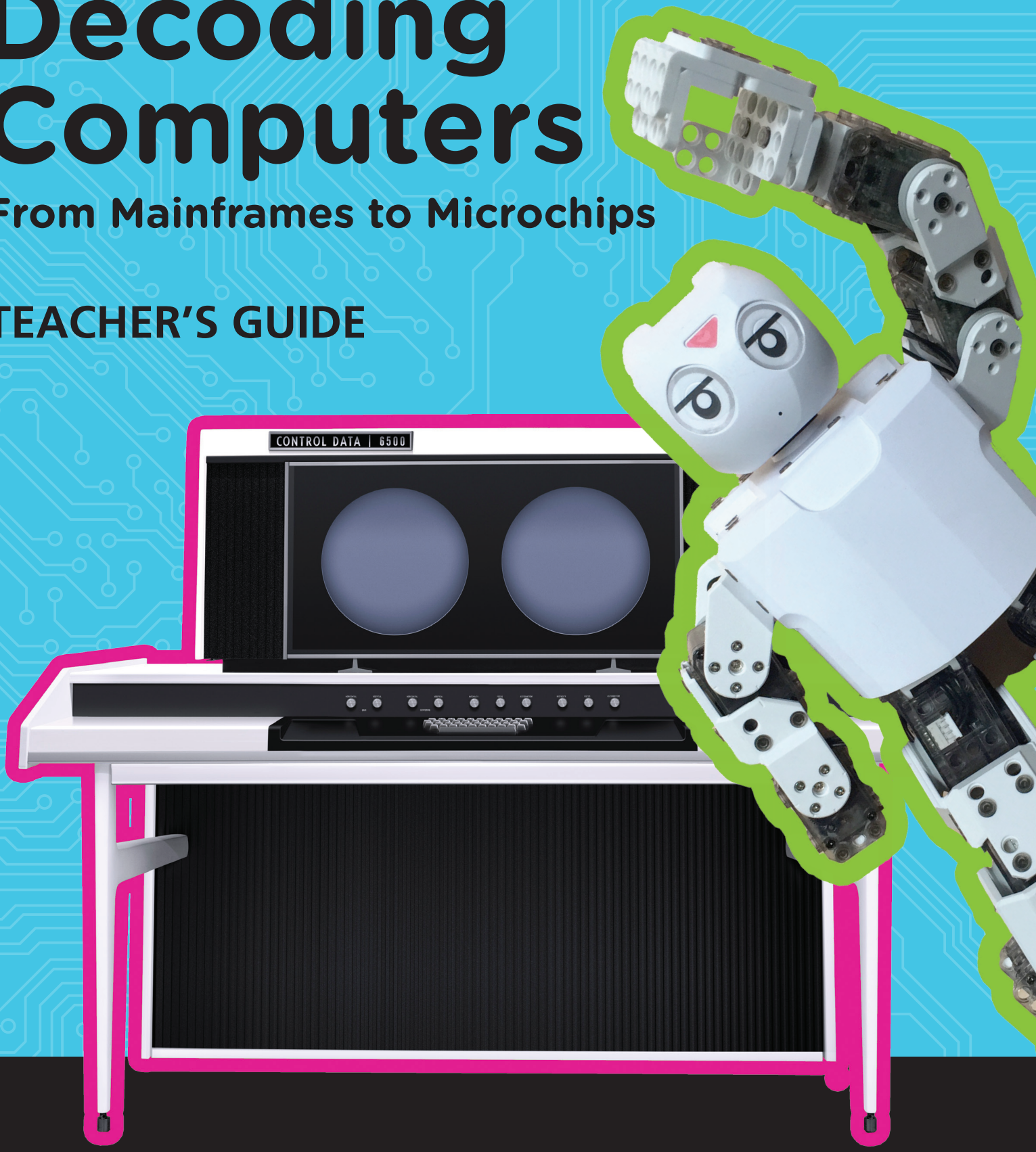
Decoding Computers

From Mainframes to Microchips

TEACHER'S GUIDE



living computers
museum + labs

The Seattle Times
NEWSPAPERS IN EDUCATION
INSPIRING STUDENTS TO LEARN

BACKGROUND INFORMATION

The Evolution of Computing

CDC 6500

Back in the day, computers were enormous, whirring machines. They filled rooms with dedicated cabinets for storage, memory, processing and printing. Teams of technicians were tasked with maintaining them. These gargantuan computers were called mainframes. It's hard to imagine today, but in the 1960s, computers were prohibitively expensive and reserved only for the most difficult operations, such as recording census data or running complicated scientific experiments. The CDC 6500 was one of the most powerful machines in the world when it was released in 1967. With a price tag of around $6 million, its clients were exclusively high-profile. The United States Air Force owned one, as did many flagship universities, such as Purdue University and Michigan State.

Manufactured by Control Data Corp. of Minnesota, the CDC 6500 was, in many ways, a unique machine. It understood a bare minimum of instructions, but that made the computer devilishly fast by 1967 standards. Since speed generates heat, CDC developed a novel approach to remove excess heat from the 6500, a water cooling system. It is hard not to imagine the risk of mixing electronics and H2O, but the mainframe's elegant design kept it safe. Much of the 6500's architecture was designed by Seymour Cray, a highly skilled electrical engineer who fit the stereotypical mold of enigmatic genius. But even he relied on colleagues to transform a blueprint into a product ready to ship.

From the very first computer to today, building machines is almost always a collaborative effort — an effort that required technical expertise, specialized tools and money. Lots and lots of money. The CDC 6500 was a case in point that computing was the domain of government and big business, far removed from the doings of much of the public. Using a computer, however, would soon become more affordable.

DEC PDP-10

Computers were big business and they cost big bucks — until the Massachusetts startup DEC came along. Digital Equipment Corp., or DEC as it was better known, was the mirror opposite of the industry's colossus, IBM. Whereas IBM represented the old order of corporate culture, with its suit-and-tie dress code and boardroom leadership, DEC represented the do-it-yourself ethos of hacker culture that emerged from the labs of the Massachusetts Institute of Technology in the 1950s. IBM guarded the inner workings of their machines as secrets. DEC, on the other hand, actively encouraged their customers to know their computers inside and