THE IDEA MELTING POT (IMP)
An openly-editable web-based community learning
resource for builders

Laura E. Nichols

Submitted to the Program of Media Arts and Sciences,
School of Architecture and Planning, in partial fulfillment of the
requirements of the degree of Master of Science in Media Arts and
Sciences at the Massachusetts Institute of Technology
September 2007

_____
Author
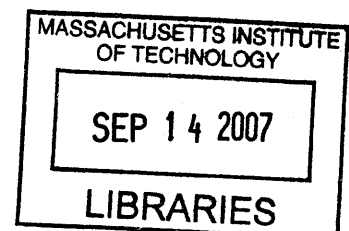Program in Media Arts and Sciences
August 2007

_____
Certified by
David Cavallo
Research Scientist, The Future of Learning Group
MIT Media Laboratory

_____
Accepted by
Deb Roy
Chair, Departmental Committee on Graduate Students
Program in Media Arts and Sciences

ROTCH

THE IDEA MELTING POT (IMP)

An openly-editable web-based community learning resource for builders

Laura E. Nichols

Abstract

This thesis discusses the development, use, and potential future for an openly-editable web-based community learning resource for builders. The idea for a resource such as this and how it might be structured stems from Seymour Papert's vision of a Constructopedia:

> [...] a browsable, interactive database, designed to help children build structures, mechanisms, and computer programs as well as to make connections to the mathematical and scientific ideas underlying those constructions. Whereas encyclopedias focus on "what is," the Constructopedia focuse[s] on "how to" and "what if." The Constructopedia [is] intended as a communal resource in which children not only get access to building tips, but also contribute their own ideas and designs [Lifelong Kindergarten, 2007].

The IMP differs from existing resources in three key ways. First, by allowing for both project pages and concept pages to be added and by providing numerous, flexible ways of navigating the site, the IMP attempts to treat learning through construction more like the immersive learning of a new language. Second, due to its collaborative nature, the IMP serves as a place where builders can reflect on their ideas, share their projects, and contribute to the learning environment. Third, the IMP attempts to support the use of whatever materials are locally available to the builder instead of only focusing on one type of material or on one particular kit.

4

THE IDEA MELTING POT (IMP)
An openly-editable web-based community learning resource for builders

Laura E. Nichols

Submitted to the Program of Media Arts and Sciences,
School of Architecture and Planning, in partial fulfillment of the
requirements of the degree of Master of Science in Media Arts and
Sciences at the Massachusetts Institute of Technology
September 2007

Thesis Supervisor
David Cavallo
Research Scientist, The Future of Learning Group
MIT Media Laboratory

Thesis Reader
Glorianna Davenport
Principal Research Associate, Media Fabrics Group
MIT Media Laboratory

Thesis Reader
Arthur Ganson
MIT Rubin Artist-in-Residence, 1999

Acknowledgements

I owe many people my gratitude for their help, generosity, and friendship during the past two years, and particularly, the past six months:

My thesis committee: My advisor, David Cavallo, for always encouraging me and for always asking me to think about the "larger picture;" Glorianna Davenport for her support and gracious feedback; and Arthur Ganson for his kind and thoughtful comments. It has truly been my pleasure to work with you all.

Highlands and Islands Enterprise for their funding and support during my workshops, and for their dedication to making the highlands of Scotland a great place to both live and work.

Jacqueline Karaaslanian for not only her patience and support, but also her gentle ways and kind words.

My office mates, Roger Sipitakiat and Claudia Urrea. There are no other people I would rather be cramped into an office with.

Kayle Sawyer and Marcos Ojeda for always listening and for helping me on developing the IMP.

Luis Blackaller, Brent Fitzgerald, and the rest of the PLW for your wonderful company and for not minding me working on your couch more often than I worked in my office.

Seth Raphael for encouraging me to see the world in different ways.

Michele Oshima for her unwavering support over the past six years and for the use of her purple couch while writing this thesis. I am truly endebted to you.

Christina Chestnut for her love and generosity, and for many late nights of thesis editing.

And, of course, my parents for always encouraging me to dream.

Contents

1 Introduction

The foundation of constructionist learning is that "people learn best through designing, building, and sharing projects based on their own interests" [Chapman, 2006], projects in which they are personally invested. To realize one's ideas through physical construction, one must be able to externalize one's ideas in some type of construction material. In the past many open construction kits, for example LEGO, have been used as the basis of such construction materials in an effort to facilitate beginners' and young people's starting to build their own designs. Unlike model kits, which allow for the creation of only one object and which provide the thinking for the builder through step-by-step instructions, open kits allow builders to realize their own designs. Much success has been achieved through the use of these kits in a constructionist environment. Construction kits, such as LEGO, K'nex, Meccano, Erector, etc. can be a great way to introduce people to constructing and robotics; the kits' materials afford rapid and solid construction, as the parts and their connections are designed for this purpose. However, constructing with only one kit or one set of materials is like writing poems with limited vocabulary and grammar: because each kit is designed to be used a certain way and because each material has its own set of limitations, a builder is constrained to use the materials only in the ways allowed by those materials. For example, LEGOs are meant to be assembled in certain ways, and as such, most LEGO constructions have qualities associated with this, such as being somewhat rectangular and limited in scale.

Additionally, like model sets, many construction kits come with step-by-step instructions that show the builder how to make two or three objects given the parts in the kit. Having such instructions is a way of providing builders with the knowledge of how to build with the kit without having to send the kit's designer or designers along with it. However, such instructions can be disadvantageous to a builder's learning and understanding of design, for if a builder only experiences construction through using kits along with step-by-step instructions, the builder is left without a deep understanding of the design and construction process, as much of the thinking about the design is provided for the builder through these instructions. When a builder then takes apart

the kit and goes to create her own designs, she is often discouraged because her designs do not live up to her own expectations. To enable learning about design, one must be encouraged to design and supported in completing one's design, not simply provided with design solutions.

The cost of these kits, especially the robotics kits, can be prohibitively expensive. As a result, currently only certain people, communities, and schools are able to access the kits, and thus the concepts enabled by using the kits in a constructionist learning approach. This is particularly true for poorly-funded and poorly-supported schools, such as those potentially found in developing countries, rural areas, and inner-cities. However, the concepts that can be learned through designing with open construction kits are not limited to only these kits; they are concepts that can be learned through designing with, interacting with, and constructing with locally available materials. These concepts include such things as gear ratios, the use of triangular shapes to provide structural stability, programming interactivity via sensors, etc., and are concepts that, if encountered while a builder is working on a project in which he or she is personally invested, could provide a rich, personally relevant entry point into deeper mathematical, scientific, and computational thinking. From a learning standpoint, there is no reason why these concepts should be limited to only the people who can afford to buy pre-constructed kits; these concepts should be made available and accessible to a larger population.

Earlier in my research, I had intended to design and explore a low-cost construction kit, but over the course of a series of workshops focused on constructing with wire and other locally available materials, I realized that instead of providing yet another kit, I wanted to provide a way to enable and encourage the use of any available local material. For example, wire, a material which can be found almost everywhere in the world, can make a solid and relatively durable basis for mechanisms; other locally available materials, such as cardboard, can make a basis for structures; and low-cost boards such as the GoGo Board, an open-source/open-hardware Logo-based board, can provide a basis for computation. However, the knowledge to use local materials in such ways is not resident everywhere; knowing how to start to use these materials without having seen previous constructions and without any guidance can be a daunting task for learners. Many people may not consider some materials to be suitable for a given

task because they have never seen or experienced the material being used in that way. For example, many people in the United States might consider aluminum cans to be trash or as an item to be recycled, whereas many people in Africa or South America readily use such cans to create pieces of sculptural art. Instead of providing builders with step-by-step instructions on using certain materials that may or may not be available or creating a different version of a construction kit, this thesis discusses the development, use, and potential future for an openly-editable web-based community learning resource for builders.

This resource, which I have decided to call the Idea Melting Pot (IMP, for short), attempts to provide users with the ability to learn about new mechanical construction concepts through both reading a general knowledge page about the concept and seeing how the concept is used in the context of different projects. All of the site's content is meant to be collaboratively maintained by the community using it, and as such, provides yet another way for users to learn: through reflection and contribution to the site. As more users contribute both projects and general knowledge to the site, the usefulness of the resource will grow; the more examples there are of projects which use any given concept, the greater context there is for a user to see and use to develop an understanding. Because the resource is web-based, it provides the opportunity for users around the world to share their local knowledge of the materials available to themselves and also potentially helps establish a construction culture around the use of such materials.

2 Background and Related Work

While theorizing about how technology will be in the future, Vannevar Bush said in 1945:

> Wholly new forms of encyclopedias will appear, ready-made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified.
>
> One can now picture a future investigator in his laboratory. His hands are free, and he is not anchored. As he moves about and observes, he photographs and comments. Time is automatically recorded to tie the two records together. If he goes into the field, he may be connected by radio to his recorder. As he ponders over his notes in the evening, he again talks his comments into the record. His typed record, as well as his photographs, may both be in miniature, so that he projects them for examination [Bush, 1945].

From a perspective of reading Bush's words over sixty years later, after Bush's words have helped shape the trajectory of technology's development, it is easy to substitute computers, the internet, wikis, and other relatively new technologies into Bush's vision. For us, the "memex" is simply the internet-enabled personal computer, and for a person equipped with such, "wholly new forms of encyclopedias" with "mesh[es] of associative trails running through them" exist in the form of wikis, blogs, and other similar websites and web resources. It is the spirit of Bush's statement as well as Seymour Papert's vision of the Constructopedia [Papert, 1995] that inspired me to develop and explore an openly-editable, web-based resource aimed at aiding people in sharing and explaining their construction projects, in learning about new concepts useful for their constructions, and in gaining inspiration to design and build things themselves. In addition to Bush's and Papert's inspirations, I drew upon current and past work at the Media Lab as well as my own experiences, and I explored the features and limitations of existing methods of sharing ideas and projects.

Throughout history, there have been numerous attempts at documenting

knowledge about construction, both in documenting the creator's actual thought, design, and construction processes, as well as attempting to collect into various documents, such as encyclopedias, the general knowledge accumulated through experience. Stated another way, there are attempts to share a specific and personal type of knowledge that is intrinsic in one person's time with one construction experience, and there are attempts to share a more general type of knowledge that is accumulated over many experiences. The Constructopedia that Papert envisioned is

> [...] a browsable, interactive database, designed to help children build structures, mechanisms, and computer programs as well as to make connections to the mathematical and scientific ideas underlying those constructions. Whereas encyclopedias focus on "what is," the Constructopedia focuse[s] on "how to" and "what if." The Constructopedia [is] intended as a communal resource in which children not only get access to building tips, but also contribute their own ideas and designs [Lifelong Kindergarten, 2007].

