Software Review: Algodoo Amy Ahearn and Sarah Gonzaga

**Learning Goals**

* What can the software/toolkit do? What is the educational/learning goal?
* Does the product meet the goal? In what ways does it fall short? Discuss conceptual structure, content, process of using software, user interface
* Compare learning this product vs. traditional approaches
* Does the nature of the product introduce new content into the curriculum?
* To what extent does the product itself do the teaching/learning work?

*Functionalities and Learning Goals*

Algodoo is a virtual physics lab that allows students to run their own simulations by arranging computational objects on a canvas. The primary learning goal is to enable students (from ages 5 to 14+) to understand and mathematize physics concepts by designing their own virtual experiments, manipulating parameters to show the effect of different variables, and connecting object-based phenomena to symbolic representations through the use of data plots.

Like most design software, Algodoo provides users with a palette of shapes (circles, rectangles, polygons), and line-drawing capabilities, but also has unique features like optics, rays, lasers, axles, hinges, gears, lenses, prisms, and springs that make it uniquely suited to exploring physics. Algodoo enables students to adjust a range of parameters within their models. For example, the physical properties of many of the objects can be changed along several dimensions including density, texture, and restitution, which encourages open-ended experimentation. The material composition of objects can also be changed, with options including gold, glass, stone, steel, rubber, helium, wood and ice.

The colorful, easy-to-use interface makes Algodoo feel more akin to a drawing studio than a lab. Nevertheless, the designers have been careful to embed graphing and computational capabilities. Students can manipulate their arrangements of objects by adding vectors to represent velocity, force, momentum and friction, and then can generate graphs that plot these vectors. This constellation of different parameters and possibilities enables students to build models of varying levels of complexity, and allows teachers to define their own specific learning goals.

*Ability to Meet Learning Goals*

Algodoo has a well-crafted, inviting interface that makes it user-friendly even for physics novices. A series of self-paced tutorials introduce the new user to the basic functionalities of the palette of tools and objects. After figuring out how all of these tools work, more advanced users can also take a tutorial about the “sketch” tool which gathers the functions of all the other tools into one place using a series of simple gestures. Once mastered, the sketch tool enables quicker design, set-up and alteration of the virtual environment.

Algodoo comes with a set of lesson plans that can usefully be sorted along several dimensions including language, difficulty level, use-configuration (demonstration, experiment, etc.) and concept. Interestingly, all of the highest-level lesson plans are not available in English yet, but do appear available in Japanese, Chinese, and Swedish. It is also difficult to tell what ages/grades the levels best correspond to, which could be a challenge for an American classroom teacher looking to integrate this Swedish software into his/her existing standards-based curriculum. While a useful starting point, some of the lesson plans are only textual outlines without accompanying visuals. With the exception of a few of the demonstrations, they do not provide teachers with links to pre-assembled simulations to start out with. This means that teachers have to toggle back and forth between the instructions and the workspace as they try to configure all of the elements and remember the steps/prompts in the learning process for the first time, which could prove challenging and tedious.

Although the introductory tutorials are fairly intuitive and straightforward, they still might prove challenging for the youngest users to master, and might be too time-consuming for the most time-pressed classroom environments. The lessons for 5-7 year olds in particular seem ambitious, not because young students are incapable of exploring these phenomena, but because they may not yet have the reading comprehension skills to follow the detailed instructions to configure these environments and master all the tool functionalities independently using the tutorials. Including a step-by-step audio guide could be helpful in this regard, or teachers could model the phenomena on a SmartBoard that the whole class could interact with.

