000 | 13.3% |
| Alice | 6,731 | 9.0% |
| CSS | 6,648 | 8.8% |
| Java | 6,240 | 8.3% |
| Greenfoot | 5,878 | 7.8% |
| CS Unplugged | 1,720 | 2.3% |
| Bootstrap | 1,674 | 2.2% |
| C# | 1,337 | 1.8% |
| Jypeli | 1,018 | 1.4% |

N=75,196

# Most reported TLEs in experience reports

Article count

Primary & Secondary Students Only

| TLE | # | % |
|---|---|---|
| Scratch | 32 | 11.0% |
| Java | 17 | 5.9% |
| Python, Arduino (not LilyPad) | 13 | 4.5% |
| AppInventor | 9 | 3.1% |
| Lego Mindstorms | 8 | 2.8% |
| Pololu 3PIs, Greenfoot, Alice | 7 | 2.4% |
| Processing | 6 | 2.1% |
| C++, CS Unplugged | 5 | 1.7% |
| Alice 2.2, HTML, AgentCubes | 4 | 1.4% |

N=290

Number of learners

Primary & Secondary Students Only

| TLE | # | % |
|---|---|---|
| Scratch | 102,580 | 77.0% |
| Bebras Challenge | 6,081 | 4.6% |
| Python | 5,941 | 4.5% |
| Arduino (not LilyPad) | 5,869 | 4.4% |
| AppInventor | 1,126 | 4.4% |
| AgentSheets | 1,057 | 0.8% |
| Scalable Game Design | 894 | 0.7% |
| Alice 2.2 | 656 | 0.5% |
| Alice | 600 | 0.5% |
| Java | 507 | 0.4% |
| Pololu 3PIs | 438 | 0.3% |

N=133,274

# Most reported TLEs in experience reports

Article count

Teacher PD Only

| TLE | # | % |
|---|---|---|
| Scratch | 8 | 10.8% |
| Alice | 5 | 6.8% |
| CS Unplugged, Lego Mindstorms, Python | 4 | 5.4% |
| AppInventor | 3 | 4.1% |
| Java, Bebras Challenge, Arduino (not LilyPad), Alice, Lego NXT-G, Polulo 3PIs, Scratch Jr., Microsoft Kinect, Google Drive | 2 | 2.7% |

N=75

Number of learners

Teacher PD Only

| TLE | # | % |
|---|---|---|
| Scratch | 299 | 47.3% |
| CS Unplugged | 71 | 11.2% |
| NetLogo | 66 | 10.4% |
| Alice | 62 | 9.8% |
| HTML | 32 | 5.1% |
| Python | 22 | 3.5% |
| Moodle | 19 | 3.0% |
| Stencyl | 16 | 2.5% |
| AgentCubes, AgentSheets, Scalable Game Design | 7 | 1.1% |
| Lego Mindstorms, Lego NXT-G | 5 | 0.8% |

N=635

# Discussion & Limitations

- Confirms findings from Grover & Pea (2013)
- Confirms that Scratch is the most vetted TLE across a cross-section of grades (including teachers)

- Limitation: Data in research papers and experience reports and curated in csedresearch.org

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# Discussion & Limitations

- What types of studies are still needed with respect to tools, languages, and environments to understand their efficacy in primary and secondary settings?
    - How can we map existing TLEs against K-12 standards to find gaps based on the needs of primary and secondary computing education?
- What would a current, comprehensive taxonomy/ontology for classifying TLEs look like as computing education expands in to K-12?
    - Construction of a Taxonomy for Tools, Languages, and Environments across Computing Education - ICER 2020

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# Conclusion

- It is important to understand the impact of TLEs on academic achievement, including social-behavioral factors like self-efficacy and sense of belonging
- It is also important to understand the context in which TLEs are used (e.g., topics, student demographics).
- This study serves as a basis for future work.

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# Thank you! Questions?

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