In a sense, the Constructopedia would bridge two fields of knowledge, the personal, project-specific knowledge contained in a single experience, and the general knowledge that is accumulated, examined, and clarified over many experiences. Through providing both general and specific knowledge, the Constructopedia would enable learning by introducing new concepts within the context of their use, and within the context of one's own personal projects. The Constructopedia would be collaborative, sustained by the community that used it. By allowing for builder contribution, the Constructopedia would help enable reflection on one's work, as well as encourage one to think deeper about what is going on in the building process. With the internet, increasingly ubiquitous computing, and web 2.0 technologies, such as wikis and blogs, which allow for multimedia, user-generated content, the potential for a dynamic, searchable, interactive, collaborative Constructopedia has never been higher.

2.1 A Brief History of Construction in Learning

The constructionist learning paradigm proposes that people learn best through working on projects that are meaningful to them. In order to make a project, materials are needed to assemble the project. In his book Mindstorms Seymour Papert proposes that adding

computation into projects can enable learners to explore the world in a different way, and, thus, learn in the ways that are best for them. Following this idea, the Media Lab first developed the use of LEGO robotics for learning in 1984 [Papert, 1980, Resnick et al., 1996]. At that time, a controller was connected to the computer which was then connected to the LEGO creation via cables. This enabled exploration through the LEGO medium of ideas in systems and feedback as well as in mechanics and gearing. With the advent of low-cost, small microprocessors, a portable, programmable LEGO "brick" was developed. This "brick" allowed for the computation to be included in the creation, and allowed the creation to be untethered from the computer. Because many schools cannot afford the LEGO bricks, Arnan Sipitakiat designed the GoGo Board, which is open and can be assembled locally [Sipitakiat, 2002]. Work by Joe Paradiso and others was incorporated in the RoBallet [Cavallo et al., 2004] to extend the wireless controllers and sensors into dance, music, animation and robotics. Paulo Blikstein's work continued the idea of low-cost construction, incorporating found materials and scavenging sensors from old electronics [Blikstein, 2002]. It is my intention to take the use of found and scavenged materials even further by enabling learners to share what they have done with the materials available to them, to see what other people have done with similar materials, and to learn how to use the materials they have in new ways.

2.2 Perspectives on Reflection, Experience, and Construction

In John Dewey's *How We Think*, Dewey discusses the importance of reflection in the learning process. He defines reflection as a form of thinking that occurs when a learner is confronted with a difficulty or uncertainty and says that under the right circumstances, this difficulty or uncertainty could lead to the learner purposefully questioning the situation and gaining new insights into what has happened. From here, he argues that reflection upon experience is an important step in developing deep and structured thought [Dewey, 1933], and as such, is something that should be encouraged in the learner. In *Education and Experience*, Dewey discusses the need for an experiential basis in education as a way to connect meaningfully with the learner. However, Dewey cautions that not all experiences are educative, and care must be taken to encourage experiences that are dynamic and that further the development of the learner's thinking. He further

16

argues that if we, as a society, believe in the democratic ideal, then we should believe in an education that encourages the learner to become interactively and democratically engaged in his or her own learning [Dewey, 1938].

In Michael Polanyi's *Personal Knowledge*, Polanyi explores the "inadequacies of articulation," proposing that there are areas of knowledge that remain unable to be articulated that he calls "the ineffable domain." In particular, one of the inadequacies of articulation is the ability to "know the topography of a complex three-dimensional aggregate" and be able to describe its particulars without being able to "describe their spatial interrelation," [Polanyi, 1958]. The idea of ineffable knowledge becomes important when the learning of mechanisms, structures, and other physical construction-based concepts is considered in a constructionist approach, as being able to "know the topography of a complex three-dimensional aggregate" is something that can be shown through building that object. Furthermore, in *Thing Knowledge*, Davis Baird proposes that objects themselves are embodiments of knowledge, and that builders can externalize their internal, ineffable knowledge into an object, sometimes without the builders even having a full grasp of the knowledge they possess. Therefore, from this it can be understood that physical construction is an important part of knowing certain topics, and that if these topics are to be understood deeply, the learner must be encouraged to engage with the physical.

In both Clifford Geertz's *Local Knowledge* and David Cavallo's *Emergent Design and Learning Environments,* the concept of local knowledge is examined, from both an anthropological standpoint as well as a learning one, as something that should be considered when dealing with different populations. Geertz argues that what is considered "common sense" in one group may not be so in another, as well as that what is socially and culturally relevant in one group may not be so in another, the latter of which is reflected in the art and artefacts that a given group produces. In Cavallo's writing, it becomes clear that by taking the local knowledge into account, education can tap into the "latent learning potential" of a culture [Cavallo, 2000]. Therefore, a given population should be encouraged to create locally inspired machines and projects out of locally available materials, and any resource aimed at helping people learn how to make things should be created with the empowerment of the local population in mind. Allowing for the utilization of local knowledge in the designs will potentially allow for

greater learning in a given group, and even beyond if the various groups can share with each other what has been made.

2.3 Existing Technologies

Currently, many websites and other resources exist which address various parts of the Constructopedia idea, but few are truly collaborative and none attempt to address learning from the standpoint of providing both more formalized general knowledge and a project-oriented context for that knowledge. The existing examples of construction resources that I will examine in this thesis are the LEGO Constructopedia, Instructables. com, LEGO's NTXLog beta, the Build-it-Yourself Build-it Blocks, *Make: Magazine* (and the corresponding website), HowStuffWorks.com, and Robbin Chapman's Pearls of Wisdom. Each has its unique approach to the problem of how to transfer knowledge about construction, with varying degrees of success. All of these examples take advantage of the internet to some degree; two have a paper component as well: the LEGO Constructopedia and *Make: Magazine*. Overall, Instructables.com, HowStuffWorks. com, and *Make: Magazine* (and its blog) are the most highly-trafficked web-based construction resources. Pearls of Wisdom and the Build-It Blocks are smaller web-based resources that focus on targeting a smaller group of builders. Pearls of Wisdom is aimed at users of the Lifelong Kindgergarten's Computer Clubhouses, a "worldwide network of after-school centers where young people (ages 10-18) from low-income communities learn to express themselves creatively with new technologies," [Lifelong Kindergarten, 2007]. The Build-it Blocks are meant for participants in the Build-It-Yourself workshops, after-school workshops that cost $10 to $17 per hour for each participant [Build-It-Yourself, 2007]. I will explore the uses and corresponding features and limitations of each example, look at how successful each are at accomplishing their desired goals, and finally at how close each comes to reaching the Constructopedia as originally envisioned.

2.3.1 The LEGO Constructopedia

The LEGO Constructopedia developed out of Fred Martin's work at the Media Lab's

Epistemology and Learning Group and the Lifelong Kindergarten Group and was sent out in a print version with the LEGO RCX kits. In its print form, the LEGO Constructopedia shows various types of mechanisms that can be made with LEGO parts as well as provides some ideas and step-by-step instructions to the type of projects one can make with LEGO Robotics (see Figure 1). The LEGO Constructopedia also exists in an animated form on the LEGO website, which helps show how the parts move together (see Fig. 2). As the LEGO website states, the Constructopedia is "[a] reference work containing articles on different aspects of construction. This is the place to learn all about how things work! This section is an ideal supplement for teachers using the LEGO Education Science & Technology range of products, helping youngsters understand principles of machines and mechanisms," [LEGO 2007].

Although the illustrations are nicely done and the animations are relatively helpful for figuring out how the mechanisms actually move, each of the mechanisms are shown without or with very little context of their potential use. In doing so the LEGO Constructopedia is just an illustrated and (in the online version) animated version of a book or resource guide. The LEGO Constructopedia is therefore limited to the content that the "experts" choose to put up, and thus is viewed by its users as "finished." As a result, it falls short of the ideal of the Constructopedia as a "communal resource in which children not only get access to building tips, but also contribute their own
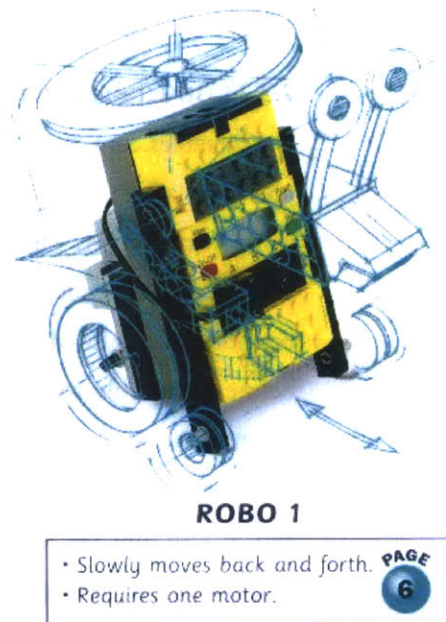
Figure 1 - An example of a project from the print version of the LEGO Constructopedia
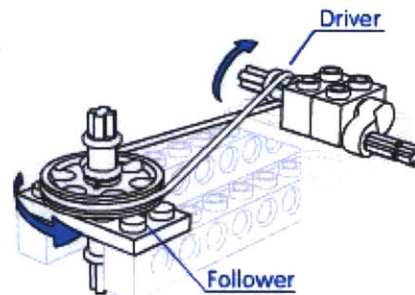
Figure 2 - A still shot of an animated mechanism from the online LEGO Constructopedia

ideas and designs," [ibid.].

2.3.2 Instructables.com

Instructables.com is a website where a user can, according to its slogan, "share what you make and how others can make it" (see Fig. 3) by posting step-by-step instructions along with images. On the main page of the site are various suggestions of ways to navigate the site, such as rotating images/articles, categories, and a search. The site is essentially a modified blog, where each project is linked to a specific user. As a result, before being able to add anything to the site, one needs a username and password. After a user account is created, users post their projects and images to the site as well as comment on others' projects. Users can also link their projects to specific categories and groups and tag their projects with appropriate keywords. Instructables.com has projects on topics ranging from "How to drill a hole" to "Quick, easy practice poi for under $5." Each project listed is able to be commented on by other users. Additionally, each project has a suggestion for related projects and forums in a sidebar on the right (see Fig. 4). In an effort to encourage contribution, Instructables.com often has judged contests for who can post the "best" project by a certain date with a given theme. In addition to building a community through posting projects, Instructables.com also builds community through discussion via comments on the projects and via the forums
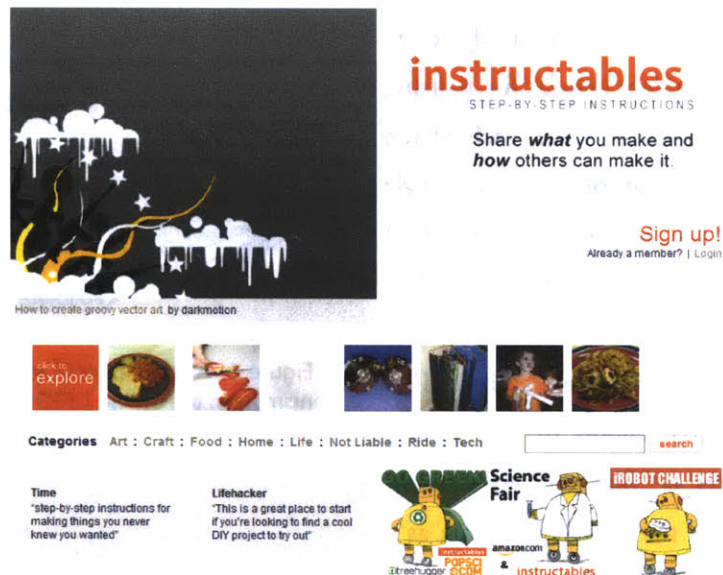
Figure 3 -Instructables.com's main page

Figure 4 - An example of an Instructable project

According to the philosophy of Instructables.com,

A key insight behind instructables is that humans are constrained to working in linear time - i.e. you do things sequentially and are generally not in two places at once. This gives us the overall framework for instructables, a way of documenting the sequence of steps that are undertaken to make any particular thing or do any task. Many of the sub-sequences will be re-useable. Why have everyone document how to drill a hole repetitively? These sorts of things should be seen as share-able sub-routines in the library of how to do things. Add to that the power of a large community filtering sub-routines for best practice and you get an expanding library of human knowledge, craftsmanship, and best practice for making just about anything.

