Computational Thinking in Libraries:
Case Studies of Youth Programs in Action

LIBRARIES READY TO {CODE}

AN INITIATIVE OF THE AMERICAN LIBRARY ASSOCIATION

about the authors

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Marijke Visser is Senior Policy Advocate at the ALA Washington Office. Her portfolio includes issues related to youth and technology as well as telecommunications policy. In her role in the Public Policy Unit of ALA, Marijke advocates for policies at the federal level that advance equitable access to information. Her advocacy raises the awareness of decision makers of the role of libraries in education, employment and entrepreneurship, civic engagement, and individual empowerment.

A full-text PDF of this case study report is available as a free download from: http://librariesreadytocode.org/

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Introduction

What is Libraries Ready to Code (RtC)?

Google's Computer Science Education team and the American Library Association created Libraries Ready to Code - an initiative based on a mutual belief that computer science isn't just about coding, it is also about computational thinking, an essential form of literacy. Literacy in all forms is at the core of library missions. Outcomes of the collaboration include: LibrariesReadytoCode.org, an online set of resources created in partnership with 30 libraries to provide guidance for libraries to facilitate coding and computational thinking programs for youth. We encourage starting with strategies and how-tos, learning more about computational thinking, and building on the skills you already have.

What is Computational Thinking?

Computational thinking (CT) refers to the thought processes used to formulate problems and their solutions (Wing, 2006). These include breaking down problems into smaller parts, looking for patterns, identifying principles that generate these patterns, and developing instructions that the computers, machines and people, can understand. It is an approach to critical thinking that can be used to solve problems across all disciplines (Google's Exploring Computational Thinking, n.d.).

In this document, the CT skills of the program facilitators are identified by three levels of expertise: (1) basic/developing; (2) intermediate; and (3) advanced.

Wing, J. (2006), "Computational Thinking", *Communications of the ACM*, Vol. 49 No. 3, pp. 33-35.

Google for Education. (n.d.). Exploring computational thinking. Retrieved from https://edu.google.com/resources/programs/exploring-computational-thinking/
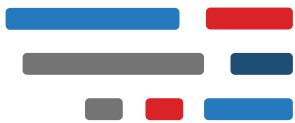
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WHAT?
Libraries Ready to Code provides computational thinking and computer science activities for libraries supported by learning pathways and professional development.

HOW?
Learn more by visiting **librariesreadytocode.org** for resources and inspiration.

WHY?
The data shows that support for computational thinking skills, problem solving, and creativity is needed.

WHO?
Libraries Ready to Code is for all youth and the library staff who support them.

Outlook
Computer science jobs pay **40% more** than the average starting salary.

Demand
90% of parents want their children to learn computer science but **only 35% of high schools** teach it.

Inequity
Girls are 10 times more likely, and **people of color and indigenous people** are 7 to 8 times more likely, to major in computer science if they try it in high school.

Need
Computational thinking is a fundamental skill set that includes finding patterns and solving problems, yet only **37% of students** say they have learned computational thinking at school.

Opportunity
Computing jobs are the **number one source of new wages** in the U.S.

"Libraries are places of lifelong learning to learn and understand new things youth may not have access to. In a community with a large minority population without access to computers, it can be really daunting. Libraries provide computational thinking in a way that even if you are not going to go into computer science you can think like a coder... Libraries are special places because we have kids of all ages so we can really reinforce things that are relevant to the community."

Cheryl Eberly
Youth Services Supervisor
Santa Ana Public Library
Santa Ana, California

What are the RtC Facilitation Pathways?

There are five RtC facilitation pathways, or key themes, found to be critical in facilitating computational thinking (CT) learning for youth. The five pathways are explained below. Each pathway has 4 stages of development: recognize, learn, implement, and communicate.

Broadening Participation focuses on recognizing, learning, implementing, and advocating for equitable and inclusive CT learning environments.

Connecting Youth Interests & Emphasizing Youth Voice centers on recognizing, learning, implementing, and advocating for CT programs that incorporate youth's unique interests and voices.

Engaging with Communities emphasizes recognizing, learning, implementing, and advocating for various community members, organizations, and stakeholders to collaborate with in planning and implementing CT activities for and with youth.

Engaging with Families focuses on recognizing, learning about, implementing, and advocating for the role and participation of families in CT library activities.

Demonstrating Outcomes Through Impact emphasizes recognizing, learning, implementing, and advocating for the need to measure and demonstrate the impact CT programs have on youth, families, libraries, and the community.

Case Studies

NOTE: We use the term *learners* to refer to youth who are participating in RtC programs in schools as this is how school librarians refer to youth. We use the term *youth*, *children*, and *teens* in programs that are in public libraries, reflecting how public librarians refer to the youth in their programs.

