

# Paths-to-Peace: A New Method for Teaching Design and Manufacturing

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## ABSTRACT

If people can be taught to creatively and efficiently identify and develop solutions to problems, then they will have a strong foundation for sustainable development. *Paths-to-Peace* is a course we have developed to teach fundamental principles of design and design management in the context of creating and manufacturing artwork so that people of all abilities can simultaneously participate. In addition to design principles such as reciprocity (if you have a problem, try the inverse to make it an opportunity), we have developed the Peer Review Evaluation Process (PREP) to help people to develop ideas individually, and then to critique each others' ideas individually, and then to come together to brainstorm solutions. This paper presents the details of this teaching philosophy as well as results from design activities that have used it.

## Keywords

Design Education, Collaborative Learning, Abrasive Water-jet cutting, Design for Development and Peace

## INTRODUCTION

Food, shelter, clothing, transportation are the basic human needs, but all are humanized and made more meaningful by art. Art, in its many forms, catalyzes mere existence into an experience and embodies aspects of the specific culture from which it springs. Art also serves as a medium of communication between cultures. We propose a system where student artists and technologists at universities around the world can create art and share it not only in visual form, but also in a physical and functional form. We hope to do this by creating centers at universities where drawings will be converted into instructions for computer controlled machines (e.g., an abrasive waterjet machining center) to cut precision parts from tile, stone, or metal that fit together like puzzle pieces to create scenes, patterns and pictures in the form of inlaid and mosaic panels and sculptures. Other artists can create music, poetry, theatre,

food, clothes...to accompany the stories contained within the panels; thus the commissioning of a panel can be a celebration of the culture that created it; and everyone loves a celebration...!

We envision schools creating paths made from stone versions of these panels to replace ugly cold concrete sidewalks with artistic celebrations of beauty and diversity created by students from each country in the world, for every other country. Figure 1 shows an example where we superimpose images of panels onto a formally cold sidewalk. From universities this can spread to high schools and beyond until students the world over are creating and sending patterns as well as receiving and making patterns from all their brothers and sisters from around the world to create and install Paths to Peace<sup>1</sup>.



**Figure 1** Superimposed images of inlaid panels, created by Linda Miller of Dream Weaver Designs, on cold sidewalks

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<sup>1</sup> <http://pergatory.mit.edu/pathways>

## TECHNOLOGY BACKGROUND: Software and Hardware

The Internet has become a powerful means of communication, with more and more people using it everyday. Yet most activities performed on the internet are primarily passive. While there is an exchange of information, there isn't necessarily an exchange of ideas. This can change if people start using the Internet to collaboratively design and create works art, which is a far more active interaction than just surfing websites. An exercise like this shall promote understanding between people. Thus, the Internet has the potential to act like paths between cultures, and we believe that art, in its many forms from drawings to food to clothes, is the universal media in which none of us can ever get enough. Therefore, if we can find a way to create and share art that people use to better their lives, we can create *Paths to Peace*. For this to happen we need software and hardware tools that are accessible to all. To this effect, we have developed a *Peer Review Evaluation Process* (PREP), a process embodied in a software tool that allows people to discuss and evaluate concepts, and low-cost waterjet cutting machines, hardware tools that allows people to implement their designs and ideas.

PREP has been developed by the i-Campus group at MIT for an internet based learning initiative called *RobotWorld*<sup>2</sup>. PREP software is loosely based on the Rohrbach Process<sup>3</sup> in which each team-member generates a set of ideas to solve a specified design problem. Ideas are described by means of drawings, sketches, and descriptions in a Functional Requirements – Design parameters – Analysis – References – Risks – Countermeasures (FRDPARRC) format<sup>4</sup>. These ideas are then circulated within the team to obtain everyone's feedback. Consequently all team-members end up providing their feedback on the ideas generated by everyone else by making notes on the original sheets of paper on which the idea was submitted. Once every team-member has reviewed all others' ideas, the entire team can now discuss all the ideas and select a best one based on the comments and feedback of the entire team. This process can be thus used to systemically evaluate the ideas that the team has generated. The PREP software tool also allows the above process to be executed in a paperless format by making use of Tablet PCs. Figure 2. illustrates a typical PREP matrix using which users share ideas. PREP is now available to anyone who has access to the internet. In this fashion,

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<sup>2</sup> <http://source.mit.edu/robotworld>

<sup>3</sup> G. Pahl, W. Beitz, Engineering Design, Springer-Verlag, New York, NY 1993, pp 89

<sup>4</sup> This process was developed as part of the curriculum for the MIT course 2.007 "Introduction to Design" see <http://pergatory.mit.edu/2.007>

software technology can enable people all over the world to communicate and exchange ideas, and conceive and evaluate designs.

