The Fibonacci Sequence

Subject Area(s)	Algebra, Problem Solving, Science & Technology
Associated Unit	None
Associated Lesson	None
Activity Title	Fibonacci's Robots
Header	None
Grade Level	7 (6-8)
Activity Dependency	None
Time Required	~120 minutes
Group Size	5
Expendable Cost per Group	US$3. In addition, the LEGO kit costs approximately US$300. One is sufficient for the entire class, and they are highly reusable.

Insert image 1 here, justified center

Image 1

ADA Description: Photo of the standard NXT robot from the basic LEGO NXT kit

Caption: Alpha Rex NXT Configuration

Image file name: alpharex_robot_nxt.jpg

Summary
Using the LEGO NXT Robotics kit, students learn how to build and program a robot. Students are assigned roles, consisting of group leader, chassis builder, arm builder, chief programmer, and Fibonacci verifier. By building a robot that moves based on the Fibonacci sequence of numbers, the students can visualize how quickly the numbers in the sequence grow. Programming the robot to move according to these numbers allow the students to break down the sequence into simple algebraic equations, so that a computer can understand the Fibonacci sequence.

Engineering Connection
The Fibonacci sequence is widely used in engineering applications such as financial engineering trading algorithms; computer data structures and sorting algorithms; audio compression; and architectural engineering. In recent years, robots have migrated from factory shop floors (serving as industrial manipulators) to outer space (serving as interplanetary explorers), hospitals (serving as minimally invasive surgical assistants), homes (serving as vacuum cleaners and lawn mowers), and battlefield (serving as unmanned air-, underwater-, and ground vehicles). This activity exploits students' fascination with robotics to expose them to the notion of sequences and develops their critical thinking skills.

Engineering Category
(2) relates math concept to engineering

Keywords
Fibonacci, measurement, programming, robotics, sequence, variable

Educational Standards
- State math/science: New York State Learning Standard
    - MST1: scientific inquiry
    - MST4: science in a physical setting
    - MST5: engineering design, computer and technological systems

Pre-Requisite Knowledge
Familiarity with Lego Robot NXT kit.

Learning Objectives
After this activity, students should be able to:
- Describe number sequences
- Illustrate Fibonacci sequence using Lego NXT
- Verify terms of sequence using vis-à-vis robot motion using measurement

Materials List

Each group needs:

- Windows PC
- Lego NXT kit (which can be purchased at http://shop.lego.com/Product/?p=8547 for approximately US$300)
- Metric Measuring Tape
- Marker

To share with the entire class:

- Paper
- Tape

Introduction / Motivation

Leonardo of Pisa, known as Fibonacci, introduced a specific sequence of numbers to the Western world in his 1202 book, *Liber Abaci*. Although the description of the sequence seems difficult, it is one of the easiest sequences to understand. The sequence starts with two numbers 0 and 1. To find the next number of the sequence, we add the two previous numbers: in this case 0 + 1 = 1. Now we have the sequence 0, 1, 1. To find the next number of the sequence, we repeat the above procedure forming 1 + 1 = 2. Now we have the sequence 0, 1, 1, 2. Repeat this procedure to get a sequence that continues forever to, what mathematicians call, infinity. The Fibonacci sequence has attracted significant attention because it shows up in nature in the form of spirals, in such things as sunflowers and snail shells. This sequence is also used to generate the famous golden ratio, which appears in engineering and architecture from the great pyramids to the Parthenon.

Today, you will work together in teams in order to learn to use to the LEGO NXT Robotics kit. While doing this, you will also learn about the importance of sequences, namely the Fibonacci sequence, and how to program the robot using a sequence. Then, your team will build a robot to learn how to measure angles as well as compute elements in the Fibonacci sequence.