out. However, DEC was so successful because it chose to not directly compete against the world's foremost manufacturer of high-end computers. Instead, DEC targeted overlooked markets: research institutions and universities. Its product line soon became favored among researchers and university students, especially the PDP-10. Released in 1967, the PDP-10, or Programmable Data Processor-10, was DEC's signature mainframe computer.

Priced between $500,000 and $1 million, the PDP-10 wasn't cheap. But you didn't have to buy it to use it. For a fee, you could rent "time" on the computer with a profoundly important feature called time-sharing. The PDP-10 was not the first machine to utilize time-sharing, but it did popularize the concept. Up to 512 users (with later models) could access the million-dollar computer to run tests, build programs, or write a dissertation. It wasn't a personal computer by any means, but it beckoned future technologies notably the plug-and-play PCs of the 1980s.

Xerox Alto

The task of the researchers assembled at Xerox PARC, or the Palo Alto Research Center, was an audacious one: Envision the office of the future and make it a reality. The Xerox Alto holds a place among the most significant in a long list of achievements at PARC. The Xerox Alto is a forerunner of the modern personal computer, popularizing the "desktop" paradigm of files and folders. It boasted a GUI, or graphical user interface, that allowed users to directly interact with what they saw on the screen. Instead of looking at a command line editor where you input code, you could drag your cursor across the screen and click on your icon. There were advancements in laser printing, which allowed you to print text and images as they were displayed on the monitor; this was called WYSIWYG, or "what you see is what you get." Like all industries, computing builds on the work of previous generations. All of these concepts had been envisioned or prototyped elsewhere; however, they were packaged together with the Alto. The Alto's hardware was simple, confined to two boards for its CPU, with most of the heavy lifting down on the software side. This elegant design decision permitted the Alto to be a versatile machine. It ran a wide variety of applications that were cutting-edge at the time, from word processing to desktop publishing. PARC also developed the Ethernet cable that became an industry standard. Because of this technology, users of the Alto could even write and send emails. The Alto was not designed as a commercial product; it was a research vessel. Some 2,000 were sold, mainly to other Xerox facilities. It ran for $40,000 and it didn't offer time-sharing capabilities; it was strictly one user per screen. It was hard to justify the expense. That would change.