One way to create literal Paths to peace is to replace ugly sidewalks and concrete paths with colorful panels that depict good things from cultures all over the world. One simple form of art that would enable this to happen is the use of tiles to form mosaics, and indeed this is one of the oldest and richest forms of art that decorates the very foundations of civilization. A modern hardware technology that can make even more intricate designs is abrasive waterjet machining which has been around since the 1960's and it is used in many countries to make two-dimensional parts from materials ranging from paper to wood to stone to metal<sup>5</sup>. Large machines meters across are typically set up to cut vast quantities of tiles to form intricate mosaics for entire buildings. However, only in the last 8 years have small precision economical machines become available such as the OMAX machines shown in Figure 2<sup>6</sup>. Most of these machines are used for the manufacture of industrial parts; however, a few are used for creating exquisite art. See for example the inlaid patterns created by Linda Miller<sup>7</sup>. Examples of her work are shown in Figure 3, which Prof. Slocum interprets as "peace comes with strength and sharing". We are now developing novel ideas to further reduce the size and cost of waterjet machines so that they become even more affordable for universities, students and artists around the world.

## TEACHING PATH TO PEACE AT MIT

After the attacks of 9/11/2001, Prof. Slocum attended a conference on Materials and Design in Egypt in November, and while observing the everlasting beauty created by Egyptian artists, and during the course of many wonderful conversations with local people, he came to the conclusion that what separates people in the world can be bridged with artwork, understanding, and the empowerment to create. He returned to the MIT and with the help of a former advisee and current graduate student and friend, Ahmed Elmouhli, created the course entitled *Path-to-Peace*. The course ran during January 2002 and is now being taught at MIT for the second time with the help of MIT Artist in Residence Mary Sherman<sup>8</sup>. The software and hardware tools described above are being brought to use to greatly increase the productivity and efficiency of the student teams.

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

<sup>5</sup> See for example [www.waterjets.org](http://www.waterjets.org) for a detailed description of how the waterjet cutting process works

<sup>6</sup> [www.omax.com](http://www.omax.com)

<sup>7</sup> Linda created the tile designs in Figure 1.

<sup>8</sup> <http://pergatory.mit.edu/2.993>

## PREP Matrix

				Legend
Ideas	razul	amsab	brian	
razul		✓	✓	
amsab	✓		✓	
brian	✓	✓		

**Figure 2** Peer Review Evaluation Process Matrix (PREP)



**Figure 3** OMAX Abrasive Waterjet Machining Centers™ used to make inlaid tiles by students at MIT



**Figure 4** Inlaid patterns created by Linda Miller of Dream Weaver Designs, who helped create the Paths to Peace course at MIT: “Love and Peace”, “Southwest Bear”, and “Wine Table”

The objective for the student teams in *Paths to Peace* is to create works of art using these design tools, that convey a message, for example, that of peace and harmony. The course includes lectures on art instruction where students learn the basics of colors, forms, shades and composition. Students are also taught the fundamental principles of design like Ocam's razor, St. Venant Principle and Maxwell's Reciprocity. Furthermore, they learn to use the PREP software tool to pace their projects appropriately.