However, the site does not quite live up to its philosophy. The projects hold true to the idea linear time in project lay out, as all steps of a project are shown chronologically by photos and corresponding explanations with an introduction that leads into what the project is about. There is a choice of either all steps being listed chronologically on one page or else each step having its own page. The site, however, does not readily enable "share-able sub-routines in the library of how to do things," for example by being able to link a project or a word/topic in a project back to another instructable. Instructables.com is also not always the most friendly site for complete beginners; because the majority of the users are hobbyists sharing their work with other hobbyists, many skills are

Figure 5 - Unfriendly comment and a response on an instructable

often taken for granted in the instructions. By showing step-by-step instructions, Instructables.com provides the thinking for the builder, and thus encourages people to replicate what has been done instead of encouraging and enabling people to create their own designs. Furthermore, when instructables which show simple skills are posted, some of the comments can be quite derisive. For example, when one user posted an instructable on "How to Drill a Hole," citing it as "one of the most common and most useful processes," another user commented "Instructables are for showing off what you've made and telling others how to do it. What next? A tutorial on how to turn on a light? Or maybe how to operate a pencil?" (see Fig. 5). Other users were quick to point out how useful this instructable is to both new and old users alike, however, comments like this show that the inherent culture of the site is more for sharing complex projects and ideas and not learning basic skills. Otherwise, Instructables.com has been very successful in building up a community of builders and hackers, and the collaborative "library of human knowledge, craftsmanship, and best practice for making just about anything" has been growing in leaps and bounds.

2.3.3 NXTLog (beta)

Unlike the LEGO Constructopedia, The LEGO NXTLog (beta) is a purely online resource that takes advantage of web 2.0 technologies to allow Mindstorms NXT users to share their designs and to tag and comment on other people's designs. In addition to showing the three most recently posted projects, the main page of the website allows a user to search through the projects by date (clicking on the "Projects" tab in the navigation bar), by keywords (in the search bar), and by popular tabs (see Fig. 6). Each project has photos of the finished project, and a few of them have close-up photos of key parts (see Fig. 7). At the bottom of each page, users can comment on the project and ask questions to the builder, potentially sparking a discussion (see Fig. 8). If a user's screenname is clicked on, it leads to a list of all of that user's work.

The NXTLog (beta) is similar in form to Instructables.com in that it allows for users to post their projects with photos and descriptions into a communal blog, and also allows for other users to tag the projects. One area, though, where the NXTLog

(beta) differs from Instructables.com is that it does not allow for users to post step-by-step instructions (with or without photos) of their work in progress. In some ways, this could be good, as it does not simply give the projects' viewers a step-by-step how-to guide to reproducing someone else's design. On the other hand, lacking this feature does not encourage people to reflect and explain their designs in depth. Additionally, by only showing finished projects and comments/tags/photos relating to those projects, the NXTLog (beta) does not "make connections to the mathematical and scientific ideas underlying those constructions," [Lifelong Kindergarten, 2007]. In other words, the NXTLog (beta) does not link the specific, project-based knowledge back to a more
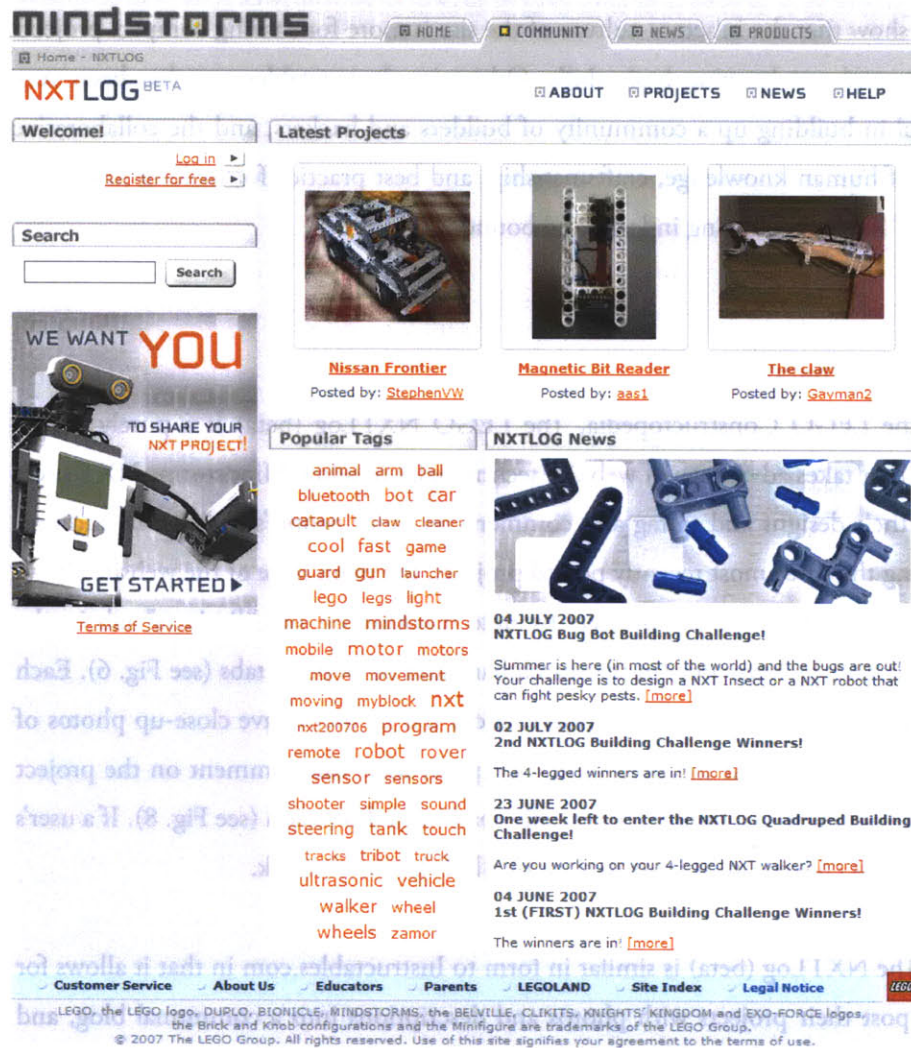

Figure 6 - The NXTLog (beta)'s main page

Figure 7 - An example project page

general knowledge base that could help builders understand the concepts inherent in the designs more in depth.

Comments   8 comments

Can you add more details and what it does to the rest of us?

Posted by "yes   Posted 2 days and 22 hours ago

cool tell some more details

Posted by BigD161   Posted 2 days and 19 hours ago

Nice job, Anders! I especially like your utilisation of LEGO beams as breadboard ;o)

Philo

Posted by Philoo   Posted 2 days and 15 hours ago

ur bots r amazing ur the best legend ever

Posted by blueeile   Posted 2 days and 12 hours ago

Ok, I don't know a heck of a lot about electronics and stuff, and after I read it I just thought "HUH!". So could you please say what it does, so all of us nitwhits can understand!

Posted by gateway57   Posted 2 days and 6 hours ago

Thanks Philo
Well more details - a reed switch is like a normal switch only different is that it reacts on magnetism. The PCF8574 has 8 pins that can be used as input or output. I used the reed switches as input to the PCF8574. Reading the status of the PCF8574 with the NXT's I2C Bus I am able to tell the state of each switch.

Posted by aas1   Posted 2 days and 5 hours ago

If you need more details of what the sensor does - I suggest you check out the video at www.norgesgade14.dk/magnet.php

Posted by aas1   Posted 1 day and 16 hours ago

wouldnt magnets break your nxt???

Posted by raspberryjam   Posted 18 hours and 38 minutes ago

Add Comment

Please log in or register to add a comment.

Figure 8 - An example comment section

2.3.4 Build-It-Yourself Build-It Blocks

Following along the LEGO Constructopedia idea are the Build-It Blocks, which are a collaboration between John Galinato at the Build-It-Yourself4 Workshop in Cambridge, MA, and the Lifelong Kindergarten Group at the Media Lab. In fact, the Build-It Blocks website has the URL http://constructopedia.media.mit.edu/ implying that it is related to the Constructopedia. Unlike the LEGO Constructopedia, the Build-It Blocks are

only online. On the main page, one can search through the Build-It Blocks by their "Uses," "Action," and "Difficulty" (see Fig. 9). When a subsection is clicked, it brings up a new page with all the pertinent articles relating to the subsection title (see Fig. 10). The articles can also be viewed all on one page without having to deal with the subsections. A bird at the top right of the page tells a user how many articles are under each subsection and encourages the user to "Try it!" when the cursor selects any of the articles (see Fig. 11). Each article consists of a list of step-by-step instructions on how to make the item shown in the article (see Fig. 12). The instructions can be navigated through one by one via a "step list" feature with a line of squares representing each step and an arrow at either end of the line to move forward or back one step. All text for the steps appears in the word balloon so that it looks like the bird is explaining what to do.

Build-It-Blocks

Return To Project | Build-It-Yourself

View All Browse (+)

How will you find it?

Uses **Action** **Difficulty**

Uses	Action	Difficulty
Critters, Puppets	Spin, Rotate or Twirl	Basic
Cars, Trucks	Shake, Dance or Flap	Intermediate
Flying Machines	Roll, Walk or Locomote	Complex
Water Contraptions	Throw or Squirt	
Action Art	Sound Off	
Architecture	Detect or Trigger	
Science Projects	Program	
Games	Presenting Projects	
Chain Machines		
Laboratory Setup		

Figure 9 - The
Build-It-Blocks
main page

Build-It-Blocks

View All   Browse (+)

I found 10 Build-It Blocks for the Use "Water Contraptions"
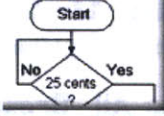
Catapult Quick   Cool Colors   Power Top Gear Train

Program Time Out   Program Tips   Sidewinder Gear Train   Spin Sideways To Vertical

Squirt Gun   Writing Poems   Writing Storylines

Figure 10 - An example of the article listings under a subsection (in this case the subsection is "Water Contraptions")

All articles contain pictures to go with each step and some articles also contain videos for further clarification.