Design Engineers Club
Rochester City School Libraries
New York

Overview of Program

The Design Engineers Club is a 10-week afterschool club for 5th and 6th grade learners at the Rochester International Academy (RIA) and the Montessori Academy held once a week for 2 hours each week at RIA in the Edgerton neighborhood. The goal of the Design Engineers Club was to provide access to a variety of engineering-infused computational thinking (CT) programs for multicultural learners of color who are refugees, English Language Learners (ELLs), and/or living in conditions of poverty. It was run by 2 school librarians and the district library director in the Rochester City School District. Learners worked in teams to learn about and engage in the design thinking process (a non-linear, iterative process used to solve problems) and participated in solving engineering problems with different tools. Learners also attended field trips to the Rochester Institute of Technology (RIT), including a field trip to Imagine RIT where they explored engineering exhibits and another field trip where the girls participated in the WE Explore program to explore the engineering design process. The program culminated with a showcase at the local public library.

AT-A-GLANCE

Age range: 9-14

Duration of program: 10 weeks, 2 hours each week

RtC pathways addressed:
- broadening participation
- youth interest & voice
- engaging with communities

Community partnerships:
- RIT
- local public library

Project staff:
- 2 school librarians
- Director of Rochester City school libraries

CT experience: Intermediate

> Making the connections with existing programs at RIT and using the library as a conduit for providing my students access to these programs is the most important takeaway from this project.

Community Profile

- Median household income: $31,684
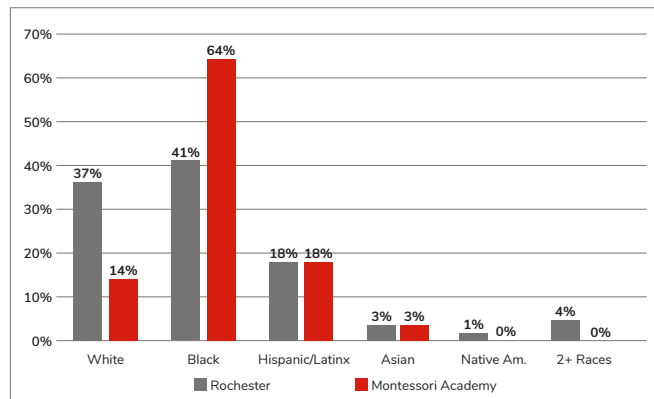- Population: 208,046
- Persons in poverty: 33%
- Persons under 18: 31%

Library Profile

- Type: school
- Location: urban
- Populations served: refugees, ELLs, minorities

	White	Black	Hispanic/Latinx	Asian	Native Am.	2+ Races
Rochester	37%	41%	18%	3%	1%	4%
Montessori Academy	14%	64%	18%	3%	0%	0%

Session Snapshot

During one afterschool session in which learners were given the task to fly a drone through a hula hoop, the group first discussed various uses for a drone, including taking pictures at soccer events (a popular sport at the school). They talked about how drones have been used as weapons in some countries, emphasizing that the drone they will use is safe and only equipped with a camera. Then, one of the session facilitators brought out the hula hoops and asked how they are used in other countries (e.g. rolling it as a game with a stick) and explained that learners will use the hula hoop as a target to fly the drone through.

The first activity used manual controls on an iPad using Tickle controls to navigate the drone through the hoop. The second activity was to program the take-off and flight path of the drone through the hoop. It took the learners multiple tries, but they all were able to get the drone through the hoop. Each learner was fully engaged on his/her turn and they all cheered each other on as they each attempted to maneuver the drone through the hula hoop.

Resources and Tools Used

- Tinkercad for designing 3D artifacts for printing
- Drones and Tickle iPad controller app to work through block-based programming
- Session plans for program

Connection to RtC Pathways

Broadening Participation
- Incorporated students' first languages and cultural experiences and knowledge into activities
- Addressed safety and transportation challenges through bussing learners to and from participation sites
- Budgeted for a translator to join learners on field trip

Connecting Youth Interests & Emphasizing Youth Voice
- Learners were given opportunites to showcase and share their work

Engaging with Communities
- Took field trips to the RIT
- Participated in a culminating showcase at the local public library where students shared 3D printed objects of their engineering projects

> **When walking through a hallway of pictures of engineers on the walls who had gone to RIT, the kids went over there, and one girl said, "I'm gonna be up here."**