Apple I

The 1970s, the decade when counterculture and silent majority clashed, witnessed a shift from the East Coast to the West Coast as the center of the computing industry. By this time, Silicon Valley hosted well-endowed universities (Stanford and UC Berkeley), venture capital firms (Kleiner Perkins), government institutions (NASA Ames Research Center), and, as it turned out, a ragtag group of idealists, hackers and hobbyists bent on creating a new world order with computers. In 1975, the inaugural Homebrew Computer Club meeting was held. What united them was a belief that computers should not be monopolized by government and big business. The members saw in computers something subversive. What would happen if the power of computing were granted to the masses? Among this motley crew were Steve Wozniak and Steve Jobs. "Woz" had a penchant for clean engineering and intuitive design, while Jobs was a born entrepreneur with a sixth sense for marketing. Inspired by the "make it yourself" philosophy of the Homebrew Computer Club, Woz designed Apple's first computer in 1977, the Apple I. Its engineering was clean, spare and elegant. Jobs capitalized on the interest the computer generated and secured a contract to sell 50 Apple I kits to a local computer store. This transaction was the start of one of the most recognizable brand names in the world.

IBM PC

By 1980, IBM was one of the largest companies in the world. Ranking in the Top 10 of the Fortune 500 List, the conglomerate garnered billions of dollars in sales annually. More than 200,000 men and women worked for the company. While IBM represented the old order of computing, it was still capable of learning new tricks. Nowhere was this more clearly demonstrated than with the IBM PC. Although the company specialized in high-end computing, the IBM PC was to be the cheapest product in the company's history. It was sold in department stores just down the street. What's more, IBM had earned a reputation for building products from the ground up; they didn't use spare parts, they used their parts. This time, however, the company purchased parts from other firms, such as microprocessors from Intel and an operating system from Microsoft. Whereas the Apple II had only a meager offering of applications, the IBM came bundled with both a word processor and a spreadsheet application. These were the original killer apps. Families and businesses could justify the expense of purchasing an IBM PC because they could now do many useful things on a computer, like budget their expenses on a spreadsheet. And it had a game, too. Imitation, it is said, is the highest form of flattery. The impressive sales of the IBM PC sparked the production of many clones that sought to ride IBM's coattails to riches. IBM's entry to the personal computer market represented a resounding endorsement of this new model of computing.

Dell Dimension XPS B733 & Windows 95

The success of the Apple II and IBM PC illustrated that hardware wasn't enough to sell computers. They needed software that was easy to grasp and useful to own. When IBM launched its PC, it commissioned a startup called Microsoft to write the operating system. Founded by Bill Gates and Paul Allen in 1975, Microsoft specialized in writing computer languages, which allowed users to more seamlessly communicate with their machines, which "speak" in the language of binary: nothing but zeroes and ones. (See our Binary Scavenger Hunt for more information). It is no small irony that in less than the span of one generation Microsoft would eclipse IBM as the foremost computer company in the world. Back in the 1980s, Microsoft began to offer a bounty of software, from Bookshelf, a digital dictionary and thesaurus, to Encarta, an all-in-one encyclopedia. And, of course, there was Word and Excel, which moved off of shelves quickly since Microsoft astutely bundled them together for a discounted price. Microsoft's ascent to market dominance was slow and steady — and it was solidified with the release of Windows 95. The launch of the operating system was a spectacle. Microsoft tapped A-list stars to celebrate Windows 95 in style. Crowds lined up at department stores for the midnight release. Much had changed since the 1960s. The PC market reached maturity and computers were now household items. Companies treated the release of operating systems and software like summer blockbusters — and the public was receptive. Windows 95 quickly became ubiquitous and was the primary operating system of desktops (another name for the PC) like Dell Dimension XPS. The rest, as they say, was history.