While the interface is fun to experiment with, in order to accomplish meaningful learning outcomes, Algodoo works best in concert with specific prompts or problems to solve that a teacher would have to provide. Currently, there are only two tutorials (related to friction and density) that specifically walk the students through a problem-solving exercise using the computational objects. These two tutorials are useful beginnings, but they simply flash questions on the screen, asking students to make their own predictions and interpret the phenomena, but never requiring them to document their learning or record their thinking. In effect, then, all of the interpretive work/computation has to occur outside of the context of the interface, which could likely lead the students to rush past these prediction/interpretation stages in an effort to get to the simulations. Thus, the ability to ensure that the learning goals are meaningfully accomplished and the simulations are understood in the context of mathematical principles is left up to the individual learner or teacher. In the absence of carefully-crafted prompts connected to real world contexts, students might never be pushed to experiment with all of the parameters or fully understand the math underlying some of the configurations of gears, planes, and wheels that they assemble. We have developed “Student Activity Learning Templates” to meet this need. The teacher can customize them for each lesson by inserting the pertinent learning goals, and then students can use them as a space to organize and track their thinking, predictions, and observations.

*Comparison to Traditional Approaches*

In the process of reviewing this product, we consulted with a third grade teacher who teaches a basic unit on simple machines to her students every year. We wanted to get a sense of how using Algodoo could augment traditional approaches to teaching physics, especially for young students. The teacher described how she typically sets up very basic experiments to model the six types of simple machines in her classroom and allows students to play with them to see how “simple machines make work easier.” She also said that she uses a “simulation” from an education website (<http://www.edheads.org/activities/simple-machines/index.shtml>) projected on her SmartBoard. This “simulation” is a series of animated videos that shows students where various types of simple machines can be found throughout typical homes. Although it usefully connects simple machines to real-world contexts, this more “traditional” computer program does not have any functionalities that allow students to manipulate the properties of objects or link them to symbolic or graphical representations. Algodoo could importantly enhance these traditional lessons by mathematizing phenomena so that students can concretely see the relationship between the machines and objects they are exploring and how their motions connect to data points on a graph. For example, when modeling a block sliding down a ramp, students can simultaneously draw up a graph and track the increase and decrease of velocity of the block at different points in time as it slides down the ramp. Additionally, Algodoo’s constructivist environment allows students to flexibly change materials, sizes, and shapes of objects without having to simply watch scripted animations. Students can more freely and easily experiment in the virtual world than the physical world because they are not constrained by the expenses and time associated with procuring supplies and materials.

**Educational Philosophy & Design Choices**

* What is the educational philosophy embedded in the product?
* What is foregrounded/backgrounded by the product? Which things become salient and which become hard to see or understand).
* How are the components of the toolkit designed? How complex is the design? How mindful of learning theory is it?
* What are the theoretical and design inspirations for this product?

Algodoo self-identifies as a software based on the “constructionist learning paradigm” and embodies many of the characteristics of open-ended scientific and mathematical microworlds outlined by L.D. Edwards in “Microworlds as Representations.” It is defined by several related education principles/philosophies: constructivism (Piaget); customized learning (Collins and Shavelson); the ability to make thinking visible using “objects-to-think-with” (Papert); authentic learning inspired by children’s play (Resnick); and emphasis on forming connections between objects and symbolic representations (Edwards).

*Algodoo as a Microworld*

Within the context of the Algodoo interface, students can experiment with a “set of computational objects created to reflect the structure of math or scientific entities” (Edwards). As with other microworlds, there is no fixed or scripted core of activities that a user is required to proceed through in a linear fashion when using Algodoo. Rather, teachers and students can use the software in open-ended ways that make sense within their own learning contexts. This is not to say, however, that Algodoo lacks a defined scope or structure: it is still a “rule-governed universe, subject to specific assumptions and constraints that serves as an analogical of some aspects of the natural world” (Edwards). As mentioned previously, Algodoo has certain parameters and a limited set of materials that students can experiment with, allowing for more fine-grained analysis of a set of phenomena. Additionally, Algodoo is a microworld that “feeds back to the student the results of their attempts to solve the problem, providing information that can be used to discover intended math relationships” (Edwards). For example, if the student builds a model that has faulty connections or does not have defining planes, the simulation will fail to run or the objects will veer off screen, providing the student with immediate feedback that some parameters need to be changed.

*“Objects-to-Think-With”*

The configurations of gears, planes, ropes and wheels that students can create become “objects-to-think-with” (Papert) and a valuable “externalization (of physics concepts) to augment the unaided mind” (Ackerman).