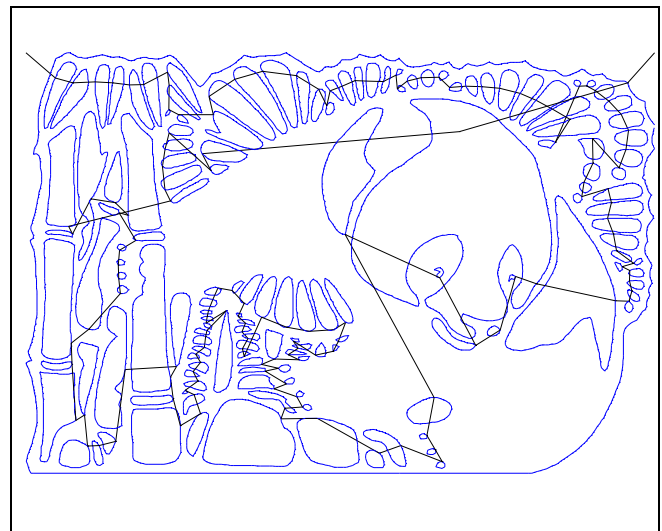
A team is typically asked to come up with a strategy to meet their objective. Each team-member submits at least three strategy ideas and posts them on the PREP matrix by logging on to the internet. All other members can download these documents, add their comments and feedback, and post the documents back online. All ideas are entered on a standard FRDPAARC sheet. FRDPARRC (Functional Requirements Design Parameters Analysis References Risks Countermeasures) sheets allow for a scientific evaluation of various ideas that have been generated by a team, as opposed to the general design selection tools such as weighted tables or Pugh charts. A FRDPARRC sheet is significantly different from these tools as it incorporates detailed analysis, risk assessment, and possible countermeasures. This makes the evaluation process very comprehensive and ensures that no idea gets rejected without due consideration. Once the team decides on a strategy, it moves on to generating concepts to implement the strategy. Concepts are made materialized by identifying the key building block or modules. After the modules have been selected, the team can proceed to identify the components that constitute each module. PREP and FRDPARRC are used at every stage of idea generation and evaluation, making the entire process deterministic.

Once a design and all its components have been selected, the final drawings can be scanned and converted into a vector-based graphics format that can then be edited with a CAD package to add the lead-in and lead-out cut lines, and no-cut traverse paths between sections. On a waterjet, the cutting process must start before the precision edge to be cut, because upon the initial piercing, the hole that is created is larger than the kerf width of the cut. The section with the lead-in and lead-out cuts is then discarded, or a smaller part cut from it.

Designs other than inlays are also possible. Figure 5 shows the dxf file for a Chinese paper cut created by Dr. Christopher Ho when he was one of prof. Slocum's graduate students. This is a stencil-like design that is a common art form in China. Imagine the beauty of such a design made from inlaid marble...See for example [www.isaacnet.com/culture/papercut.htm](http://www.isaacnet.com/culture/papercut.htm) and [www.chinesefolkart.com/papercuts/](http://www.chinesefolkart.com/papercuts/)

The strength of this approach towards teaching design for development and peace is that students need not be in the same classroom, they can be in entirely different parts of the world. The interaction necessary to come up with a work of art is sufficient to create an understanding between people from different cultures.

Figures 6 and 7 present some of the artwork produced by students from the previous Paths-to-Peach course offered at MIT during January 2002, and also during July 2002.



**Figure 5** The dxf file with lead-in and lead-out and traverse lines for a Chinese Paper Cut Panda, ready for the waterjet cutter to do its thing.

## OTHER EMBODIMENTS







There are of course many different artforms that can build paths between cultures. An example is the Animaroots™ toy stuffed-animal characters created by one of Prof. Slocum's students, Amilcar Fuertes for his Bachelor's Thesis on teaching children about platform-based manufacturing and design<sup>9</sup>. Figure 8 shows the array of Animaroots. These figures are shown in Figure We anticipate that there are no limits to the creative ways that students can find to build bridges to other cultures.