Although the Build-It Blocks have a web address that says they are a constructopedia, there are many differences between the Build-It-Blocks, the LEGO Constructopedia, and the Constructopedia as it was originally envisioned. Like the

online LEGO Constructopedia, the Build-It Blocks take some advantage of the ability of the web to enable multimedia, such as videos, sound, and navigability. It also adds a minimal amount of crosslinking between pages. Unlike the LEGO Constructopedia, the Build-It Blocks show examples of things ostensibly made by the kids at workshops, which gives it a more do-it-yourself (DIY) feel. However, the web page itself also has a DIY feel, which results in difficult navigation. Similar to the LEGO Constructopedia, the concepts and projects listed are not added by the users, thus limiting the scale of the information the site can provide. Each article shown has step-by-step instructions on how to do precisely the project shown, which reduces the aesthetic touches the builder can apply to adornments. By focusing in each Build-It Block only on how to make a particular item, the specific knowledge of how to make that item is never linked back to the more general knowledge of how the engineering of the item works. Furthermore, by only showing one example of each design solution, a beginning builder is never able to
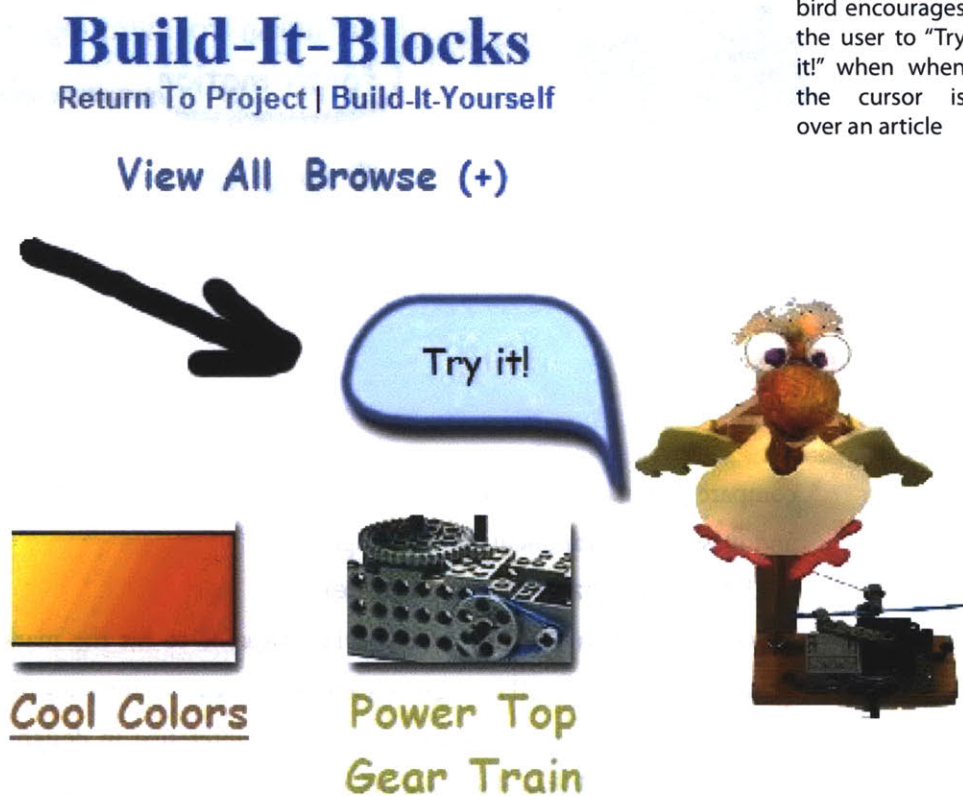
Figure 11 - The bird encourages the user to "Try it!" when when the cursor is over an article

Figure 12 - A Build-It-Block

compare designs in order to build their own contextual understanding of the essential and inessential components of the design.

2.3.5 Make: Magazine (and its website)

Make: Magazine is the most recent DIY magazine to hit the market, and although there have been other DIY magazines and movements in the past, *Make: Magazine* has succeeded in generating a new wave of people interested in designing, building, and hacking things and then sharing about their work. The magazine itself is in print form,

30

but the corresponding website (http://www. makezine.com) takes advantage of blogging to both link to a variety of project sites and to allow for user contribution and feedback. The fact that readers/users can comment and submit projects to be posted to the blog has helped *Make: Magazine* develop a strong reader/user community. *Make: Magazine*'s website's main page is colorful, exciting, and full of links to various projects (see Fig. 13). The barrage of information, colors, and photos on the main page might overwhelming to some, but the navigation bar is clearly placed at the top of the page and makes it easy for the user go to his or her desired section. The second feature on the left side of the main page is the latest blog postings: the most recent posting with a photograph, the rest of the postings listed only by title and a brief description (the titles and brief descriptions are not shown on the example main page shown in Fig. 13, but can be seen upon scrolling down *Make: Magazine*'s website). The next feature on the right side of the main page is a section for videos and podcasts showing various highlighted projects, followed by other links to projects. Additionally, a listing of links to various "Categories" and links to the archives by date can be found at the bottom of the page (see Fig. 14), which is one of the main organizing features for the blogged links, and adds to the site's overall navigability. It is also

Figure 13 - A view of Make Magazine's main page on their website

Make Categories

Altoids and tin cases »
Announcements »
Arts »
Bicycles »
Cellphones »
Computers »
Crafts »
DIY Projects »
Electronics »
Events »
Gadgets »
Gaming »
GPS »
Green »
Halloween »
Holiday projects »
Home Entertainment »
How it's made »
Imaging »
Instructables »
Interviews »
iPod »
Kits »
LEGO »
Made On Earth »
Make Challenge »
MAKE PDF »
MAKE Playlist »
MAKE Podcast »
MAKE Store »
MAKE Video »
Maker Faire »
Makers »
Mobile »
Modern Mechanix »
Music »
News from the Future »
Online »
Open source hardware »
Paper Crafts »
Podcasting »
Portable Audio and Video »
PSP »
Retro »
Reviews »
Ringtones »
Robotics »
Science »
Something I want to learn to do...
»
Telecommunications »
The Maker File »
Toolbox »
Toys and Games »
Transportation »
Virtual Worlds »
VoIP »
Wearables »
Weekend Projects »
Wireless »

Make Archives

July 2007 »
June 2007 »
May 2007 »
April 2007 »
March 2007 »
February 2007 »
January 2007 »
December 2006 »
November 2006 »
October 2006 »
September 2006 »
August 2006 »
July 2006 »
June 2006 »
May 2006 »
April 2006 »
March 2006 »
February 2006 »
January 2006 »
December 2005 »
November 2005 »
October 2005 »
September 2005 »
August 2005 »
July 2005 »
June 2005 »
May 2005 »
April 2005 »
March 2005 »
February 2005 »

OFFICIAL HONOREE

2007 WEBBY AWARDS

weblog awards
the 2007 bloggies
best craft weblog

Make videos

Latest videos

Figure 14 - The "Category" and "Archive" listings at the bottom of Make Magazine's main page

possible to search through the site with a Google-based search. The navigation bar has links to the "Blog," the latest issue of "*Make: Magazine*," tutorial "Podcasts," "Projects" listings, "Forum/Community" listings, and the "Make Store."

Aside from helping build a community around construction through blogging and commenting, *Make: Magazine*'s blog serves as a way for the editors to collect links to projects that people have done and posted somewhere else on the web, to organize these links, and to inform their readership of the links, but it is not a place users can post their own projects. The "Podcasts" section serves as an organizational tool for various how-to podcasts on topics ranging from "how to make a jam jar jet" to how to "make a balloon flinging siege weapon" (see Fig. 15). But, like the blog, the "Podcast" section is created and maintained by a set group of individuals and is not open to public posting.

The "Projects" section lists the kits that *Make: Magazine* offers to sell in addition to listing the projects that are submitted to the *Make: Magazine* group on Instructables. com (see Fig. 16). *Make: Magazine* relies on Instructables.com to host the projects' images and descriptions (see Fig. 17). The "Forums/Community" section is the most user interactive place on the site, a place where people can post their questions and

Figure 15 - The *Make: Magazine* "Podcast" section

(hopefully) get answers from the *Make: Magazine* community. The forums also have their own specialized search, where one can search by topics, comments, or users.

Make: Magazine and its website have been successful in creating a strong and thriving community that centers around DIY and hacking. The website's use of user-generated content with the blog, where people can suggest projects that should be posted, and the forums, where people can ask questions about making things and get answers from the larger community, has been a driving force behind creating and maintaining such a community.

However, both the blog and the forums have their flaws when it comes to helping the beginning maker learn about making things. Because *Make: Magazine*'s community is so large, having all the users be able to contribute to the main page in a blog format

Figure 16 - The *Make: Magazine*
"Projects" section

could pose a challenge due to the number of posts per day. Also, with such a large community, it would be hard to maintain a standard level of quality with a blog format, as each entry can only be edited by the person who created it. As a result, only the main staff make posts which are based off of suggestions by the users. Also, because the blog's

format is time-based, only the newest entries are shown on the main page, thus making it harder to search and find older, yet still relevant entries. In addition to the blog, having the forums be the main form of user contribution leads to *Make: Magazine*'s website having a lot of specific, project-based information without supporting or encouraging a collection of more general how-to knowledge. For example, the forums allow people to ask specific questions about their projects to the larger community, but nowhere on the

Make Your Own Project

Be a part of the MAKE community on Instructables to share and show your projects.

Making things is part of being human. Whether you make bikes, kites, food, clothing, protocols for biology research, or hack consumer electronics, good instructions are critical.

Instructables is a step-by-step collaboration system that helps you record and share your projects with a mixture of images, text, ingredient lists, CAD files, and more. We hope to make documentation simple and fast. Show your colleagues how to operate a machine, show your friends how to build a kayak, show the world how to make cool stuff.

Featured Projects the MAKE Instructables Group

Increase the capacity (runtime) of your laptop battery »

This instructable is intended to show how one may replace the dead li-ion/li-poly cells of a laptop battery and how one may increase the capacity of the battery by adding extra cells.

posted by xeijix on May 15, 2007

The Three Card Monte - An Origami Wallet »

Figure 17 - The *Make :Magazine* "Project" page, linking to articles from the MAKE group on Instructables.com

site is there a list of frequently asked questions.

2.3.6 HowStuffWorks.com

HowStuffWorks.com is a website that has articles on how various things are done. Topics range from "Can China Control the Weather?" to "How Holograms Work," with everything in between. The pages are organized into categories like "Auto," "Health," "Science," etc. A list of the categories can be found on the left side of the main page under "Explanations." The website has a rotating set of featured articles shown one at a time with a large image at the top of the page which has a list of smaller featured articles below it (see Fig. 18). These articles are useful in providing a way to start exploring the site for people who are new to it or who have nothing they wish to specifically find. If a user is there to find something specific, there is a Google-powered search at the

Figure 18 - HowStuffWorks.com's main page

top of the page. For example, if one is interested in knowing about gears, one could search for "gears," and would get a list of articles related to gears (see Fig. 19). In this example, each of the search hits are actually subsections of the overall topic "How Gears Work" (see Fig. 20). For any given subject, there is a main article which explains the subsections and also has, if appropriate, links to other articles which involve the subject. At the top of a section or subsection, there is a hyperlinked table of contents, and there is a navigation bar at the bottom of each subsection with "previous" and "next buttons to take one to the next subsection.

