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# What do we know about computing education for K-12 in non-formal settings? A systematic literature review of recent research

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# Outline

- Rationale
- Aims
- Method
- Results
- Conclusions and implications

# Rationale

- Providing opportunities for young people to develop knowledge, skills and enjoyment of computing is becoming increasingly important
- Formal computing provision in schools differs greatly between countries
- Non-formal learning can become a way to overcome limitations of formal teaching opportunities
- Studies on non-formal computing education have tended to be inconsistent in reporting findings, particularly relating to learning outcomes

  For example, our initial literature search found:

  - Inconsistent reporting of formal/informal learning contexts
  - Lack of detailed reporting on the impact measures of non-formal CEd
  - Sometimes a focus on one type of programming activity

# A definition of non-formal education

Non-formal education can be defined as

> “institutionalised, intentional and planned by an education provider. The defining characteristic of non-formal education is that it is an addition, alternative and/or complement to formal education within the process of life-long learning of individuals"
>
> (UNESCO, 2012, p11).

# Aims

Our aims were to:

- Provide an overview of recent research in non-formal computing education with young people of school age
- Understand the goals, methods and impacts of non-formal computing education
- Provide a starting point for more rigorous research in this area
- Set a research agenda on non-formal learning in computing

# Research Questions

1. RQ1: What has been the focus of non-formal computing education research in terms of
   a) the learners engaged in the activities?
   b) the purpose of the activities and who provides them?
   c) the computing topics covered?

2. RQ2: What impact does non-formal computing education have on learners according to the research?
   a) Cognitive impact
   b) Affective impact
   c) Wider impact

# Scope

Learners aged 5-18

Physical settings (not online or hybrid)

Regular (> 4 sessions) or immersive (at least 5 hours)

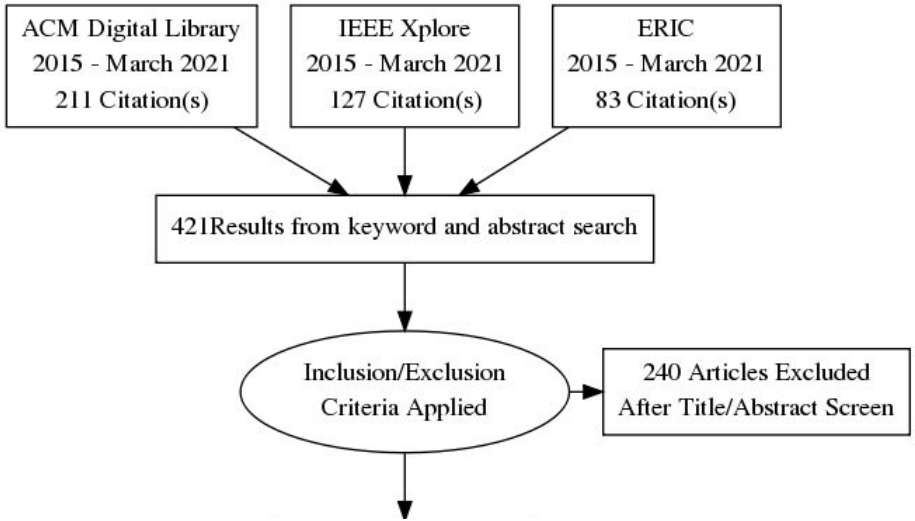
Non-formal setting (supplement to everyday school lessons)

Published since 2015

Focus on teaching computing

Report on substantive qualitative or quantitative data to measure impact

# Method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Inclusion/Exclusion
Criteria Applied
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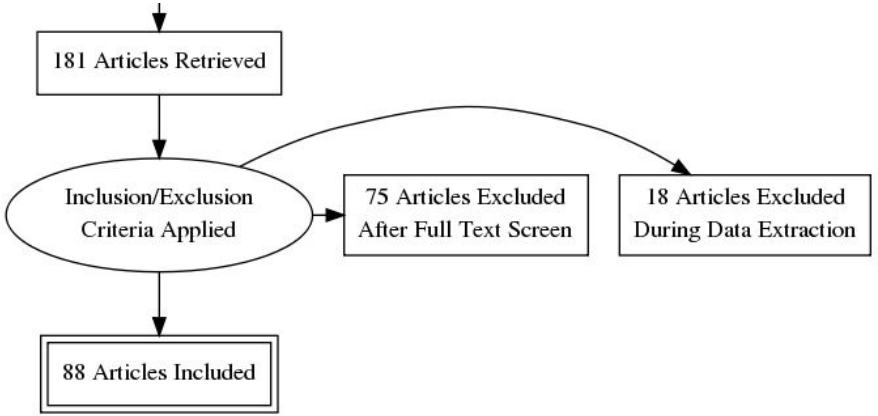
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Inclusion/Exclusion
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75 Articles Excluded
After Full Text Screen
18 Articles Excluded
During Data Extraction
88 Articles Included

