PLTW COMPUTER SCIENCE

Activity 4.1.1

Computing Impacts All Fields

Introduction

The applications of and disciplines affected by computing are too numerous to count. Autonomous robots managed by computer programs are now doing everything from assembling our cars to exploring the Universe. These incredible applications are made possible, in part, by the rapid advancement of computing technology.

(c)

Robotics itself benefits from **simulation**, a field of computing that uses digital models of real life circumstances and phenomena in order to predict outcomes to those situations. In this unit we focus on how simulation can be used effectively to impact all fields.

Materials

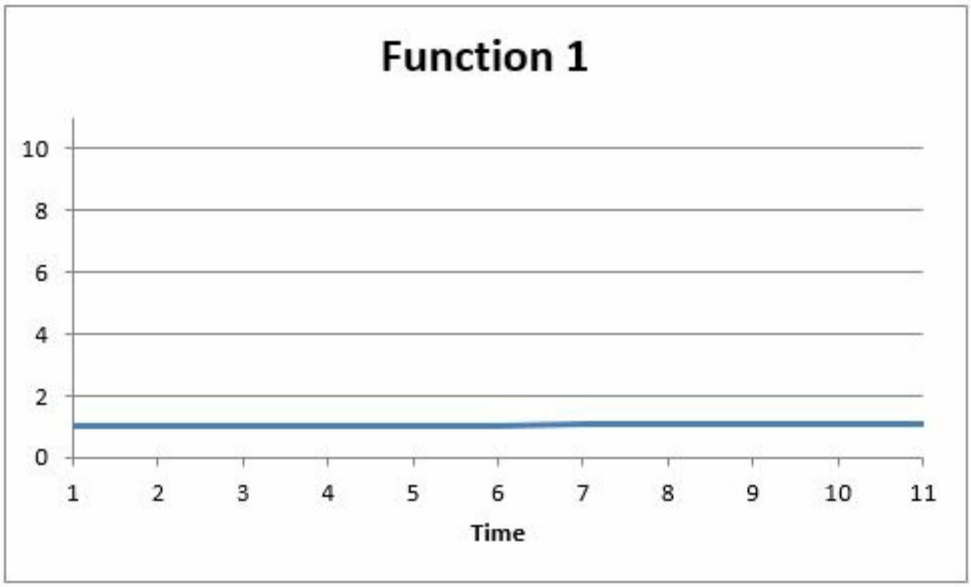
- Paper and a writing utensil
- Calculator
- Computers with Internet access

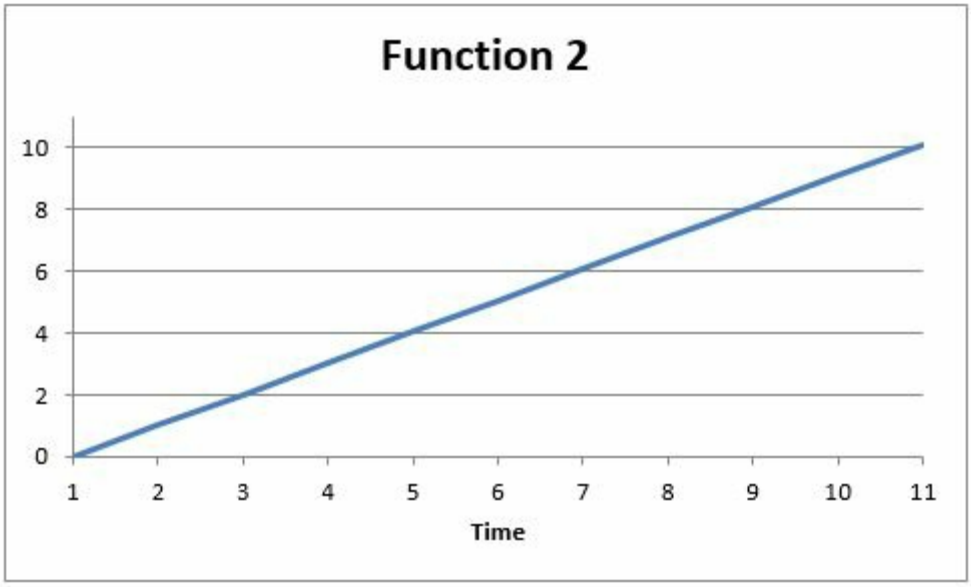
Procedure

Part I: Moore's Law

1. Form pairs as directed by your teacher. Meet or greet each other to practice professional skills.
2. Refer to your downloadable resources for this material. Interactive content may not be available in the PDF edition of this course.