HowStuffWorks.com is a great place to find general answers to seemingly. However, it does not allow for users to contribute to content of the site outside of the

Figure 19 - The results of a search for "gears"

"Opinions" section which cannot be seen unless one is a member of the site. Because all the information on the main site (not the "Opinions" section) provides a seemingly objective view of "how stuff works," part of the total potential audience is lost due to the fact that the information is presented in only one way: users are not encouraged to

Figure 20 - A subsection (spur gears)

form a community around the site.

2.3.7 Pearls of Wisdom

The Pearls of Wisdom came from Robbin Chapman's work with the Media Lab's Lifelong Kindergarten group's Computer Clubhouse. The pearls had "a similar goal as Constructopedia but [extended] the idea to using a community of learners as the source for the knowledge database. The larger goal is to cultivate a constructionist cooperative [...]" [Chapman, 2006]. In the final form, the pearls were a way for users of the Computer Clubhouses to share with each other what they had done and how they had done it. When creating a pearl, the user was given three text boxes with the titles "What I did," "How I did it," and "What I was thinking about." After a pearl is created, the user who created it is able to edit it until he or she is satisfied. The pearls are only available to users who are on the Computing Clubhouse network, not to the general public, and are meant to be used in conjunction with social mentoring to encourage the learners to reflect on their work [Chapman, 2006].

According to Chapman, the pearls the users made, at first, were small with little writing to explain the projects, but as the users learned that other people were actually looking at their pearls, they tried to make them more complex and more comprehensive. At the end of the study, the users who utilized the pearls the most were the ones who were most capable of talking about and explaining their work in depth, thus showing the potential usefulness of such a tool as a resource for encouraging reflection, and thus learning. Another finding that Chapman discusses is that the group of users who had little or no social mentoring to encourage reflection produced little to no pearls, but the group of users who had the social mentors encouraging reflection produced a large number of pearls. This shows the importance of group social dynamics on the learning and reflection process.

3 Design Considerations

In designing the IMP, I had several goals in mind. The first goal was to create a resource that can help people learn to construct: both when there is not an experienced person around to share his or her knowledge and when there is not a local culture of resident knowledge, in particular of hacking or of building one's own designs. Unlike many of the aforementioned sites which provide step-by-step instructions that can prove disadvantageous for the learner, the IMP attempts to enable learning through providing a flexible way of navigating through the site. This allows the user to travel freely from general knowledge to the idea's context in various projects and back again. The underlying design metaphor is to treat the learning as building a new expressive fluency more like the learning of a new language, the language of expression through construction. Similar to immersive language learning, the IMP attempts to provide a culture for learning new construction "vocabulary" through the context of projects. Instead of giving builders a construction "dictionary" or "phrase book" with simple grammatical rules and then expecting them to express their ideas, the builders are encouraged to develop their own ideas and learn how to express themselves from their own understanding derived from the context and examples provided.

The second design goal of the resource is to serve as a place where builders can reflect on their ideas, share their projects, and contribute to the learning environment. In doing so, the resource potentially aids the learner in their reflection both outside and inside a constructionist workshop setting. As was discussed by Chapman in her thesis describing the Pearls of Wisdom, there are many computational tools for constructionist learning, but very few focus on encouraging and enabling the learner's own reflection, [Chapman, 2006]. According to Dewey, reflection is important in developing deep and structured thought in the learner [Dewey, 1933].

The third goal is for the IMP to support the use of whatever materials are locally available to the builder instead of only focusing on one type of material or on one particular kit. This is important for two reasons: first, to be as inclusive as possible to different populations, and second, to enable a deeper understanding of design

40

"vocabulary" by seeing concepts in the context of different materials and to thus enable a wider range of expression for the builder.

3.1 Wire, Mechanisms, and Workshops

Over the past year, I have had first-hand experience running numerous short workshops which focused on getting people to make kinetic sculptures when provided with a motor, some wire, a GoGo Board, a touch sensor, craft materials, cardboard, and other locally found materials. Wire was chosen to provide the main basis for mechanisms and structures, because it is flexible, durable, strong, can be found most anywhere in the world, and is easily formed with a relatively small set of tools. Cardboard, was chosen as another basis for structures because it, too, is strong (in different ways from wire), reasonably durable, easily formed with a small set of tools, and readily-available locally. The GoGo Board was chosen as a basis for computation and sensing because of my own familiarity with it as well as the fact that it is open-source and open-hardware. The other materials were found locally, and ranged from such things as colorful felt and pipe cleaners to googly eyes and ping pong balls.

Instead of running workshops which focused on the creation of a vehicle or building, as has been done many times in past robotics workshops, I chose kinetic sculptures as the theme of my workshops. This is because of my own interest and experience in making them, but also because in doing so, I wanted to open construction to a group of people with more diverse interests than vehicles and buildings, to a group of people who would otherwise not be drawn to an activity called "robotics." This was my way of attempting to allow and encourage freedom for builders to construct an object that they personally cared about.

Most of these workshops were held in schools in the highlands of Scotland, as the workshops were funded through Highlands and Islands Enterprise; one workshop was held in Costa Rica through the Omar Dengo Foundation. The workshops ranged in duration from two hours to two days. Participants were, for the most part, students aged eleven to fourteen years old, though three of the workshops, including the Costa Rica workshop, featured participants who were teachers. The participants of the student workshops were not selected for any special talents, but instead were whole classes which

41

were chosen because the schools were interested in having me come work with their students. The participants of the teacher workshops were voluntary. No participant had prior experience building with wire, however most had prior experience with LEGOs and craft materials, and a few had prior experience working with robotics and programming. In every workshop, all were asked to work in groups of three to five people and all were given the same task: to build a kinetic sculpture in the allotted time using a motor with a sensor to control it and the materials given. The Costa Rica workshop had the additional theme of taking inspiration from one's surroundings, particularly nature. As an introduction to each workshop and as an idea generator, all were shown photographs and videos of projects from other workshops as well as of my own projects.

Although I had wanted the duration of the workshops to be longer, as I knew that from my own experiences constructing that one's understanding about mechanisms and structures develops as experience increases, this was never a possibility due to many factors. However, it was through these numerous short workshops that I began to conceive of the IMP as a site to address the specific needs of beginners to mechanical and robotic construction, particularly such construction with raw materials and such construction in the absence of any local construction culture.

3.1.1 Learning Through Context

It was during the course of these workshops that I first noticed the effect of a learner's experience base on their project's outcome. As was expected, builders who had prior experience designing and building their own projects were more adept at coming up with effective design solutions for their group's project. For example, without any help from me or anyone else, one student demonstrated and explained a working crank to his group as a mechanism that could provide the motion for making a lid open and close. Upon asking, I learned that his father was a mechanic, and that he had learned about cranks because he had previously seen his father working on one.

However, unexpectedly, as I facilitated more workshops, I began to notice that the complexity of the projects the groups were attempting was increasing and that the time it took the groups to complete their projects was decreasing, even though these were

42

not the same groups and the students were of an equivalent level to begin with. Although this was partially due to my own learning how best to facilitate workshops, I noticed that the experiences builders were referencing in their designs were not only experiences from their lives, but also the experience of having seen the examples of other people's projects . I had shown these examples to them at the start of the workshop. They also benefitted from the experience of interacting with other builders in the room. The more examples I had to show the builders at the beginning, the more they were inspired and instructed by these designs and the more complex their own designs became. Similarly, the more the builders were encouraged to look at each other's designs, the more complex their own designs became. Stated another way, the more context the builders had, the greater their own understanding of what was possible given the available materials.

It is from this observation that the IMP's design draws its first goal: to provide context for learning the "language" of construction. By having people submit their projects to the site, more context is developed, and thus, in the absence of any other context, such as an experienced workshop facilitator, the IMP provides a way for builders to see what is possible. However, the IMP is not simply a place for users to share their projects; it attempts to link them back to their underlying ideas in mathematics, physics, engineering, etc., which follows from the original concept of the Constructopedia [Lifelong Kindergarten, 2007]. Through the use of a wiki's ability to easily crosslink pages, the IMP aspires to provide a way for builders to both read about more general and formalized principles of structure and mechanisms and to see how those principles used in actual projects.

3.1.2 Collaboration and Reflection

In addition to providing context for learning about construction, the IMP is also meant to serve as a way for learners to reflect on their experiences, as an augmentation to a constructionist workshop setting as well as to the overall learning experience outside of such a setting. Through both contributing projects to the site and participating in maintaining a general knowledge database, users are encouraged to reflect on their ideas and design process and to collaboratively contribute to the learning environment. According to Dewey, reflection is important in developing deep and structured thought,

as it is during reflection that learners start to question their experiences [Dewey, 1933]. As was discussed by Chapman, there are many computational tools for constructionist learning, but very few tools which focus on encouraging and enabling the learner's own reflection, [Chapman, 2006]. The Pearls of Wisdom were created as a constructionist reflection tool in order to fill this gap between workshop experience and a user's own reflection and deeper understanding, as a place where users could share their projects with other users and reflect on their experiences making the projects. In Chapman's studies, it was found to be useful as such when used in the context of workshops in the Computer Clubhouse which encouraged its use. At the end of her studies, the people who used the Pearls of Wisdom the most were the ones most able to thoroughly and clearly explain their work. The IMP attempts to build upon the Pearls of Wisdom's success in encouraging and enabling reflection through sharing projects by expanding this reflection to include collaboratively maintaining a general knowledge base.

Once again, openness for expression is a key for realizing potential benefits. In the case of reflection and publication in IMP, the goal is to be open for the contributor to determine what to demonstrate; to what to link; how to describe; and what to show. Just as there is no use of models, pre-fabricated materials, or step-by-step instructions for construction, so too is there not a template or menu for contributing to IMP. By being open to how the designer thinks about their creation, they designer must decide how to best express and link their projects to the underlying ideas as well as to the context of the site.

3.1.3 Raw Materials

The third goal of the IMP is to support the use of whatever materials are locally available to the builder instead of only focusing on one type of material or on one particular kit. This serves two main purposes: first, by opening up the range of materials which can be used, the potential for a builder's expression and subsequent learning is increased, as the builder is not constrained to working with only one material type and the inherent limitations of that material, and second, by supporting the use of locally available materials, a greater population gains access to the concepts which can be learned through construction.