The thing about history, however, is there is always more of it. Enter the internet. One of the applications that ran on Windows 95 was Netscape, an early internet browser. The internet was still a fledgling in the 1990s. Even so, you could already read the headlines on Yahoo!, bid for videocassettes on eBay and chat with your buddies on America Online. The dotcom crash of 2001 and 2002 sent the computer industry into a tailspin. Many companies went bankrupt or were bought outright. When the industry recovered, it redoubled its investment in the internet.

COMPUTER SCIENCE IN SCHOOLS

A 2015 Gallup poll reports that 90 percent of parents want their children to study computer science as part of their school day. But only 40 percent of schools teach computer programming. We're lucky: Washington State is one of only a handful of states taking the lead by putting computer science standards in place. But many of our students do not experience computer science lessons during class time, despite the fact that computer science is the fastest-growing STEM field and one of the top providers of job opportunities in our region.

To date, more than 700,000 Washington State students have participated in Hour of Code thanks to the grassroots efforts of teachers like yourself. Do you know your administration's stance on computer science?

Resources for you:

https://code.org/promote/letter

https://code.org/advocacy/state-facts/WA.pdf

https://code.org/files/Making_CS_Fundamental.pdf

https://code.org/files/open_letter_for_cs.pdf

COMPUTER SCIENCE IN ALL FIELDS

Computing is a fundamental part of 21st century life. About every occupation in our modern economy — from art to zoology — depends on technology and people who know how to use it. Like reading or writing, computer science is key to the success of Washington kids, whether or not they choose to pursue STEM.

Computer science is not just coding. Dissecting circuits, computing in binary, naming the parts of a computer — there are so many ways to teach computer science within your subject field.

Go beyond robots. Website creation, video editing, music composition and digital art are ways to get students to create with computers.

Entrepreneurship and computing go hand-in-hand. Some of the world's top grossing companies are in tech. But beyond that, businesses big and small depend on computational skills like data analysis, algorithms and project management.

Sports and computing. If you follow professional football, you've seen coaches and players huddled around the ubiquitous blue Microsoft Surface tablets. Today's tablet computers have more computing power than many desktop models, and it is put to use for myriad tasks: touch-screen visuals, game strategies, play concept and design, and of course tracking everything from scouting reports to training and rehab regimens — not to mention keeping tabs on what your rivals are up to.

HOUR OF CODE & CSEDWEEK — DEC 4–10

Computer Science Education Week is an annual program to inspire K-12 students across the world to take an interest in computer science. Held every second week of December (usually in conjunction with Grace Hopper's birthday on Dec. 9), classrooms and offices around the world celebrate computer science with hackathons, coding challenges and community volunteering.

It doesn't matter whether you are an expert or a complete coding novice, #CSEdWeek is a great opportunity to celebrate computer science with your students. One of the easiest ways to get involved is to take part in the *Hour of Code Challenge*. Launched by the nonprofit Code.org in 2013 and supported by numerous universities, tech companies and even the president, Hour of Code has reached tens of millions of students in over 180 countries through their 60-minute programming tutorials. Tutorials are freely accessible online, support CS learning down to the kindergarten level, and span 45 languages. You don't always need computers to participate, either: Hour of Code provides many "unplugged" lesson plans and YouTube videos to help inspire all types of communities. To date, Hour of Code has served almost half a billion students worldwide — will your students take part?

Your district may have special incentives for teachers who want to training on teaching computer science or technology skills. Ask your administrator how you can get started.

Code.org also offers many professional development opportunities. To find one in your area, go to Code.org. Living Computers is another teacher resource, playing host to a variety of professional development seminars by local and national collaborators. Keep an eye on their event calendar for teacher-centric opportunities in 2018.

