**DESIGN ATTRIBUTES**

These codes describe the prototype at the end of the session.

DESIGN ATTRIBUTES - specific attributes of the design that can indicate the complexity or other aspects of the prototype.

* NUMBER-PARTS - number of parts used in final prototype.
* NUMBER-STEPS - number of steps/blocks in final program.
* CREATIVITY - subjective rating of whether design did (or did not) shown originality (4 highest to 1 lowest)
* FUNCTIONALITY - rating of how well the ride meets the design criteria.
* PROCESS - rating of the subject’s engineering design process specifically with respect to causal reasoning and planning (4 highest to 1 lowest)
* RATING - overall rating using a rubric; mean of above 3 aspects - creativity, functionality, and process (4 highest to 1 lowest)
* STABLE - final design is stable (1/0)
* SYMMETRICAL - final design is symmetrical (1/0)
* SCALE - final design is to scale (1/0)
* USE-COMPUTER - subject used the computer to animate the prototype. (1/0)
* USE-CRAFTS - the subject used craft materials (includes blocks) in the prototype. (1/0)
* USE-DIRECT-COUPLING - the ride uses direct coupling of motor to axle to move. (1/0)
* USE-GEARS - the ride uses gears to move. (1/0)
* USE-MOTOR - the rides uses a motor. (1/0)
* USE-PULLEYS - the ride uses pulleys between to move. (1/0)
* USE-SENSOR - the ride uses a sensor. (1/0)
* USE-PLANNING - the student produced planning artifacts on paper before building. Post-make builds are not counted. (1/0)
* TIME - elapsed time of build. Not judged in any way but captured as a possible item of interest.

**ENGINEERING DESIGN PROCESS PHASES**

These codes describe the engineering design process. In the case of clear, overlapping design phases, code the verbal with [2:*name*] and then indicate the end with [2:END]

BUILD-NORMAL - normal building, which includes looking for parts unless the looking for parts was researching the feasibility of a potential design or subsystem. If the subject is describing what they are doing now, count as building and not planning.

BUILD-REBUILD - rebuilding (fixing) something that built previously. This includes building it in a different way as well as reattaching a subsystem that fell off for example.

EVALUATE-PHYSICAL - evaluate by testing physically.

EVALUATE-VERBAL - evaluate without any physical test by talking.

EVALUATE-VISUAL - evaluate by looking without touching or talking.

EVALUATE-SYSTEM - evaluate the whole system including the program by running the program.

PLAN - subject was planning some aspect of their design, typically verbally. Do not count describing what the subject is currently building. That should be coded as building. If the subject is verbalizing what they are planning to build in the future, even if it is the immediate future, count as planning.

PROBLEM-SCOPING - subject tries to clarify the problem as defined by the researcher, typically by asking a question and/or gathering more information about the problem (not about a possible solution, which is research).

PROGRAM-NORMAL - Programming the robot.

PROGRAM-REPROGRAM - Fixing a previous program.

RESEARCH - researching a problem or possible solution. Looking for parts can be considering research if it is affecting major design decisions before building starts or during the build. Otherwise, consider it part of building. If there is a small build that is part of research that is evaluated, consider that research as well.

SHARE-OUT - the student is sharing out without being prompted. Normally not used since sharing out is part of the post interview. However, this should be used if the student is sharing out unprompted. Specifically, use this code if the subject is making post-make drawings.

**DESIGN PROCESS - Strengths and Challenges**

These categories and codes describe behaviors seen during the design process that relate to strengths and challenges during the task. Codes *in italics* were added from theoretical frameworks or existing research.

CAUSAL REASONING - subject exhibiting aspects of causal reasoning. Some codes have values of + (successful), - (unsuccessful), or = (neither successful or unsuccessful).