Because each material and construction kit has its own set of inherent physical constraints, the type of objects that can be created with it is limited. Similarly, the concepts learned through constructing with a particular material or kit is limited by its physical constraints. For example, LEGO bricks are designed to be connected in a certain way, and thus builders learn how to make structures around these constraints. However, builders never have to think through these connections on a deep level, as much of the thought has been provided for them through the kit's designed affordances. These constraints also limit the expression of the builder to designing an object that is of a small scale and rectangular in shape. For another example, wire is inherently ductile, and thus can be shaped into flowing and organic forms as well as more linear ones. Because of wire's physical flexibility, though, it is unable as a single strand to bear much weight lest it buckle, and thus must be reinforced structurally through adding more wire or changing the geometry of the design. In working with wire, the builder learns how to reinforce a structure in a different way than how one might reinforce a LEGO structure, and can also explore a wider range of potential scales and forms than with LEGO. However, no material is inherently "better" than another; each has its own strengths and weaknesses for a builder to explore in their designs and each can provide a rich entry point into learning various concepts. Constraining a builder to using only one material or kit, though, is like telling a person writing a poem that they should only use a certain grammar and vocabulary in writing it. New "grammars" and "vocabularies" exist within each material.

Because construction kits, such as LEGO, have had their "grammars" and "vocabularies" thoroughly analyzed in constructionist workshop settings, and because of the idea that the inherent limitations of materials shape what can be learned with them, I chose to use raw, locally available materials. Since wire is a raw material that can be found almost anywhere in the world and is a material that has a rich history of being used to create a variety of structures and machines, it is the material I chose to use as the basis for mechanisms and structures in my workshops. Thus, wire is the material whose "grammar" and "vocabulary" I explore most in depth in the IMP. Additional materials whose "grammars" and "vocabularies" I explore in the IMP, though not as deeply as wire, are cardboard, various adhesives, craft materials, and fabrics.

As I observed during the course of the workshops, there are certain limitations

associated with constructing with raw materials that are not encountered with construction kits, particularly if a builder has no prior experience constructing with raw materials. These are limitations which a resource that aims to support the use of any material must address. For example, when working with wire, pliers and wire cutters must be used to shape the material into one's desired design. However, many of the students participating in these workshops had never used pliers or wire cutters before and thus had no idea how these tools were meant to be used. The students who had no prior experience would often try to mimic the students who seemed to know how to use the tools. This usually resulted in their attempt to squeeze the wire in the flat part of pliers in an effort to cut it because they had seen other students doing so with wire cutters and successfully cutting the wire. Having a collection of general knowledge and advice in addition to a collection of projects on the IMP provides a way for beginning builders to share and learn about basic construction concepts, such as which tools can be used for a given task and how they can be used, without needing an "expert" there to help them correctly use the proper tool.

Additionally, as discussed earlier in this chapter, the more examples the participants were shown at the beginning, the more complex their designs became. These examples provided context for the builders to consruct their own understanding of what was possible given the available materials. Since many people have no prior experience as to how a raw material might be used in construction, providing context is crucial for enabling builders to develop their own understandings of what is possible with such materials. By allowing users to freely contribute their projects to the site, the IMP provides an ever-growing context of projects. Furthermore, because the IMP is web-based, it enables builders from around the globe to share knowledge about local uses of materials with other people in places where those materials might also be, thus potentially providing a more diverse context for a material's use.

3.2 Wikis

For the IMP's implementation, I chose the MediaWiki platform because it best suited the design goals of the IMP. First, because a wiki treats all pages as content pages, it easily enables cross-linking between pages. This is useful for establishing a way to

traverse between "vocabulary" and its context in projects and vice versa. For example, in a project's page, users can surround words and phrases in the project's description with two square brackets ("[[" and "]]") in order to link these words and phrases back to pages which explain them. Similarly, a general page is able to not only give a definition, but to link back to projects in which the concept are used.

Second, because a wiki is openly-editable, all users are able to contribute to the site; this is important for encouraging and enabling a builder's reflection and thus deeper learning. When builders contribute to the site, they must think about how best to state their ideas in order to share them. In doing so, builders reflect on their own building experiences, potentially gaining new insights and establishing a more disciplined way of thinking about their experiences.

Third, a wiki allows for a wide range of media to be added to the site. Users can contribute not only photographs, images, and text, but also animations and videos. This is useful because the IMP is focused on providing a way for people to learn about constructing moving objects. Instead of trying to interpret motion from a static diagram, users are able to see animations and videos which show this motion on the site, thus providing a more clear context for learning the concepts of motion.

Finally, just as a wiki's content is open, the platform itself is also open, thus allowing anyone to contribute code to the platform's functionality. Because the mediawiki platform already has a strong open-source community, the IMP is potentially able to use the community's contributions to its own advantage by incorporating code such as javascript and php add-ons and plug-ins that aid the overall user experience into its own source code.

3.2.1 Wikipedia

The potential usefulness of a wiki and the scale, quality, and depth of its contents are best exemplified by Wikipedia. When looking for an online resource, Wikipedia is one of the first places users go. It provides a way for users to collaboratively contribute to its database of information, and is quite useful for providing many answers. However, Wikipedia is not a useful construction tool, nor is it conceived as such. Through exploring Wikipedia's articles on mechanisms, devices, and other engineering and

47

construction concepts, I have frequently found that they are full of information that is not immediately relevant to the concepts' usage, such as the history of a particular mechanism, as well as that the articles are often conglomerations of information copied and pasted into Wikipedia from a variety of other sources. Also, I have often found many of these articles to be "stubs," incomplete articles which contain only one or two brief sentences. A potential reason for the lower than average quality of the engineering articles is due to these articles receiving less traffic, and thus fewer editors, which is understandable, given that Wikipedia's goal is to be a collaborative encyclopedia, not a construction resource. However, the IMP still draws upon Wikipedia as a model for how a wiki website can be structured and as a successful example of the potential of collaborative contribution.

4 Design and Implementation

In this chapter, I will discuss the features and functionality of the IMP in its current form and also explore its successes and limitations.

4.1 Reflection Through Collaborative Contribution

As was discussed in the previous chapter, the IMP utilizes the MediaWiki platform as the basis for its development. In building the IMP on this platform, it was my goal to make the site as open to contribution as possible. This potentially enables learners to engage in their learning by actively and collaboratively contributing content as well as helping shape the functionality of the site by contributing and implementing new code. On a wiki, everyone has an equal voice, which ties back to Dewey's argument that if we, as a society, believe in the democratic ideal, then we should believe in an education that encourages learners to become interactively and democratically engaged in their own learning [Dewey, 1938]. By allowing open and collaborative contribution, the IMP attempts to address its second design goal: to provide a tool to encourage reflection. As users contribute to the site, they must reflect on their own experiences as well as think through how best to explain their thoughts. However, as can be seen from Wikipedia and other wiki projects, open collaboration has its limitations. If only there are only a few people editing a large number of articles, the resulting quality is generally lower; this is also a limitation of the IMP.

4.2 Navigation of the Site

The IMP offers a variety of ways to navigate the site's content, unlike most of the resources discussed in Chapter Two which often provide only one or two ways for a user to, do so. For example, the IMP offers a search bar (see left-hand side of Fig. 21), a navigation section on the main page (see Fig. 21), categories and links within the articles, and a curated featured content section on the main page (see Fig. 21). Each of these features

serves a different navigational purpose, and, in turn, provides flexible access to the site's content to allow for the navigation and learning styles of various user populations.

The IMP provides a search feature to accommodate users who want to quickly find a specific topic. On the IMP, this is the standard MediaWiki search which provides results sorted by "relevance" not only for matching titles but also for matching page text. It also provides the option to "create this page" if the text which was searched for does not currently exist (see Ill. 4). Since the IMP contains both projects and general information articles, both are returned as search results, and users can determine which is more relevant to their quest.
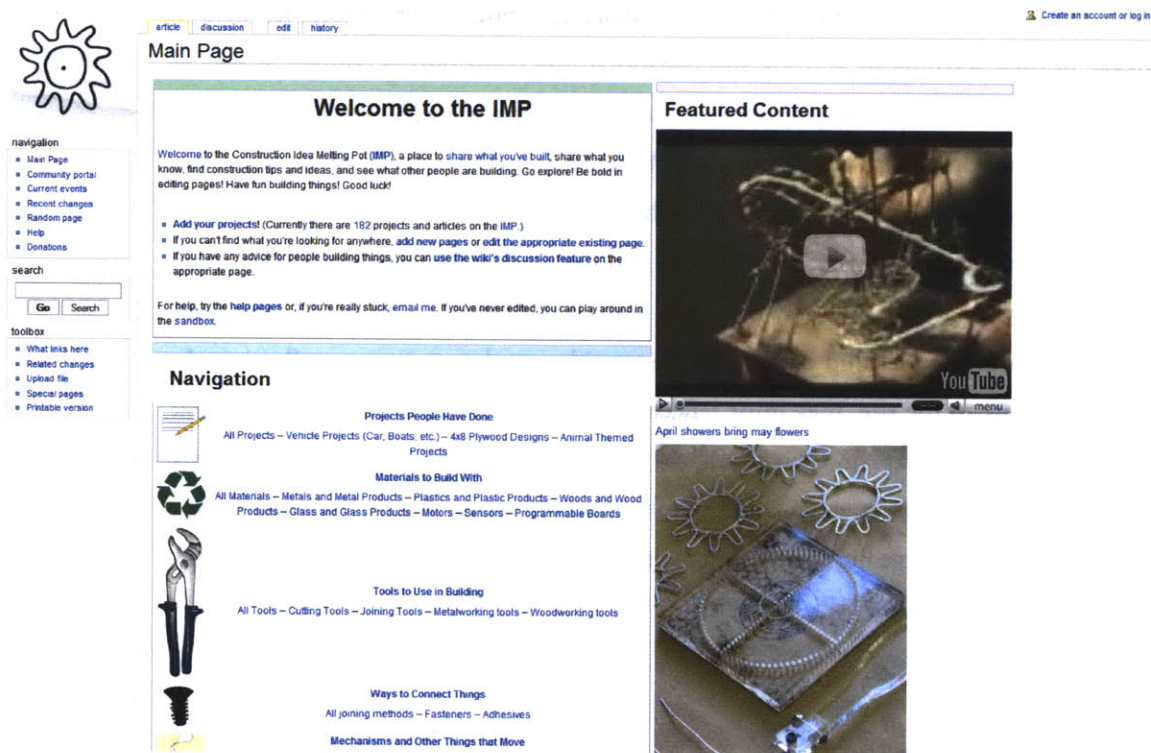
Figure 21 - The IMP's main page

The navigation section on the main page provides a way to navigate the site for users who have an idea of the type of article (a new mechanism, a new tool, a specific project theme, etc.) they are trying to find but may not know what it is called. The navigation section is divided into several sub-sections and each sub-section has a list of categories within it. "Projects People Have Done" is the first sub-section option, as the first goal of the IMP is to provide, through projects, a context for learning new construction "vocabulary." Following this, the navigation section breaks down building into the different "grammars" and "vocabularies" that go into a project, such as "Materials to Build With," "Ways to Connect Things," "Tools to Use in Building," etc. One can select the sub-section for a list of all the articles within that sub-section, or if one is searching for something a bit more specific, one can

Navigation

Projects People Have Done
All Projects – Vehicle Projects (Car, Boats, etc.) – 4x8 Plywood Designs – Animal Themed Projects

Materials to Build With
All Materials – Metals and Metal Products – Plastics and Plastic Products – Woods and Wood Products – Glass and Glass Products – Motors – Sensors – Programmable Boards

Tools to Use in Building
All Tools – Cutting Tools – Joining Tools – Metalworking tools – Woodworking tools

Ways to Connect Things
All joining methods – Fasteners – Adhesives

Mechanisms and Other Things that Move
All Mechanisms – Simple Machines – Rotation to Rotation – Rotation to Linear – Linear to Rotation – Linear to Linear – Intermittent Motion – Combinations of Mechanisms

Structures and Devices
Structures – Devices

Adding Computation to a Project
Computation – Sensing – Programming

Useful Concepts
A list of concepts – Geometries – Simple Machines

Figure 22 - A close-up of the navigation section of the IMP's main page

select one of the categories within a sub-section. For example, if a user needs to cut something while working on his or her project, but does not know what tool might be useful, he or she could select the "Cutting Tools" category under "Tools to Use in Building." By including navigation sub-sections on materials, tools, and joining methods, the IMP seeks to address its third goal, to support the use of all materials.