# Limitations

- Covered just 6 years of studies
- Only 3 databases focusing on computing, rather than maker, engineering or learning sciences
- Representative and systematic rather than exhaustive
- Much of the research included appeared to be by institutions reviewing interventions they ran, rather than being run by other educators
- The wide ecosystem of non-formal may not be being researched

# Results

RQ1: What has been the focus of non-formal computing education research?

**a) Learners**

- Most studies in the US (then the UK)
- Lower secondary age group was most common (n=43), then upper high school (n=35)
- Few studies focused on primary age group (n=9)
- More female-only cohorts (n=32) than male-only cohorts (n=1)
- Focus on broadening participation (inc. black or African American females, Latina females, girls of colour, minority youth and boys) (n=37)
- Lack of detail on socioeconomic status
- Few studies reporting about students with disabilities

| Cohort mix | No. of studies |
|---|---|
| All female | **32** (36%) |
| All male | **1** (1%) |
| Mixed, more female | **12** (14%) |
| Mixed, more male | **28** (32%) |
| Mixed, even | **4** (5%) |
| Unspecified | **14** (16%) |

# Results

RQ1: What has been the focus of non-formal computing education research?

**b) Providers and purpose of non-formal activities**

- Most studies were University-organised (n=81)
- Some work by non-profit organisations, tech companies, makerspaces, etc.
- Most studies (n=67) took place in immersive multi-day settings (e.g. summer camps) with fewer regular events (n=21) and few one-off events (n=2)
- Purpose and outcomes of their participation differ:
  - Broadening participation of under-represented groups (n=37)
  - Interest development (n=27)
  - …

**c) Computing topics**

- Most studies focused on programming (n=26) followed by mobile apps (n=17) and making games (n=15)

# Results

RQ2: What is the impact of non-formal computing education on learners?

**a) Cognitive measures**

- Cognitive outcomes measured included knowledge (n=13) and skill (n=17) development
- Measurement approaches included pre-post tests and focused case studies

**b) Affective measures**

- Affective outcomes measured included:
  - Interest (n=22)
  - Perception (n=14)
  - Engagement (n=13)
  - Self-efficacy (n=25)
  - ...
- Measurement approaches included surveys and interviews

# Results

RQ2: What is the impact of non-formal computing education on learners?

**c) Wider impact**

- Wider impact measures were of intention further study the subject (n=6) and societal (n=2)
- Measurement was with the number of applications for tertiary study, interviews and field notes.

# Conclusion

- Broadening participation of underrepresented groups in computing was the most common goal (females but also ethnic minorities, students in low-income areas)
- Most studies used quantitative methods (for both cognitive and affective measures) to report outcomes
- Non-formal computing education was programming-heavy for the included studies
- We suggest affordances of non-formal computing may include:
  - Access and awareness
  - Cultural relevance and equity
  - Practice and personalisation
  - Fun and engagement
  - Community and identity
  - Immediate impact

# Implications

- For formal teaching, findings about non-formal settings may be useful
  - Indication that open tasks may be particularly effective for learning and engagement in non-formal settings
  - Active teaching of problem solving  in non-formal settings can lead to independence
- More research is needed to understand regular after-school non-formal learning experiences
- Need to carefully design programmes to achieve targeted outcomes for specific learners in non-formal settings

# Next steps

We suggest future research should:

- Be more consistent and transparent in its reporting
- Measure the impact of both specific and regular non-formal computing education opportunities
- Provide more detailed qualitative analyses to investigate the key factors that can lead to significant changes in outcomes
- Study learning in different contexts around the world (to support a wider range of young people in difficult circumstances to become digital creators and innovators)

# Questions?

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