To learn how to host Hour of Code in your classroom, go to:
https://hourofcode.com/us/how-to

To learn more about Hour of Code:
https://hourofcode.com/us

To see Hour of Code activities:
https://csedweek.org/learn

Code.org also offers many professional development opportunities. To find one in your area, go to **Code.org**.

CLASSROOM ACTIVITY — BINARY SCAVENGER HUNT

Have students read the Living Computers / NIE program "Decoding Computers" (**ad.seattletimes.com/FlippingBook/NIE/2017/LivingComputersMuseum**) for background information before completing the activity below.

Vocabulary

Ask students to look up the following terms in the dictionary and then use each term in a sentence.

- Binary
- Bits
- Transistors
- Byte
- Command (in the context of computer science)

Activity

Binary Scavenger Hunt

Note to teachers — the first part of this activity can be done in the classroom and the second half is intended to be used in the museum as a self-guided tour activity. If you cannot make it to the museum, ask your students to do research on their own or in pairs to find the answers.

Living Computers: Museum + Labs

BINARY SCAVENGER HUNT

Computers use a system called binary to store and process data. When wires carry information through a computer, the electricity triggers tiny transistors to switch back and forth between two states—ON or OFF (1 or 0).

Computers represent transistor states in binary digits 0 and 1—or, **bits** for short. Bits are rarely seen alone in computers. They're usually bundled in 8-bit collections called bytes.

To go from a byte to a command, early programmers had to translate the computer's binary code from numbers into something more useful for humans—like letters or symbols.

A	■□■■	■■■□	J	■□■■	□■□■	S	■□■□	■■□□
B	■□■■	■■□■	K	■□■■	□■□□	T	■□■□	■□■■
C	■□■■	■■□□	L	■□■■	□□■■	U	■□■□	■□■□
D	■□■■	■□■■	M	■□■■	□□■□	V	■□■□	■□□■
E	■□■■	■□■□	N	■□■■	□□□■	W	■□■□	■□□□
F	■□■■	■□□■	O	■□■■	□□□□	X	■□■□	□■■■
G	■□■■	■□□□	P	■□■□	■■■■	Y	■□■□	□■■□
H	■□■■	□■■■	Q	■□■□	■■■□	Z	■□■□	□■□■
I	■□■■	□■■□	R	■□■□	■■□■			

Use the Binary Decoder Table above to decode the clues below for the timeline (reverse). Use ■ as 1 and □ as 0. Can you find these famous "living" computers in our collection?

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___ ___ ___	■□■□ ■■■■ ■□■■ ■□■■ ■□■□ ■■■■
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___ ___ ___ ___ ___	■□■■ ■■■□ ■□■□ ■□■■ ■□■■ ■■■□ ■□■□ ■■□■ ■□■■ □■■□

Living Computers: Museum + Labs

BINARY SCAVENGER HUNT

1964 ___ ___ ___ **- 7**
The oldest working computer in our collection. It was acquired from the University of Oregon where (believe it or not) it performed all kinds of physics experiments over the years—including bomb detection—on only 9kB of memory.

1967 ___ ___ ___ **6500**
This computer is an example of pure, brute-force computing. It was developed by Seymour Cray, father of the supercomputer, and has its own refrigeration system!

1973 ___ ___ ___ ___
Developed by a company famously known for its copiers, this computer featured a bit-map display, a graphic user interface, and even a simple pointing device: the mouse.

1975 ___ ___ ___ ___ ___ ___ **8800**
This computer started out as a hobbyist kit for $439. After you built it, you still needed a keyboard, a monitor, and an operating system to really make it work. This is where Microsoft got its start.

1977 ___ ___ ___ ___ ___ **II**
One of the first personal computers known for its clean design, adaptability, and strong presence in schools. It was made by a company founded by two Steves.

1979 ___ ___ ___ ___ ___ **400**
This computer was made by a well-known video game manufacturer. It rose to fame through releasing arcade games you could play in your own living room.