* *CONTROL-VARIABLES* - subject attempted to control variables to isolate a cause. (+/-/=)
* *INFERENCE* - subject made a inference as to why something occurred, typically while troubleshooting. (+/-/=)
* *MAGICAL-THINKING -* subject attributed an effect to a magical cause.
* *MULTIVARIATE-REASONING* - subject attempted to deal with multiple variables at the same time. (+/-/=)
* PROJECTION - A simple cause and effect projection. X will happen because of Y. In the pilot study, there was a separate code for significant incorrect projections. These will be noted as -- here. (+/-/=/--)
* *SYSTEMS-THINKING* - the subject showed an understanding of the complete system he or she designed and how the different subsystems interrelate. (+/-/=)

DESIGNERLY PLAY - exhibiting explicit signs of designerly play

* CREATIVE-PLAY - subject shows creative play by using mini-figures, verbalizing story lines, etc.
* TALK-TO-ROBOT - the subject talked to the robot as if it were a living being. This is also known as anthromorphisation.
* PLAYFUL TALK - elements of “humor, puns, teasing, music making, and other word play”

DESIGN PRINCIPLES- codes indicating aspects of design noted. Codes have values of 1 or 0.

* SCALE - student was concerned about the proper scale of his/her design.
* STABILITY - the subject was concerned with stability issues or the design had stable or unstable attributes.
* SYMMETRY - Subject built symmetrically or is concerned about symmetry or balance. Negative sign indicates that asymmetrical qualities of the design were noted.

DESIGN PROCESS - codes indicating aspects of the design process noted.

* CONNECTOR-META - subject showed structural or meta knowledge of LEGO connectors either verbally or clearly demonstrated in their building process.
* IDEA-FIRST - subject indicated verbally that they were looking for specific parts to instantiate a design idea.
* PARTS-FIRST - subject indicated verbally that they were looking at parts to help them come up with a design idea.

PHYSICAL - codes indicating challenges with the physical aspect of building

* FINE-MOTOR - subject exhibits difficulty with fine motor operations such as attaching LEGO pieces.

PROBLEM-SOLVING - codes indicating some secondary aspect of problem solving as seen in the context of a robotics open-ended challenge. Most codes have values of + (successful), - (unsuccessful). If unsuccessful, they used the strategy but it did not help or actually hurt their efforts.

* *ATTEND-CONSTRAINTS* - subjects attending (or not) to the constraints of the problem (ride is specified to be safe and interesting). (+/-)
* MATH - student used math to help solve a problem. (+/-)
* PERSISTENCE - the subject was persistent in solving a problem. Note that, as seen in the pilot study, this can be non-optimal if the subject needs to do a significant redesign and is reluctant to do so. (+/-)
* PROBLEM-SOLVED - subject solved or did not solve a significant problem that was encountered and a solution attempted (+/-)
* SCIENCE - the student used science to help solve a problem. (+/-)
* SEMI-CONCRETE - A semi-concrete projection or test, where the subject, for example, brings a part up to another part to evaluate whether it will fit but does not end up needing to put the part wholly next to the other part. (+/-)
* SEQUENCING - the subject was concerned with building or programming in a certain order required to solve the problem. (+/-)
* TROUBLESHOOTING-TACTIC - the subject used a general purpose tactic for troubleshooting, such as stepping back to examine their design, looking at a design from different angles, or using the WeDo or NXT connection information for troubleshooting. The exact tactic used is noted. (+/-)
* *SYSTEMIC-TESTING* - subject used a through and systemic plan for testing the system. (+/-)

**SUBJECT ATTRIBUTES -** attributes of the subject determined by interview or by classroom and technology teacher

* GRADE- second or sixth (2 or 6)
* GENDER- male or female (M or F)
* LEGO experience at home - (1 or 0)
* SELF-EFFICACY - self-reported confidence in building and programming LEGO robots (1 low to 5 high)

**RESEARCH PROCESS**

These codes indicate something about the research process itself.

* HELP - The researcher gave help to student. This is noted as a code so it will not be counted as an action of the subject.
* IMPORTANT - an important and significant event occurred that might benefit from further analysis.
* WAIT - student had to wait for researcher or was temporarily interrupted in some way. This can also include side talk with the researcher that is not related to the experiment. This is used so that this time is not counted in any analysis. For example. This is used when the researcher paused the student to take a photograph.