Teens Teach Tots
Maryvale High School Library
Arizona

Overview of Program

Maryvale High School offers a year-long, 2-semester elective course called Early Childhood Education (ECE) as part of their Family and Consumer Science (FCS) program. In the course, learners learned about child development, developed literacy and numeracy activities infused with computational thinking (CT) appropriate for preschool-aged children, and implemented the activities with selected local preschoolers. In collaboration with the ECE teacher, the school librarian designed and taught the developmental literacy aspects of the course, which includes the sequence of how young children learn to read. The five FCS classes taught during the 2017-18 school year also incorporated CT as a literacy—teens learned about CT and developed and implemented a CT activity for preschoolers. The goal of the Teens Teach Tots program is to bring CT to more students at Maryvale HS and to spread CT knowledge throughout the community. Approximately 130 high school learners in grades 9-12 completed the course. 17 preschool learners were engaged in 12 days of CT activities that were developed by the high school learners over the course of 6 weeks. A final weekend showcase event was hosted in the school library for parents and siblings to attend.

AT-A-GLANCE

Age range: 14-18

Duration of program: 1 semester course

RtC pathways addressed:
- broadening participation
- youth interests & voice
- engaging community
- engaging families

Community partnerships:
- classroom teachers
- local public librarians

Project staff:
- 1 school librarian

CT experience: Advanced

> The preschool and child development classes need to modernize. It's not just taking the kids out and bouncing the ball to each other, but the teens need to learn [computational] thinking skills and pass those on to the little kids.

Community Profile

- Median household income: $54,496
- Population: 1,626,078
- Persons in poverty: 22%
- Persons under 18: 33%

Library Profile

- Type: school
- Location: urban
- Populations served: Latino/a

	White	Black	Hispanic/Latinx	Asian	Native Am.	2+ Races
Phoenix	44%	7%	42%	4%	2%	3%
Maryvale HS	3%	4%	91%	0%	1%	1%
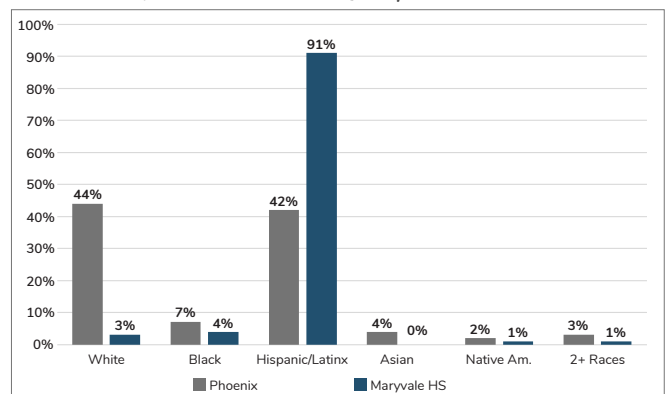
Session Snapshot

Learners, in teams or individually, were tasked with creating interactive activities for preschoolers that focused on one of the main components of CT (abstraction, algorithmic thinking, pattern recognition, or decomposition). Activities could be done on the floor, at tables, or at computer stations.

Working as a team, two learners demonstrated their lesson on pattern recognition to the rest of the class. They passed out maracas and played a song about shaking maracas and following along with the rhythm, encouraging the rest of the class to participate in shaking their maracas. After the performance, they asked the class what patterns were repeated in the song. When asked how they came up with their lesson idea, learners noted that music is a universal language that everyone, including kids, can recognize patterns in.

Resources and Tools Used

As needed in each session, such as:
- musical instruments like maracas
- technology tools such as Code-a-pillar, Cubetto, tracking mice, and a 3D printer
- toys and games like puppets and dominoes

Connection to RtC Pathways

Broadening Participation
- Incorporated CT into a non-tech elective course

Connecting Youth Interests & Emphasizing Youth Voice
- Learners selected or created their own materials and designed activities to work with preschoolers
- Learners had opportunities to share their work through the showcase

Engaging with Communities
- Engaged school administrators, STEM teachers and students, local public librarians, and local politicians to see the high school learners in action, especially at their showcase event

Engaging with Families
- Invited families in the neighborhood to the showcase event and shared a handout on CT with these families

> **All students took notes and participated in discussion [about CT]. The "lightbulbs" went off when they realized how much they use code/decoding in their school day.**

Partners in Technology
Normal Public Library
Illinois

Overview of Program

The Partners in Technology program matched and supported pairs of 10 to 14-year-old youth and adults in the community to work together on joint computational thinking (CT) projects and learning. The goal of the Partners in Technology program was to offer developmental, or psychosocial, mentoring to enhance the social, emotional, and academic skills of youth participants.

Adult/youth pairs met at the library for 45-minutes once a week for 8 weeks. Adult mentors were professionals and graduate students recruited from local businesses and universities. To sign up, youth were asked to identify a technology project, tool, or topic they were interested in.