In terms of the technical implementation of this feature, the navigation section works by using the "[[Category:]]" function in the MediaWiki platform, so only articles that have this added to them are able to be listed in the navigation section. When new categories are created, they can be added to the categories listed under the corresponding

sub-section on the main page, thus providing an ever-evolving navigation to suit the needs of the user population. However, one limitation of this feature is that categories must be manually added to each article. Therefore, articles which might otherwise be designated within a category but which lack the appropriate tag can be missed because they are not listed in the navigation section.

The IMP also enables a user to wander through the site by using the MediaWiki platform's ability to crosslink between content pages. Any given page can link to any number of other pages on the site through placing two square braces ("[[" and "]]") around the desired word or phrase to which one wishes to link when creating or editing the page. This ability to wander through the site is an important feature, for two reasons. First, it enables articles on new construction concepts to be linked back to their contextual use in projects, and conversely enables words and phrases in projects to be linked back to an article explaining them. This functionality allows for users to construct their own understanding of new construction "vocabulary" through both seeing a definition and and seeing the "vocabulary" used in a context.

Second, the ability to wander through the site from page to page allows for users to serendipitously come across articles which could prove useful to their own projects. In design, ideas often come from unexpected places. For example, even if a user searched for one specific article, he or she might be curious about the links to similar articles or project. Upon following links through several pages, he or she could end up finding an an article that, although unrelated to their original search, proves useful for their design. Again, this functionality is limited by the manual nature of having to add links to a page, and thus potentially useful articles may not be discovered if they lack a way to navigate to them.

To pique the curiosity of visitors and to draw them in to exploring the site, the main page provides a curated "Featured Content" section (see right-hand side of Fig. 21) which shows both a project and a construction concept. Each is represented with a photograph or embedded video to demonstrate clear examples of the article's content as well as provide a sense of the site's purpose. Beneath each photograph or video, there is a link that goes back to the full article, thus encouraging users to begin exploring the site in more depth.

Since one cannot envision exactly how users may appropriate the site, the

participatory nature of the wiki architecture is key. If participants discover that new attributes are needed or useful, they can add them. This is in the spirit of the benefit of construction in the overall project.

4.3 Videos and Animations

One limitation of many resources which seek to inform their users about mechanisms and mechanical design is that they have only static photographs or drawings of the examples. If one has never seen how various things move, then it can be hard, or sometimes even impossible, to visualize the motion that can be produced by building the mechanism or device shown in a static image. Because the IMP's focus is on aiding builders, particularly beginners, who want create moving objects, it is necessary to provide information about motion in the clearest possible way; it is easiest to understand motion by seeing motion. Thus, I have added the feature of flash video embedding to enable the addition of video and animations to the site. This was made possible via the VideoFlash php extension
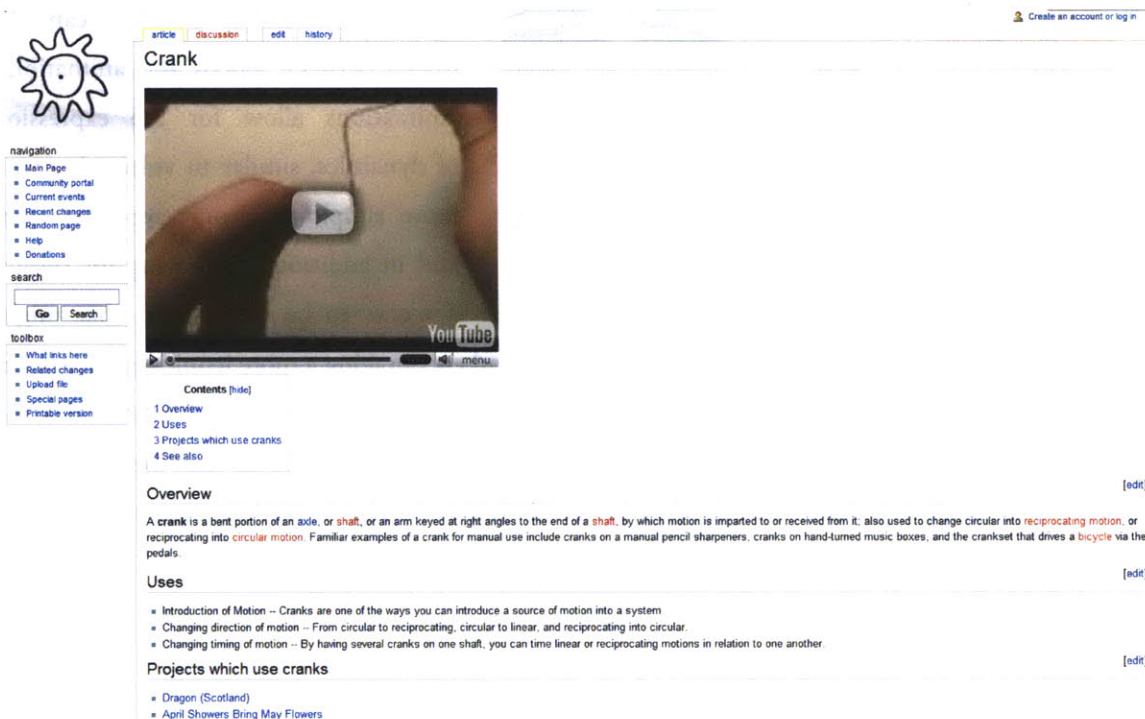

Figure 23 - An example of a page with an embedded video

which was created by Alberto Sarullo for the MediaWiki platform. Through the use of the videoflash tag ("<videoflash>" and "</videoflash>"), users can embed any video from a video hosting site such as YouTube or Google Video into a content page (see Fig. 23). Thus, all users can contribute their own videos of their projects and explanations to a hosting site and show it in the IMP.

In addition to enabling video embedding, the IMP also employs the use of short animations to demonstrate the motion of mechanisms and devices (see Fig. 24). This feature of the IMP provides for more general representations of motion, and thus potentially encourages deeper understanding of the motions of different mechanisms and devices. According to Scott McCloud's Understanding Comics, people respond differently to cartoons than to realistic drawings and photographs. He argues that because a cartoon is a simplified, iconic representation, it provides a framework onto which viewers can project themselves. The simpler the representation, the more of themselves viewers can project. A portrait can represent only one person, he argues, but a smile icon can represent anyone (see Fig. 25) [McCloud, 1993].

Figure 25 - Iconic face vs. individual face

A similar parallel can be drawn between videos and animations. Animations allow for the expression of dynamics, similar to videos, but as a more simplified, iconic representation, and in addition to allowing for certain elements to be emphasized that might not otherwise be in a video. In providing and encouraging a more iconic representation of the motions of different mechanisms and devices through the use of animations, the IMP hopes to enable users to better project their own project ideas onto the mechanism or device shown in an animation, and thus encourage a user's appropriation of the knowledge for their own purposes.

Ratchet

A **ratchet** is a device used to restrict motion in one direction. This sort of behaviour is useful in many areas, such as in turnstile, spanners (where rotation in confined surfaces can be achieved easily), winders, jacks, hoists and others.

Ratchet and pawl   [edit]

Ratchets work generally by having a form of gearwheel or rack (as in rack and pinion) that, instead of having regular teeth, have teeth set off at an angle, and a stiff, thin protrusion called the pawl (a) or the click that rests against the gearwheel (b). When the gearwheel is rotated in one direction, the protrusion raises and clicks back in place. Because of the shape of the gearwheel it is difficult to push the protrusion back and over the tooth of the gear. Alternatively, this gearwheel can be set in a molding shaped to admit rotation of this gearwheel in one direction only. If the gearwheel is rotated backwards the molding and the teeth will clash.

See also   [edit]

- freewheel

Examples   [edit]

Categories: Mechanisms

This page was last modified 20:28, 10 July 2007.   This page has been accessed 27 times.   About fMP   Disclaimers

Figure 24 - An example of a page with an embedded animation

5 User Study

During the month of July 2007, I introduced the IMP to a group of approximately twenty-five high-school students in Boston who were working at the South End Technology Center's "Learn to Teach:Teach to Learn" program. The participating students attended the program Monday through Thursday, 9 a.m. to 3 p.m.. For the first three weeks, the students worked on learning different skills that they could use in a project, such as how to use the laser cutter, how to use HyperScore to create music, and how to program in Scratch. At the beginning of the final week, the students, working in groups of five or six people, were asked to come up with an idea for a project that incorporated all the different areas they had studied. The rest of the week was then spent working together on designing and building their project.

Throughout the program's duration, I was stationed in the fabrication laboratory (fab lab), as it was the location that seemed most relevant to the IMP's goals. During the first three weeks, whenever a group of students would come to the fab lab, I would introduce the IMP to them, get them to create a user account, and walk them through creating a new page. In the final week of the program, while the groups were working on their projects, I reminded the students about the IMP, and encouraged the groups to make a page for their group.

None of the students I worked with had ever contributed a wiki before, yet many seemed excited about both sharing their projects on the site and exploring what projects other people had done. With this set of users, the students seemed most interested in the project pages of other people, particularly those with images and videos. Navigating the site through the "Featured Content" section seemed the most popular route. Users tended to wander through the site without any real purpose, which makes since, given that the majority of time the users spent navigating the site happened before they had any projects of their own (the first three weeks of the program). However, if there was a term used in a project that they did not understand, they would follow the link to the concept page and then either go back to the project page they had been looking at or else go to another project page that was listed on the concept page. Only one of the

56

students used the "[[Category:]]" function; she did so only after I explained to her what a "category" was, because she wanted her group's project to be listed on the main page of the IMP.