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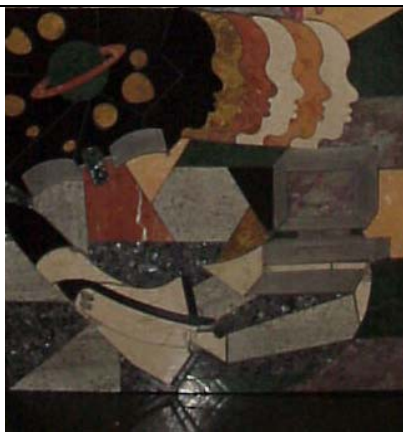
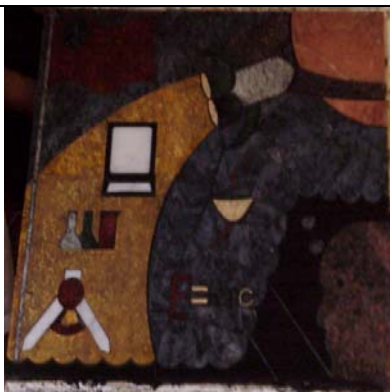

<http://pergatory.mit.edu/animaroots/><sup>9</sup>



From Independent Activities Period (IAP) Jan 2002

		
<p><a href="#">Mosque from Malaysian culture</a>, by Nur Aida Abdul Rahim</p>	<p><a href="#">Gandhi</a>, by Amandeep Loomba</p>	<p><a href="#">Shalom</a>, by Amir</p>
		
<p><a href="#">Rose dragon</a>, by Frances Wong</p>	<p><a href="#">Snowflake</a>, by Monica Rush</p>	<p><a href="#">Chinese goldfish</a>, by Ming-fai Fong</p>
<p><b>Figure 6</b> Inlaid tiles from the first <i>Paths to Peace</i> course during January 2002</p>		

From OME NASA RISE Program August 2002

		
<p><a href="#">D.E.A.</a>, by Gustavo Alverio, Sandra Dillahunt, and Carlos J. Espinal</p>	<p><a href="#">There is no limit to what a mind can do</a>, by Chad Baker, Stacie Meadows, Anthony Pullen</p>	<p><a href="#">Quintessence</a>, by Kenneth C. Jones, Jocelyn I. Hadrick, and Octavio Mesner</p>
<p><b>Figure 7</b> Inlaid tiles from the 2nd <i>Paths to Peace</i> course during July 2002 (<a href="http://web.mit.edu/ome/RISE02/">http://web.mit.edu/ome/RISE02/</a>)</p>		

## CONCLUSIONS

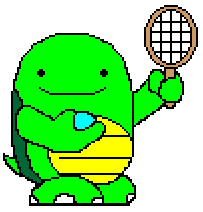

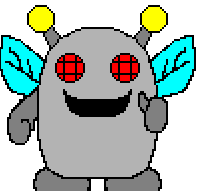



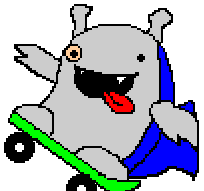
Students in the *Paths to Peace* courses learned design and manufacturing process, had great fun, and truly seemed to finish with a far better appreciation for other people and cultures. We thus hope that this vision of *Paths to Peace* designed by people from all over the world. will be shared by people from all over world. We hope students will start creating panel designs and posting them on [www.pathstopeace.org](http://www.pathstopeace.org) and also making panels from all over the world and installing them at their own universities. We hope all universities become symbols of the web of knowledge and understanding that can give our world a chance to reach its full potential.

We believe that in particular, if creators of ideas are reminded to think about references, where the idea came from or by what was it motivated, they will remember to

learn from history. If creators of ideas are reminded to think about the risks of an idea and the possible countermeasures, then perhaps they will avoid the mistakes of the past and take the right path. Could people use this process to make more efficient evil? Perhaps, but we believe that this method will do more to help people create Paths to Peace.

## ACKNOWLEDGEMENTS

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	<i>Arpin</i> is a tiny turtle tot He loves to jump and play a lot		<i>Hops</i> is a silly little bunny He loves to sing and dance and be funny
	<i>Buggles</i> is a bouncy baby bug She loves to jump and juggle		<i>Jules</i> is rompin' racoon She is as silly as a loon
	<i>Elbee</i> is a little lamb He loves to read about Shazam!		<i>Pahja</i> loves to sing a song He wants you to sing along
	<i>Finster</i> is a feisty little shark She loves to do things on a lark		<i>StingRu</i> is a energetic ray She loves to run and play
<b>Figure 8</b> Animaroos™ by Amilcar Fuertes (silly poems by Slocum)			