*Connections Between Objects and Symbolic Representations*

Like NetLogo and other microworlds, a key feature of Algodoo is that it links instantiations of math and physics concepts to “symbolic or graphical representations” (Edwards). This is exhibited at the most basic level when a student selects a circle from the palette of objects and the calculation of the radius automatically appears inscribed on the shape. When students adjust the dimensions, the measurement of the radius also automatically updates, allowing them to see the relation between a numerical representation and the physical properties of the shape. On a more complex level, when students set up and run experiments—for example, tracking the rate at which an object moves down ramps with different properties of friction—this data can be plotted on a graph so that students can make both observational and numerical comparisons.

However, unlike NetLogo or Scratch, the coding environment is not transparent to the Algodoo user. Algodoo has some capabilities to link numerical/symbolic representations to the phenomena it models, but it does not transparently provide students with access to code. The fact that this dimension is moved to the background of the simulation means that it does not have the “glass box” approach to modeling that Wilensky describes. Although students can get feedback from the simulation on the way that they alter parameters and move objects, it does not “impose the need for precise statement…through attempting to make the computer understand and perform” (Feurzeig) and therefore falls a step short from “helping the student strive for self-consciousness and literacy about the process of solving problems (Wilensky).

*Authentic Learning Inspired by Children’s Play*

Importantly, Algodoo enables situated learning connected to a students’ own interests and questions. For example, one of the pre-made lesson plans asks students to recreate their own playground in the virtual world and experiment with the physics involved in their swing sets, slides, and see-saws. Thus, like some of the project Resnick describes, Algodoo “look(s) to children’s activities in which the use of materials is both rich in potential mathematical content, and naturally linked to formal notations” (Mindstuff) for inspiration. By allowing students to build environments and configurations that mimic real-life settings and phenomena, Algodoo helps to close the gap between “totally dissociated learning” and “compelling authentic reasons to learn math” (Papert). When used in connection with solving real-world design problems, Algodoo aligns with some of the same principles as turtle math including the continuity principle (math and physics can be made continuous with well-established personal knowledge) and the power principle (empowering learner to perform personally meaningful tasks that could not be done without it) (Papert).

 Additionally, as mentioned before, Algodoo has some of the aesthetic qualities and appealing interface of a design studio, which might make it more inviting to students who have experience with visual art or graphic design, allowing it to overcome some of the “cultural barriers (that) impede children from making scientific knowledge their own” (Papert, Mindstorms).

*Customized Learning, Public Sharing*

Finally, unlike the type of simple machines animation that the 3rd grade teacher said she traditionally uses in her classroom, Algodoo has the potential to provide the type of customized learning that Collins and Shavelson describe because students can construct and tweak their own simulations and design them based on personal interests. When students alter properties and parameters to try to see which object will most quickly travel down a slope or sink to the bottom of a liquid first, for example, the computer program “makes the process more visible both the informed observer and the children themselves” (Papert). It is unlike a standard computer environment “used to put children through their paces” (Papert) or for passive consumption like those computer programs “designed by and for the television generation” (Resnick). While Algodoo can be individualized, like Scratch and NetLogo, it offers a gallery for public sharing of projects. This showcase contributes to “building knowledge structures” because it contributes to the creation of a “context where the learner is consciously engaged in constructing a public entity” (Ackerman).

**Classroom Applications & New Learning Activities**

* What are some examples of activities you could give a class using this product?
* What kind of classroom or learning environment would work with the product?

The software has the capability to be used on both individual tablet computers (with a touch-screen interface), personal computers, or large smart boards, allowing it to be adapted for both individual student experimentation or whole class demonstrations.

We have designed a package of materials to accompany Algodoo in the classroom. All can be found on our website: <http://algodoo.yolasite.com/>

* **Website for Teachers:** *“Algodoo in the Classroom”*
* **Introductory Video for Teachers**
* **“Using Algodoo in the Classroom” Checklist**
* **Student Activity Template**
* **Activity 1: Exploring Gears and Gear Ratios**
* **Activity 2: Rolling Down a Ramp**

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