The librarian guided the matching process, monitored activities, provided resources as needed, and created a website with curated resources to guide pairs through potential scaffolded activities on different technology topics. Regular feedback and a mentor reflection session allowed staff to support the working pairs from week to week.

AT-A-GLANCE

Age range: 10-14

Duration of program: 8 weeks, 45 minutes each week

RtC pathways addressed:
- broadening participation
- youth interests & voice
- engaging community
- demonstrating outcomes

Community partnerships:
- professionals in local businesses
- graduate students from local universities

Project staff:
- 1 public librarian

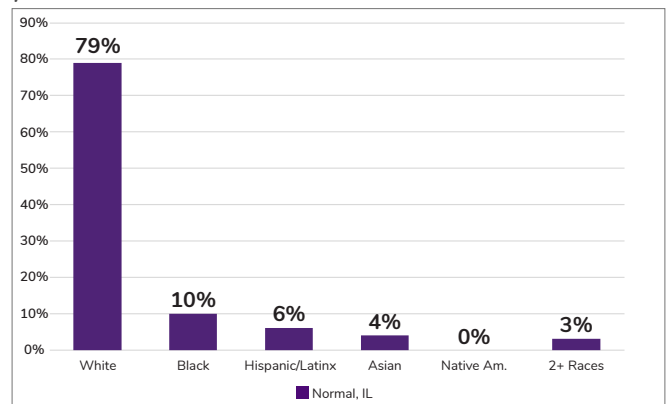**CT experience:** Basic/developing

> Exploration is a hallmark of Partners in Technology. Partners are encouraged to challenge themselves to try out new things, even if neither has any previous knowledge or experience, learning and growing in their understanding together.

Community Profile

- Median household income: $54,496
- Population: 54,284
- Persons in poverty: 22%
- Persons under 18: 23%

Library Profile

- Type: public
- Location: suburban

Bar chart — Normal, IL:
- White: 79%
- Black: 10%
- Hispanic/Latinx: 6%
- Asian: 4%
- Native Am.: 0%
- 2+ Races: 3%

Session Snapshot

On a Wednesday evening from 3:00-6:30 PM, four different Partners in Technology pairs met at small tables in the children's section of the library reserved for them. Pairs used laptops to look through potential activities before deciding on what they wanted to work on. There were 4 youth/mentor pairs: (1) A girl and a CS professor who worked on a Javascript activity; (2) A girl and a graphic designer who developed simple Scratch games from a book the mentor purchased; (3) A girl and an Art Education graduate student who worked on TinkerCad; and (4) A boy and a Tech Administrator at a local university played around with an Arduino circuit board and a Raspberry Pi using Python.

Mentors often prompted their mentees on what to do. One asked, "Any questions you have on this, or anything you want to do in our final week? We could go back to something you liked? We've done a lot! There's more Scratch books we could check out or LEGO WeDo we could make or the bot we could use." Another said, "I know last time we did circuits. Do you want to keep doing that?"

Resources and Tools Used

- Online lesson plans from Sphero, Ozobot, and others to get ideas on activities for programming
- Tech tools based on students' interest, including TinkerCad, Scratch, Raspberry Pi, and Arduino circuit boards

Connection to RtC Pathways

Broadening Participation
- Used various strategies in outreach efforts to recruit a range of youth and mentors

Connecting Youth Interests & Emphasizing Youth Voice
- Gave community mentors freedom and let youth lead in what they wanted to learn
- Emphasized youth interest-driven programming and production-oriented work

Engaging with Communities
- Gathered community input and used existing successes to guide new library programming

Demonstrating Outcomes Through Impact
- Collected regular feedback from mentors and youth participants and made changes based on the feedback

> **Even beyond just the work that they've been doing, whether they were doing in Scratch or JavaScript or whatever, the relationships are really important to me... Pretty much everyone said they would do it again, somebody said they were 110% likely to do it again.**

The Road to Code
Waseca Public Library
Minnesota

Overview of Program

The Road to Code was a systemwide approach to providing computational thinking (CT) opportunities for youth in the community served by the Waseca-Le Sueur Public Library System. The goal of The Road to Code program was to introduce and develop CT skills in youth ages 3 to 15. The initiative was implemented via three program strands at the central library.

The three programs were:
- *Little Coders* for 3- to 6-year olds and their caregivers to try out unplugged activities and simple technology games;
- *Level Up* for 7 to 12-year-olds to develop more sophisticated skills through project-based activities; and
- *Creator Studio* for ages 10 to 15 to work with program staff and mentors to focus on projects related to robotics and game design as well as giving them exposure to career paths that involve CT skills.