Vocabulary / Definitions

Word	Definition
Infinity	Unable to be counted, unlimited
Robotics	The science or study of the technology associated with the design, fabrication, theory, and application of robots
Sequence	(noun) An ordered set of numbers, shapes, or other mathematical objects, arranged according to a rule
Term	One of the numbers in a sequence
Variable	A symbol used to represent a value

Image Insert Image 2 here, right justified

Image 2
ADA Description: Drawing of Leonardo of Pisa (Fibonacci)
Caption: Leonardo of Pisa (Fibonacci)
Image file name: fibonacci.jpg
Source/Rights: www.wikipedia.com, Public domain

Procedure

Before the Activity

- Make a "street" on the floor using the pieces of paper (the long way) connected using tape. This is used so that the marker does not make marks on the floor.

With the Students

1. Divide the class into groups of 4-5 students.
2. Allow the students to choose which job they want (group leader, builders, pen attacher builder, chief programmer, and Fibonacci verifier).
    a. Group Leader
        i. Locates parts needed for construction of chassis and arm
        ii. Assists the chief programmer with Mindstorms NXT.
    b. Builder
        i. Constructs robot according to attached pdf document robot manual. Any small, mobile robot is ok, so modifications are encouraged.
    c. Pen attacher
        i. Devises a way to attach a pen to the robot using Legos and tape so that the pen draws on the ground as the robot drives.
    d. Chief Programmer
        i. Writes a program that moves the robot according to the Fibonacci sequence. Example: the third term is 1, so the robot's wheels should

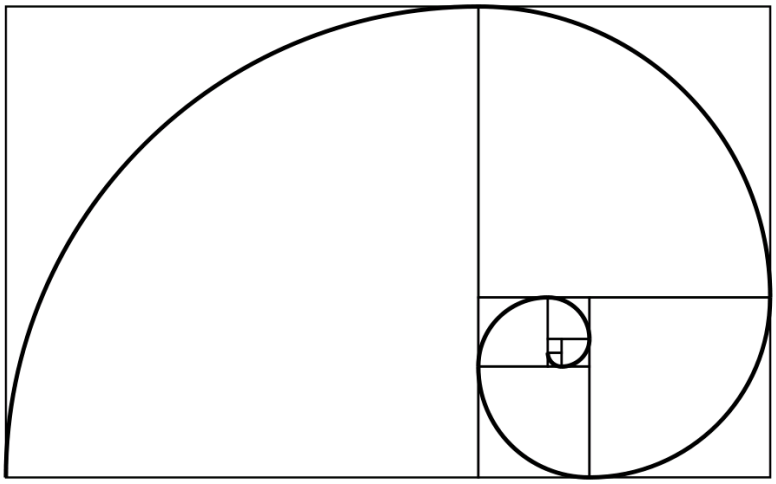
move 1 full rotation and then stop. The fourth term is 2, so the robot's wheels should only move 2 full rotations and then stop.

e. Fibonacci Verifier
    i. Assists the chief programmer
    ii. Verifies that the robot moved according to the Fibonacci sequence
    iii. Records data

3. Build the robot and start programming
    a. The group leader locates and brings the building pieces needed by the chassis builder
    b. The chassis builder builds the robot
    c. The pen attacher conceptualizes the arm, talks it over with the group leader, and starts to build when the chassis is finished. While the chassis is being built, the arm builder can locate the pieces necessary for the arm. If the chassis still is not built, the arm builder can help the chassis leader.
    d. The chief programmer starts with programming in Mindstorms NXT. The programmer should draw out the program on a sheet of paper first.
    e. The Fibonacci verifier works with the programmer giving suggestions and working as a team with the programmer as the leader. The verifier should also compute the first 10 terms of the Fibonacci sequence.
4. Build the robot's pen attachment
    a. The group leader works with the chief programmer and the Fibonacci verifier.
    b. The chassis builder works with the pen attacher.
    c. The pen attacher builds the pen attachment and takes the lead of building, with the chassis builder for support.
    d. The chief programmer continues programming.
    e. The Fibonacci verifier continues programming with the chief programmer.
5. Place the marker in the robot's arm
    a. Test to see if the marker draws on the "street" when the robot moves.
6. Teach the robot
    a. Program the robot to run on the "street" using the attached NXT program.
    b. The Fibonacci verifier marks with a pen on the street every time the robot stops. The verifier then measures the distance between adjacent marks. The distance should be increasing according to the terms of the Fibonacci sequence. The verifier records all data and verifies the program worked correctly. If incorrect, repeat step 6.
7. **Extra Credit**
    a. If your previous program did not use variables, try re-writing the program so that the robot can compute the Fibonacci sequence infinitely.