The impact of computing is taking a lot of people by surprise. Computing power has grown exponentially, and human brains are nearly incapable of anticipating exponential growth. The two following graphs each represent a different function. One is linear, and the other is exponential. Of these graphs, which appears as though it is growing the fastest and why?





3. The function represented by Function 1 is an exponential function, $y=1.01^x$, whereas the function represented by Function 2 is linear, y=1.01x. Use a calculator to find the values of each function when x is 1000 and record them.
4. An exponential function will always outgrow a linear function given enough time. Determine the value x at which the exponential function from Step 3 achieves a higher value than the linear function using a method proposed by your instructor, or one of your own choosing. Describe the method you used.
5. Exponential growth is responsible for some very curious and startling phenomena like flu outbreaks. Given some simplifying assumptions, the spread of the flu can be modeled by an exponential function. Assume that every day each person who has the flu spreads it to one additional person. The first person to contract a disease is typically referred to as *Patient Zero*. The spread of the disease from one infected individual to another is represented by $f(x)=2^x$ where x is the number of days and f(x) is the number of people infected. Given this

function the entire human populace of the earth would be infected in one month. On what day do you think people would begin to notice this flu outbreak? Why did you choose that day?

6. One of the most remarkable observations of the 20th century is a trend described by Intel co-founder Gordon E. Moore that has come to be known as **Moore's Law**. While it is not actually a law, this 1965 prediction states that the number of transistors on integrated circuits doubles every 18 months. Moore's Law continues to hold today and is another example of exponential growth.

   The speed of a processor is often measured in the number of floating point operations per second **(flops)** that it can perform. Sketch a graph of number of flops vs. time using the following record-breaking super computers:

   - 2006 RIKEN's MDGRAPE-3 at 1 petaflop
   - 2009 Cray Jaguar at 2 petaflops
   - 2012 IBM's Sequoia at 16 petaflops
   - 2013 China's Tianhe-2 at 34 petaflops

7. Given your graph, how many petaflops would you expect the fastest computer in the world to be able to execute in 2015?

8. Speed is not the only aspect of computing that is changing significantly. A table displaying various benchmarks by year is shown below.

Property	Name	Year	Value
Network Speed	ARPANET	1984	54 Kb/s
Network Speed	NSFNET	1994	18,480 Kb/s
CPU Clock Rate	Altair 8800	1975	2 MHz
CPU Clock Rate	IBM PC	1981	5 MHz
CPU Clock Rate	Intel P5	1995	100 MHz
CPU Clock Rate	AMD	2011	8,631 MHz
Bits of RAM per Dollar	NA	1984	25,600
Bits of RAM per Dollar	NA	1994	41,800
Bits of RAM per Dollar	NA	2004	37,000,000
Bits of Hard Disk Space per Dollar	NA	1974	12,380
Bits of Hard Disk Space per Dollar	NA	1984	41,210
Bits of Hard Disk Space per Dollar	NA	1994	7,067,000

Bits of Hard Disk Space per Dollar	NA	2004	11,820,000,000

Do one or more of the following using the Internet as directed by your instructor:

- Find a benchmark for Internet speed in 2004.
- Find the clock rate of the fastest current production processor.
- Find the number of bits of RAM you can buy for a dollar today.
- Find the number of bits of hard disk space you can purchase for a dollar today.
- (Optional) Find exponential regression equations based on the data points listed as well as the data points you found and use those equations to make predictions about future technology benchmarks.

9. As directed by your instructor, brainstorm with your partner and then with the class some radical ways that computing might change our lives, taking into account the exponential growth of technology that you examined in the last part of this activity.

Part II: Distributed Solutions

Distributed computing aims to solve problems in which data are gathered by multiple processors and must be communicated, collected, combined, and analyzed in order to find a complete solution to a problem. Later in this lesson, you will run simulations multiple times, utilizing as many different processors as you have on your classroom computers to allow you to run more simulations per minute. In application, the processors working in parallel might be part of the same chip or spread out across an entire geographic area.

10. Use the Internet to research one distributed computing project to share with the class. You may want to start your research by simply searching for “List of distributed computing projects.” Find one that interests you and prepare a 30-second summary of what its goal is, how it uses multiple computers to accomplish that goal, and why the goal is important. Present as directed by your instructor.