Outreach and support for branch libraries and staff was provided through professional development and distributable program kits.

AT-A-GLANCE

Age range: 3-15

Duration of program: ongoing

RtC pathways addressed:
- broadening participation
- youth interests & voice
- engaging families
- demonstrating outcomes

Community partnerships:
- IT professionals

Project staff:
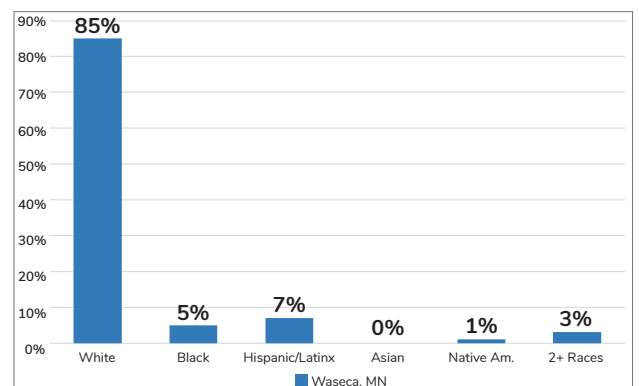- 3 public librarians

CT experience: Advanced

> These kids have had the opportunity to use their imagination...Any time we had a program, they're working through problem solving skills, they're prototyping and testing and reflecting and editing and they were all learning skills no matter which class they were going through.

Community Profile

- Median household income: $45,345
- Population: 8,978
- Persons in poverty: 10%
- Persons under 18: 28%

Library Profile

- Type: public
- Location: rural
- Populations served: rural

Bar chart — Waseca, MN:
- White: 85%
- Black: 5%
- Hispanic/Latinx: 7%
- Asian: 0%
- Native Am.: 1%
- 2+ Races: 3%

Session Snapshot

In a session of Little Coders, the librarian lined up the children and told them they were going to do some dancing. She organized 4 color dots in a row on the easel. Each color was associated with a dance move. She had the children sequentially do each move. Then they did the sequence with music, with the librarian calling out the colors and moves. She then put up a new row of colored dots and asked the children to identify what to do next for each color, calling on different children to give each child a turn. They ran through the dance sequence - once without music and then with music. The next two times the children designed the sequence; the librarian asked what color to add, identified each move, and then did the move to music. The children laughed and danced as they watched the librarian and each other for cues on what dance moves to do according to the sequence they were following.

For the second activity, the librarian gave each child one piece of a 3-part sequential puzzle and asked them to find the other pieces which were hidden around the room. Children ran around the room grabbing pieces, as the librarian asked them questions about what comes next in the sequence. The children seemed adept at doing this without much assistance. Caregivers helped them translate pictures into a story sequence (e.g. an egg and a baby frog and a frog into an egg turns into a baby frog that grows into a frog) or finding the right words (e.g. a tadpole instead of a baby frog).

Resources and Tools Used

- For younger kids: Cubetto, sequencing puzzles, block building using pattern recognition
- For older kids: Sphero, Scratch, Kano Motion Sensor

Connection to RtC Pathways

Broadening Participation
- Developed system-level program kits for all library branches and provided professional development in RtC concepts to branch library staff

Connecting Youth Interests & Emphasizing Youth Voice
- Implemented peer-to-peer learning and problem-based activities to allow for freedom and progress

Engaging with Families
- Created new forms of outreach and communication with parents to teach them about effective uses for screen time and the benefits of learning coding and CT
- Developed take-home materials for families to encourage learning and extension of CT activities at home.

Demonstrating Outcomes Through Impact
- Garnered regular feedback from library staff, caregivers, and youth and made iterative changes to kits based on this feedback

> **Little Coders really introduced CT skills to parents and I think that's a group that can grow for years now 'cause we're starting when they're so young... We're just sort of raising awareness of these topics and their place in our community.**

Image Credits

Design Engineers Club photos: Courtesy of Caitlin K. Martin

Teens Teach Tots photos: Courtesy of Jean Kilker and Caitlin K. Martin

Partners in Technology photos: Courtesy of Cedric Wilder

The Road to Code photos: Courtesy of Brianna Bleeker and Caitlin K. Martin

Photo on page 19: Courtesy of Brianna Bleeker

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Demographic Data

All community profile data for the 4 case studies was found on the U.S. Census Bureau's American Fact Finder website, American Community Survey population estimates 2017 (https://factfinder.census.gov/)

Rochester Montessori Academy and Maryvale High School demographic information was retrieved from the U.S. Department of Education's Institute of Education Sciences, National Center for Education Statistics, 2017 (https://nces.ed.gov/)