Smart Rods (Hardware) Interim Report

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Project Specification

What is the problem to be solved

What are cuisinaire rods

What are their pros/cons?

How should my product improve upon them?

Define what it should do (think unit tests)

Use original spec

Background

What exists in the market

Association of teachers of mathematics magazine – use of cuisinaire rods

Design Choices

Several design choices have been made so far in the course of this project, each of which is justified below.

Where should electronic complexity lie?

Some form of electronic device has to be used to identify the relative positions of the rods, but we have some choice in where this device exists. If we want to keep our product to be simply a set of rods, then the only place for the device is within the rods themselves. The rods would each need to be able to communicate with each other, to discern relative position, and also with either a controller that relays messages to the server or to the server directly.

Unfortunately, this solution brings several impracticalities. Firstly, the size of the rods has to be kept small, which constrains the size of battery we could embed into them. They will have to be capable of transmitting and receiving wireless messages, and even perhaps perform some amount of processing, so their power consumption will be too high for a battery of that size. Charging the batteries would also be impracticable; consider a classroom of around 30 students, each with a set of dozens of rods, and it becomes clear that the hassle of having to charge each device individually would outweigh any benefit of the product to a teacher.

Another issue concerns the identification of rods and their assignment to students: remember again that each student needs their own set of dozens of rods, and that any information these rods transmit will be attached to that child’s profile. The teacher would have to perform the frustrating and repetitive task of assigning each rod to a student, causing a considerable amount of inconvenience. Additionally, we must keep in mind that our target users are children, who may have the tendency to take rods from another student, misplace their own rods, or perhaps even throw rods around the classroom – all of these actions could cause sets of rods to be mixed together, leading to incorrect data being sent to the server, as progress from one student will be attached to the profile of another.

The last issue is economic: each of these rods will require several electronic components, including a processing unit and wireless transceivers, driving the cost of each unit up considerably. This is especially relevant as the smaller rods are easily lost in the classroom, so replacements would likely need to be purchased, increasing ongoing costs further.

An alternative solution to putting complexity in the rods is to design a playing board with which the rods can interact, and embed the majority of the electronics in that instead. The board would resemble a chess board, with grid squares guiding the placement of rods. The students arrange their rods on the board, which can identify the positions of the rods through some means, and communicate that data to the server. This alleviates all of the problems detailed above. The board is large and can house a larger battery than the rods, so there would be no power problem. There would only be one board per child so there are fewer devices to charge and much less work involved in assigning devices to children, also meaning that mixing of rods is not an issue, as it is the board which is unique to the child, not the rods. The cost to replace rods would be much lower as they would not contain as much electronics, and the overall cost would be lower as only the boards would require processing and communications equipment, as opposed to fitting one to every rod.

During an interview with a primary school teacher, we were informed that having a board may actually aid in the students’ learning, as having a grid could help them conceptualise how the rods fit together.

How should the board detect rod positions?

Having settled on the use of a board, the next design choice to be made is what technology it will make use of to detect where rods have been placed. The chosen method needs to have the following characteristics to be viable: it must be able to *reliably* detect rods and their positions, as any errors may mislead and confuse the child, weakening the product’s effectiveness as an educational tool. It should be *economical*, as there could be up to hundreds of these products in use at an institution, and since they will likely be using public funding they will be under budget constraints. It should remove as much *complexity* from the rods as possible, for the reasons outlined in the above section.

how will the slate detect a rod is on the grid?

1. By weight
   * This would be temperamental as the children will be touching the board a lot, which will make it difficult to distinguish between a child’s hand and a rod. Also it will be very difficult to distinguish between rods.
2. Magnetic fields
   * We could give each rod a different strength magnetic field and detect them using that, but that would not be reliable as the grid squares are quite small so it would be difficult to determine exact location
3. RFID Chips
   * This has a similar problem as magnetic fields, as the range of RFID is too high to be able to distinguish between the small squares on the grid. It will also be expensive to install many chips into the rods.
4. By light colour
   * We can have an RGB LED flash and measure the reflected frequencies to determine which rod is on which grid square. This is the best option because it is cheap to install LEDs, it does not suffer from location uncertainty, and it keeps the rods very simple – in fact the schools can keep the same rods they already have. Too expensive.
5. By Shorting resistors
   * Cheap and simple to implement. Very little complexity required in rods.

Implementation Plan

Rods

**Magnets**

Will need to install magnets inside plastic rods. This will give them weight and help them stick to the board

**Colours**

Need to decide what colours to use and find those inks for the 3D printer

**3D Printer**

Need to learn to use 3D printer

**Connection to board**

Different possibilities for connections w/ pros/cons

Board

**Wireless Comms**

*Security*

How much security is needed? Not sensitive info.

*Localisation*

Don’t mix transmissions with other classrooms

*Antenna*

Need to fit antenna for comms, factor this into board size.

*Controller*

Can this all be done with arduino?

*Hub*

Do we need a separate mains powered device to communicate with boards or can they communicate directly with router?

*Data Structure*

– Classroom ID

– Board ID

– Time

– Grid of positioning (calculate rod placements or just individual grid squares?)

*Protocol*

HTTP to server?

**Power**

*Battery*

Size of battery, what power management circuits need to be in place? Will Arduino draw too much power? Need mains power? Aim for ~90 Mins

*Charging interface*

Need transformer? Ask a power electronics  person.

**Rod Detection**

*Hardware*

Need arduino? How to control

Use ready made sensors? <http://bit.ly/2fSaKxD> (£0.99 **(£1.188)** eachfor 400) too expensive?

*LEDs*

Find correct size/shape

**Material**

What is the board made of – 3D print?

**Size**

Determine size of board and draw grid, allow for margins

Evaluation Plan