Image Insert Image 3 justified center

Image 3
ADA Description: Drawing of Fibonacci spiral on top of nautilus shell to show Fibonacci in nature
Caption: Fibonacci in nature
Image file name: fibonacci_nature.jpg
Source/Rights: public domain www.wikipedia.com



Attachments

fibonacci_program.pdf (Fibonacci Robots Program)

fibonacci_program.rbt (Fibonacci Robots Program)

fibonacci_worksheet.pdf (Fibonacci Robots Worksheet)

fibonacci_worksheet.doc (Fibonacci Robots Worksheet)

fibonacci_worksheet_answers.pdf (Fibonacci Robots Worksheet Answers)

fibonacci_worksheet_answers.doc (Fibonacci Robots Worksheet Answers)

Robot manual.pdf (Robot building guide)

Safety Issues

None

Troubleshooting Tips

If there is not enough room on the floor for the robot to travel, use ½ or ¼ rotations instead of full rotations of the robot wheels.

Investigating Questions

Included in the attached worksheet.

Assessment

Pre-Activity Assessment

What's a robot? Have students discuss and explain the components of a robot necessary for moving in a pattern and drawing its trajectory path. Components should include items such as the brain (NXT brick), motors, assorted Lego pieces, attachments for pens or markers to draw, and a program to allow it to operate autonomously.

Activity Embedded Assessment

What affects the distance traveled by the robot? Have students hypothesize what factors will affect the movement of the robot as it moves through the program and completes the sequence. Factors could include wheel size, initial rotation value, programs that include steering or pivot/swing turns, etc.

Post-Activity Assessment

Worksheet: Have each student complete the attached worksheet and answer all of the analysis questions. The questions on the worksheet included in this activity can be used or modified to test the knowledge each student has gained from this exercise

Engineer it!: Have the students think about the Fibonacci sequence and how it could be used in engineering designs that use it. For example, spiral fans and pumps that reflect the same shape described by a Fibonacci spiral are shown to increase the efficiency of energy, and buildings. See the website http://www.treehugger.com/files/2005/06/paxfan_an_effec.php for an example.

Activity Extensions

Have the students research how Fibonacci sequence relates to right triangles, or where is Fibonacci sequence found in nature, etc. Also, see Teach Engineering activity Phi: The Golden Ratio.

Activity Scaling

- For lower grades, allow students to simply create a chain of motor blocks that move the robot by the pre-determined terms of the Fibonacci sequence.
- For upper grades, students should only use variables to program the robot to produce the terms of the Fibonacci sequence, and display the recent term on the NXT brick. Have students move the robot to the Fibonacci spiral.

Additional Multimedia Support

None

References

http://mindstorms.lego.com. The LEGO Group. Accessed January 27, 2009. LEGO, MINDSTORMS, the Brick and NXT configurations are trademarks of the LEGO Group.

http://www.teachers.ash.org.au/jeather/maths/dictionary.html. Jennifer Eather. Accessed January 27, 2009. (Source of mathematical definitions)

http://www.maa.org. The Mathematical Association of America. Accessed January 27, 2009 (Source of photo of Fibonacci)

http://www.refsdal.no/eirik/. Eirik Refsdal. Accessed January 27, 2009. (Source of photo of NXT Alpha Rex)

www.mathacademy.com Copyright © 1997-2008, Math Academy Online™ / Platonic Realms™, PO Box 1337, Radford VA 24143. Accessed January 27, 2009.

Other

Redirect URL
http://gk12.poly.edu/amps/

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