1981 ___ ___ ___ **PC**
This computer was the company's first experiment into personal computing and had a huge impact on the market. It came with a Microsoft operating system—MS-DOS 1.0.

FIELD TRIPS

Living Computers: Museum + Labs is committed to providing hands-on, immersive learning experiences in computer science to all K-12 students. A field trip to LCM+L is a fantastic way to expose both students and adults alike to the fascinating and rapidly changing world of coding and computer history.

Our education programs foster strong computational skills that translate across a wide variety of disciplines and grade levels. LCM+L field trips support the following standards:

- Washington State Computer Science K-12 Standards (CS-K12)
- Next-Generation Science Standards (NGSS)
- Partnership for 21st Century Skills
- Washington State Common Core (Math & ELA)

Field trip packages have a flat-rate fee that include:

- Full Museum Admission for ~32 students as well as adult chaperones
- One 60-minute facilitated activity -OR- 90-minute programming-based activity
- Reserved space for a brown-bag lunch and bus parking

Book your class trip for 2018 by emailing us at **fieldtrips@livingcomputers.org**. We recommend inquiring at least two months before your desired date.

Access

Living Computers is committed to providing access to quality computer science education to all K–12 students. We are proud to provide significant discounts to eligible student groups. Email **fieldtrips@livingcomputers.org** for details.

Living Computers: Museum + Labs

PREPARING FOR YOUR VISIT

Before Leaving School

- Break up your classes into chaperones and groups according to the following ratios:

  1 chaperone per 5 students under 10 years
  1 chaperone per 8 students under 17 years

- Leave student backpacks at school or on the bus. Chaperones are welcome to use our lockers on-site to secure their belongings free of charge.
- We have storage for student coats and lunches in a the front of the museum when you arrive.
- Remember to use the restrooms before leaving.
- Arrive at the museum 15 minutes before your program start time. If you will be late, please call 206-342-2020.

Arrival at the Museum

- Once at the museum, teachers should check-in at the front desk. Students should wait on the bus or on the Main Entrance ramp.
- At check-in, teachers should provide total student and chaperone counts, as well as payment. All students and chaperones will receive a **colored wristband**. This is your ticket to the museum.
- Once inside, an LCM+L staff member will collect student belongings and direct your group to the Labs for a **15-minute orientation**.
- After students are dropped off, bus drivers are welcome to tour the museum free of charge.
- If you arrive separately from your teacher, please wait in the museum lobby.

Lunch

- LCM has a public, self-service café space available for school groups to eat. However, we do not have food options.
- To make room for others, limit students to 20-25 minutes to eat and bus their own tables.

Payment

- Preference for payment (invoice, check, or credit card) must relayed to LCM+L prior to your visit.
- If submitting payment via purchase order, your PO must be received by LCM+L one week from the date of your visit.

MUSEUM RULES

Treat humans and technology with respect.
No running, pushing or roughhousing.

Scoot over, take turns, and cheer others on.
Technology is made for sharing.

Help keep track of each other.
Stick with your chaperone.

Keep all food or open-container drinks
in the Café only. **Robots don't like liquids.**

Staff Expectations of Chaperones

- All chaperones must keep their **LCM+L Clipboard** and **Chaperone Badge** clearly visible at all times while on the exhibit floor.
- Chaperones should refrain from excessive cell phone use while supervising students.
- Chaperones are responsible for being good facilitators and enforcing Museum Rules (above).
- Chaperones should ask questions! No chaperone should feel they need to know everything. Our tour guides are enthusiastic and friendly.

Living Computers: Museum + Labs

CHAPERONE GUIDE

Field Trip Schedule

Teacher Name:	Teacher Cell #:
Lunch Time:	Lunch Location:
Departure Time:	Meet-Up Location:

Students in my Group	Lost Location:
1.	6.
2.	7.
3.	8.
4.	9.
5.	10.

Scheduled Exhibits or Programs	Location	Time

Must-Visit Exhibits