It seemed that the hardest tasks for the students were figuring out how to make a new page and figuring out how to add images to a page. However, neither of these was so challenging that they could not figure it out. For making new pages, the students mostly asked me or else asked a friend next to them how it was done. One or two of the students used the help page on how to add projects. In the first iterations of the students' project pages, they were all text (see Fig. 26). However, after the students explored the site further and saw the images and videos of other projects, they started asking me how they could upload their own images and videos. Having both images and videos seemed very important to a few students. In one of the groups, one girl took the responsibility of being the one who went around documenting her group's work. Her group's project page is the one that was the most complex in the end (see Fig. 27).
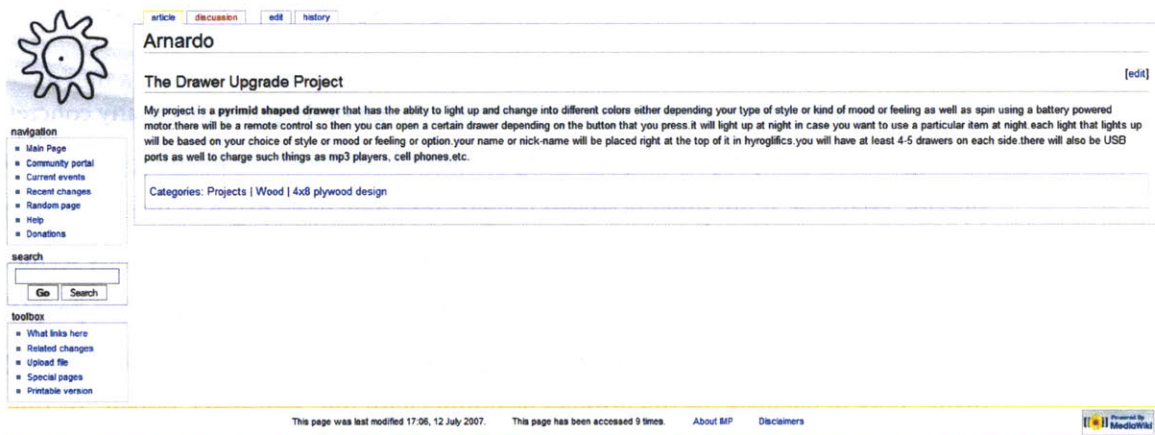

Figure 26 - One student's first project page
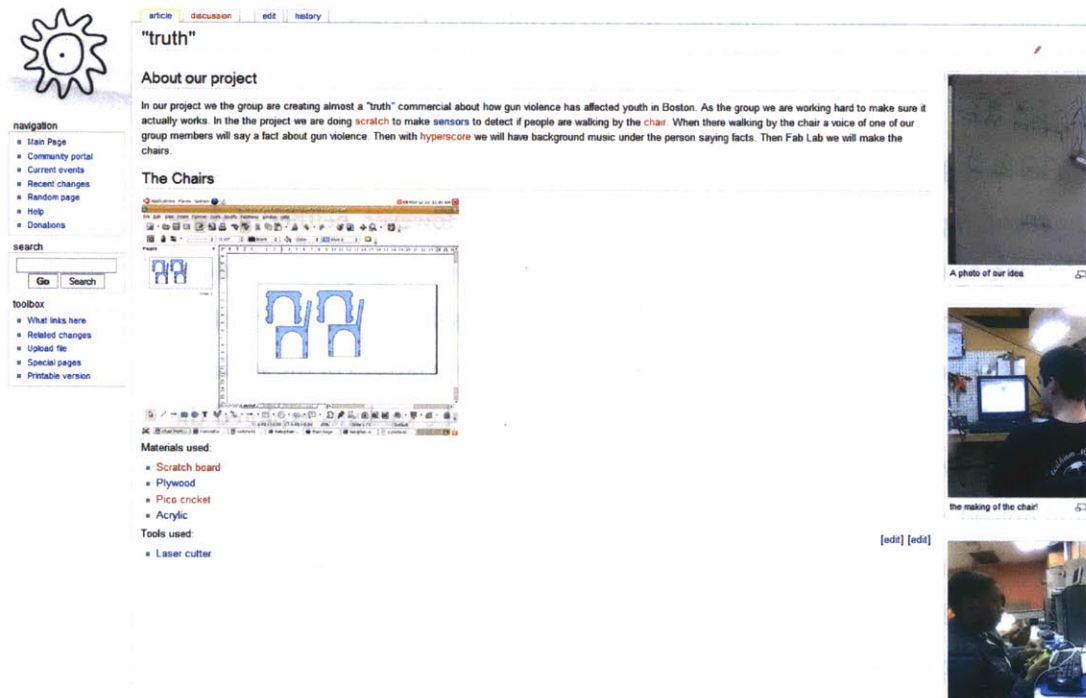
Figure 27 - A more completed group project page

The user study I conducted is not broad enough or deep to provide any concrete findings about how people will potentially use the site or about the learning potential of the site. However, it did provide several insights into how users begin to interact with it. First, the social aspect of sharing one's projects and contributing to a community seemed important to the users. The students seemed most excited about seeing other people's projects, particularly asking if they were people they knew. This was reflected in the way many chose to navigate the site through beginning with the "Featured Content" section. Second, the way a user chose to navigate the site depended on the user's intentions upon visiting the site. Users who were not currently working on projects tended to explore the site more freely, following their curiosities. Users who were seeking one particular answer tended to search for it. For example, one group of students was making a type of car alarm, and thus searched the site for "car alarm." Finally, the ability to add images and videos seemed important to the students, and several asked me for help doing so.

58

6 Conclusions

Although many construction resources currently exist, the IMP differs from them and builds off of them in three main ways. First, the IMP aims to provide not only articles introducing new construction "vocabulary" but also to encourage understanding of the "vocabulary's" use through allowing users to see new concepts in the context of projects. This allows for users to learn about the "language" of construction in a way that is much more like immersive language learning. Instead of asking new builders to read a "dictionary" of construction and to then use the concepts in their projects, builders are able to navigate through the site in various ways, constructing their own understanding from the context of the projects in which concepts are introduced. To further the understanding of mechanisms and motion, the IMP allows for a variety of media, including videos and animations, to be added to the site, thus enabling more clarity and flexibility than static images and text alone can provide. Furthermore, the IMP as a whole attempts to potentially serve as a "culture" in which to learn a "language" of construction in the absence of any such local culture.

Second, all of the IMP's content is openly editable which is important for two reasons. First, collaboratively contributing to the site encourages users to reflect on their building experiences, thus potentially aiding in the learning process. Second, the larger a site such as the IMP is, the more useful it is, as it provides more examples to explore, and thus provides both more context for learning new ideas and more potential fodder from which to build ideas.

Third, the IMP attempts to enable the use of locally available materials by focusing not only on the structures, devices, and mechanisms that one can make, but also on materials and the tools and joining methods for use with them. Additionally, because each of these new concepts are tied back to a context in projects, users are able to see in other people's projects materials which may be available to them but for which they had never considered for use in construction.

In its current implementation, however, the IMP only has articles and projects which focus on the use of a few key materials, materials which were used in the workshops

59

I conducted: wire, cardboard, craft materials, etc.. Therefore, the IMP currently presents only a small glimpse of its potential future use. In its current conception and design, however, the IMP is intended to and able to grow beyond this initial implementation. The IMP's overall scope is focused on building a community around the "language" of construction and projects which show its usage and context. Because of this, the audience of the site is potentially smaller than a site such as Wikipedia. However, the IMP hopes to draw users from the existing DIY community as well as new users who are specifically interested in construction. In doing so, the IMP hopes to form a new community around exploring the "language" of construction and showing projects which demonstrate the context and usage of this "language."

Because of the site's ability to be added to by anyone, it is able to grow and be adapted to different construction uses. However, for the IMP to be truly useful both as a learning guide and simply as a resource, many more users need to contribute to the site, both in adding general construction "vocabulary" and in adding projects for context. It is too much content for one person or a small group of people to edit alone. The potential is there, though; through future work of myself and hopefully many others, the IMP can become an effective resource for people who are learning about construction and who want to build things of their own.

7 References

Baird, D. (2004). *Thing Knowledge: A Philosophy of Scientific Instruments.* University of California Press. Los Angeles, CA.

Blikstein, P. (2002). *The Trojan Horse as a Trojan Horse: Impacting the ecology of the learning atmosphere.* MIT Master's Thesis. MIT Media Lab, Cambridge, MA.

Build-It-Yourself Build-It Blocks. (2007). http://constructopedia.media.mit.edu/

Bush, V. (1945). "As We May Think". *The Atlantic Monthly.* Volume 176, Number 1, July 1945, Pages 101-108.

Cavallo, D., Sipitakiat, A., Basu, A., Bryant, B., Welti-Santos, L., Maloney, J., Chen, S., Asmussen, E., Solomon, C., Ackermann, E. (2004). *RoBallet: Exploring Learning through Expression in the Arts through Constructing a Technologically Immersive Environment.* In Proceedings from International Conference of the Learning Sciences. California, USA.

Cavallo, D. (2000). "Emergent Design and Learning Environments: Building on Indigenous Knowledge Sources". *IBM Research Journal.* Volume 39, Issue 3-4, Pages 768-781.

Chapman, R. (2006). *Pearls of Wisdom: Technology for Intentional Reflection and Learning in Constructionist Cooperatives.* MIT Doctoral Thesis. MIT Department of Electrical Engineering, Cambridge, MA.

Dewey, J. (1938). *Experience and Education.* Touchstone. New York, NY.

Dewey, J. (1933). *How We Think.* D.C. Heath and Co.. Boston, MA.

Geertz, C. (1983). *Local Knowledge: Further Essays in Interpretive Anthropology.* Basic Books. New York, NY.

HowStuffWorks.com's Website. (2007). http://www.howstuffworks.com/

Illich, I. *Deschooling Society.* Harper and Row. New York, NY.

Instructables Website, The. (2007). http://www.instructables.com/

IMP Website, The. (2007). http://construct.mit.edu/

LEGO Constructopedia, The. (2007). http://www.lego.com/education/default. asp?x=x&l2id=3_3&page=4_1/

Lifelong Kindergarten Group Website, The. (2007). http://llk.media.mit.edu/

Martin, F. (1995). "The Art of LEGO Design". *The Robotics Practitioner: The Journal for Robot Builders.* Volume1, Number 2, Spring 1995.

Make: Magazine Website, The. (2007). http://www.makezine.com/

NXTLog (beta). (2007). http://mindstorms.lego.com/NXTLOG/default.aspx/

McCloud, S. (1993). *Understanding Comics.* HarperCollins Publishers, Inc.. New York, NY.

Papert, S. (1980). *Mindstorms: Children, Computers and Powerful Ideas.* Basic Books. New York, NY.

Papert, S., and Resnick, M. (1995). "Technological Fluency and the Representation of Knowledge". Proposal to the National Science Foundation, MIT Media Laboratory, Cambridge, MA.

Polanyi, M. (1958). *Personal Knowledge: Towards a Post-Critical Philosophy.* University of Chicago Press. Chicago, IL.

Resnick, M., Berg, R., Eisenberg, M., Turkle, S., and Martin, F. (1996). Beyond "Black Boxes: Bringing Transparency and Aesthetics Back to Scientific Instruments". Proposal to the National Science Foundation.

Sipitakiat, A., Blikstein, P., and Cavallo, D. (2002). *The GoGo Board: Moving Towards Highly Available Computational Tools in Learning Environments.* In Proceedings of Interactive Computer Aided Learning International Workshop. Carinthia Technology Institute, Villach, Austria.