11. In some cases humans are still better at solving certain problems than computers. Computers can still be used in a complementary fashion to allow for **crowd sourcing**. These projects rely on humans to do the part of the task that is hard for computers, and then the computers take over to combine and analyze data. Use the Internet to research one crowd sourcing project to share with the class. You may want to start your research by simply searching for “List of crowd sourcing projects.” Find one that interests you and prepare a 30-second summary of what its goal is, how it uses computers and humans to accomplish that goal, and why the goal is important. Present as directed by your instructor.

Part III: Simulation and Modeling

12. The final lesson of this course will focus on **simulation and modeling**, a subfield of computer science dedicated to using the power of computers to examine or predict real life phenomena in all fields. The reach of simulation and modeling is so broad that you could pick any field and

learn about an interesting simulation used to help people in careers or research within that field. You will prepare a 2-4 minute presentation with your partner detailing work in simulation in one of the following fields.

- Manufacturing and 3D printing
- Architecture, construction
- Neuroscience
- Civil engineering
- Medicine
- Movies, animation, graphic video games, and virtual realities
- Marketing and sales
- Economic trading and commodities flow
- Global economic development
- Environment
- Conservation
- Agriculture
- Energy production
- Chemistry/Physics
- Education
- Clothing design and fashion
- 2D Art
- Music

Your presentation must include:

- –An introduction explaining generally how simulation is used in your chosen field.
- –A description of at least one specific simulation in that field, including a graphic that illustrates the result of that simulation.
- –An overview of at least one career associated directly with simulation in the chosen field.

13. In your own words, describe what theme(s) and common elements you see running through the presentations.
14. People don't all have the same access to computing resources. Some countries have older infrastructure. Almost all countries have some people with better access to the computing resources that are there. Pick one of the topics above and describe how that inequality interacts with the innovation that was described.

15. For the AP CS Principles *Explore* Performance Task you must find three recent, credible sources of information about a computing innovation that:

    - Has or could benefit and harm society, economy, or culture
    - Consumes, produces, or transforms data
    - Raises a storage, privacy, or security concern regarding data.

    In each unit of this course, you will investigate particular impacts of computing innovations on society. In this activity, find one or more articles referenced in the ACM TechNews archive, **http://technews.acm.org/archives.cfm**, about the impact of a computing innovation related to one of these areas:

    - simulation

- robotics
- crowd sourcing
- distributed computing
- science
- production from agriculture, manufacturing, or mining
- business

Other topics may be explored at the discretion of your teacher. Find relevant summaries of news article from the ACM TechNews and read the original articles being summarized. Complete some portions of the *Explore* task described below as directed by your teacher.

- Task part 1. Create an audio, video, or visual artifact that illustrates, represents, or explains the computing innovation's purpose, function, or effect. (3 page/1 minute/30MB max)

- Task part 2. Essays

    - Name the innovation and its purpose and function. Describe how your artifact illustrates, represents, or explains the computing innovation's purpose, function, or effect. (Approximately 100 words.)
    - Describe the tools, technique, and process you used to produce the artifact. (Approximately 100 words.)
    - Explain the beneficial AND harmful effect(s) the innovation has or could have on society, economy, or culture. (Approximately 250 words.)
    - Describe the data; the consumption, production, or transformation of data; and the storage, privacy, or security concern(s) directly related to the innovation. (Approximately 250 words.)
    - Use APA-style citations to correctly reference the article(s).

Note: This step is adapted from the official College Board Explore Performance Task but it does not duplicate the content of College Board Task or Rubric. The task provided here contains elements that are different than the College Board Performance Task and Rubric. Please reference official College Board materials.

Conclusion

1. Describe a way that you could envision using the power of the human brain through crowd sourcing to enhance the quality of your life.
2. Describe a way that you could envision using the power of the computer through distributed computing to enhance the quality of your life.
3. Summarize a presentation, other than your own, on simulation and modeling from this activity.
4. What are some of the implications of the exponential change in computing power, storage space, data collection, and/or price by 2024?
5. Because of the exponential explosion of computing power available to society we are now able to undertake the kind of distributed computing, robotics, and simulation projects that you have learned about in this activity. Given what you know now, answer the following questions:

    - – What do you think computers will never be able to do?

- – What do you hope computers will never be able to do?
- – What wishes do you have of computers that you believe they will never be able to achieve?

6. Explain how the exponential growth in computing power will impact one field of interest to you.
7. Nearly all areas of society and the world are being deeply impacted by the rise in computation. What is it that the underlying cause of these impacts has in common? People have used computational aids for millennia. What is it about computation in our current time period that makes these impacts so profound and so widespread?