Cultivation Strategies

For Computational Thinking and Engineering Design Talent in Students

Support for talented students can be scaled from simple interventions within the context of the class project to broader school- or district-level support. The below interventions apply to cultivation of both Computational Thinking and Engineering Design.

- In-project Cultivation - The teacher provides extra challenges to identified students within the class, either asking specific students to go beyond the minimum requirements of the project or providing challenge activities as an optional bonus to the entire class.
- Classroom Cultivation Activities - The teacher provides extra cultivation activities to identified students, by encouraging them to utilize extra technology components within class assignments that do not include technology used for the entire class. For example, during a class poster making project, a teacher could permit students or suggest to students that they incorporate robotics components if they feel comfortable doing so (perhaps for extra credit).
- Extra-curricular Cultivation - Outside of the scope of the initial Arts & Bots class, the school provides support and encouragement for identified students to participate in computational thinking or engineering design talent cultivating clubs or independent study activities.
- Class Track Recruitment - The school or district employs targeted advertising and recruitment in order to enroll identified students in existing STEM programs which students may not have considered on their own.
- University Partnership - The school district works with university partners to provide identified students with opportunities to participate in enrichment activities at the university.

Extension Activities - Computational Thinking

- Use loops (for a finite number of times) multiple times in the program to create repetitive motion, like dancing.
- Create *sequences* with *subsequences*
- Use audio clips and time the program to correspond to the audio clip lengths for an increased programming challenge.
- Create multiple audio *expressions* and use those in *sequences* to play songs or compose new music.
- Use sensors in a meaningful way to provide a greater programming challenge.
    - Use a sensor in the middle of a *sequence* to choose a behavior, i.e. use the sensor as more than just an "on-switch" for the robot.
    - Create a program where a range of sensor values corresponds to a range of activities (i.e. levels of brightness corresponding to different types or intensity of movement)
    - Use more than one type of sensor, with each sensor regulating different aspects of the robot. For example, a light sensor regulating servo motion in some way; and then a sound or range sensor regulating color.
    - Use multiple sensors simultaneously by putting sensor loops inside *subsequences* which are nested other sensor loops.
- Make two robots that interact with each other or two teams program their robots to interact (for example the robots trigger each other's sensors or co-present a project).
- Program in Scratch (or another supported language like Java) instead of Visual Programmer. [Coming in the future: video tutorials on Scratch.]
    - Control a Hummingbird output by making it proportional to a sensor input ("proportional control"). For example, make a servo's position mimic a potentiometer position or a distance sensor slowly dim or brighten a LED).
    - Use variables and logic operators to compare sensor readings and make output choices, for example compare the readings of two distance sensors and turn toward the one that is closer.
    - Use inputs from a keyboard or mouse to puppet a robot's behavior, for example press the "L" key to turn on LEDs and press it again to turn them off.
    - Complete list of supported languages available at http://www.hummingbirdkit.com/learning/software
- Make a video tutorial on how to program a certain behavior

Extension Activities - Engineering Design

- Increase the number of outputs used in the robot.
- Make a robot where all the electronics and mechanism actuation are cleverly hidden completely from view.
- Use specific output types. For example, full rotation motors provide a greater design challenge than the other types of motors.
- Create a hinge from cardboard etc. that is opened and closed using kit motors.
- Make a robot with symmetric motion actuated by a single motor, for example butterfly wings that open and close.
- Implement two or more types of motion (rotary motion, linear motion, oscillating motion, reciprocating motion, curvilinear motion).
- Make a challenge robot with restrictions on types and quantities of materials.
- Make a tutorial video on using certain components or building a certain mechanism.
- Create a robot that performs a specified task. Some examples include:
    - a robot that draws a picture
    - a robot which remains outside a box and pops a balloon inside a box
    - a robot that opens and closes the blinds based on outside light levels
    - a robot that clears a table top without falling off the edge itself or a prototype for an automatic snow removal robot
    - a robot that follows a black line drawn on a white surface (hint: use a light sensor)
    - a robot candy dispenser or a pill dispenser for an elderly person
    - a robotic arcade game (e.g. a pinball-like machine)
- Make a robot that has joints and degrees of freedom that are not directly controlled by a motor, but that are indirectly controlled. For example, a tail with many joints swishes back and forth, but only the joint in base of the tail has a servo.
    - Related research topic: underactuated systems
- Make a robot where a motor creates pulling (tension) or pushing (compression) motions (instead of spinning). The motor can pull parts using string, tooth floss, etc. Alternatively the motor can push parts using popsicle sticks, dowels, etc.
- Research pop-up books online or at the library. Make a pop-up book and actuate it.
    - One nice reference book is Elements of Pop Up by James Diaz
- Uses two or more simple machines in a robot (lever, wheel and axle, pulley, inclined plane, wedge, screw).
- Research an engineering topic and create a robot based on your research. Possible research topics include:
    - Rube Goldberg machines
    - simple machines
    - motion conversion mechanisms (a nice resource is: http://www.robives.com/mechs)
- Create your own sensor (additional instructions coming in the future).
    - Technical description of hummingbird electrical specifications: http://www.hummingbirdkit.com/technical/datasheet
- Create your own outputs (additional instructions coming in the future).
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