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A Television Program to Engage Children in Engineering Design

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Introduction

This paper describes a television program entitled LAZYBONES which is currently under development by WGBH, a leading producer of children's (e.g. ZOOM) and science programming (e.g. NOVA). The purpose of the program is to allow children, especially 10- to 14-year-olds, to become intellectually engaged in engineering design. By this means, it is hoped the program will improve technology literacy and encourage more young people to pursue engineering as a profession. The concept of the show is to have teams compete in automating everyday tasks in whimsical ways. The contestants will use technology such as microcontrollers and machine tools, providing the viewing audience needed exposure to the inner workings of modern engineering.

This paper first presents the motivation for the new television program and the structure of the development team. The concept of the show is then articulated and an early feasibility test is described.

Motivation

Providing children positive images of engineering has never been more critical. Engineers have led a technological revolution that has affected all our lives. Yet, children generally do not understand how most technologies work, how technology is used in everyday products, or what an engineer does. The National Academy of Engineering committee on technological literacy noted these trends and suggested a possible cause:

> *Most people have very few direct, hands-on connections to technology, except as finished goods. They do not build the devices they use, tinker with them to improve their performance, or repair them when they break. Because of this lack of engagement, people today learn relatively little about technologies through direct experience.*[1]

Coupled with the lack of public understanding is the dearth of students, especially women and minorities, studying engineering in school and pursuing engineering careers. In 2002, fewer than six percent of the 1.1 million seniors who took the ACT Assessment college entrance and placement exam planned to study engineering in college.[2] This is down from a high of nearly nine percent in 1992. In

1999, only 20 percent of the students at engineering schools were women. In that same year, of those employed in a science and engineering occupation, minority women were only five percent and Asians, blacks, Hispanics, and American Indians combined were only 18 percent. This is all despite the fact that in the 2000-2010 period, employment opportunities for science and engineering jobs are expected to increase by about 47 percent (about 2.2 million jobs).[3] The data show that the problem of declining engineering enrollments is becoming critical.

This "pipeline" issue is directly related to the lack of engineering and technology education for K-12 students. There have been some recent attempts at addressing the problem. The International Technology Education Association "Standards for Technology Literacy: Content Standards for the Study of Technology" and "Massachusetts Science and Technology/Engineering Curriculum Framework" are two attempts to improve the situation. But even with these standards in place, only 14 states require some form of technology education for K-12 students and few state frameworks cover engineering and technology as stand-alone topics.

Exposing children to engineering has generally fallen to enrichment programs. Although there is rising involvement in these programs, students participating are still a small, self-selected group (comprised mostly of those already showing an interest in science and math). In addition, since these programs do not exist in all communities, they do not always reach minorities and girls. Furthermore, they are often targeted to high school and middle school students. Studies, however, show that most kids are turned off to science and math *before* they reach middle school. Putting kids on an earlier track to engineering may help reverse the trend that points to a future shortage of engineers.

Positive images of engineering in the popular media may help correct both the public misperceptions and the college enrollment shortfalls. For good or ill, young people are exposed to media in large volumes and are strongly influenced by it. Recognizing this, the National Academy of Engineering called for the media and the engineering profession to collaborate.

> *Saturday morning television, movies, and other popular media should be strongly pursued to incorporate engineering, math, and science messages. The full resources of the engineering profession…should be brought to bear on this action.*[4]

To summarize, weakness in technology literacy and mistaken public perceptions of engineering are serious problems. Engaging young children with engineering is a promising part of the solution, and popular media is a powerful means to accelerate and broaden this effort.

Background on Project Organizations

In response to the issues and opportunities described above, an effort has been launched to develop a new television show and associated outreach programs. To begin this project, it was essential to assemble a network of organizations and a team of people with the needed skills, experience, and resources. This section describes the organizations and some of the people involved so far.

WGBH is Boston's public television station and a producer of educational materials in many media (television, radio, IMAX movies, on-line resources, etc.). For the new children's

engineering program, the team at WGBH is led by Kate Taylor and Marisa Wolsky as executive producer and producer of the new program. Kate is the Director of Children's Programming at WGBH. She also currently serves as the Executive Producer of ZOOM and PEEP AND THE BIG WIDE WORLD, an animated science series for preschoolers. As Science Producer, Marisa is responsible for developing ZOOM's science and math content. Working closely with the Science and Math Content Directors, Content Manager, and working group of advisors, she oversees the process of transforming kids' ideas into educationally rich science and math segments. She is also a producer on the NSF-funded preschool science series, PEEP AND THE BIG WIDE WORLD.

A first step of the WGBH team was to secure a planning grant from the National Science Foundation. The goals under the planning grant were to: establish a board of advisors; identify a content director; develop ways that viewers can become involved with LAZYBONES activities through outreach and Web; write the series curriculum; design the game; test the engineering challenges with kids; develop evaluation plans; and create a business model.

To complement the skills of the WGBH team, partnerships were formed with people at MIT. To provide technical advice on the engineering curriculum and development of design challenges, Assistant Professor Daniel Frey was selected as content director for his experience with hands-on engineering design education. MIT undergraduates Derik Thomann and Nathan Ball joined the team as part of MIT's Undergraduate Research Opportunities Program. They played a central role in developing prototype design challenges. Nate and Derik conceptualized the challenges, formulated kits of materials, and tested the feasibility of the challenges.

Early in the development, the team decided to pursue a game format for the television program. To provide expert advice on game play, Peter and Greg Olotka, a father and son team who have many years of experience in designing games in every form of media, helped with the scoring, judging, and overall structure of the game.

Having formed a team with an appropriate mix of skills and experience, the next step was to develop the concept for the new television program. The next section describes the iterative process that was pursued.

The Concept of the Program

When WGBH originally proposed an engineering television program to the National Science Foundation, the concept of the program could best be described as *Junkyard Wars* for kids. While this concept was being explored, *Operation Junkyard* premiered on Discovery Kids' NBC Saturday morning block. Although there are differences between the two shows, and *Operation Junkyard* is no longer on the air, there were too many similarities. This prompted WGBH to return to the drawing board. The team spent many months brainstorming new concepts. During a session with MIT undergraduates, one student commented that, as a kid, he enjoyed imagining and constructing ways to make his life lazier. Out of this, LAZYBONES was born.

LAZYBONES (working title) is a new television show for 10- to 14-year-olds that's part game show, part engineering, and loads of fun. The title's aim: not to promote slothfulness, but rather to use humor and whimsy to hook its target audience and turn them onto the creativity and

productivity of engineering. Each week LAZYBONES' eight players, ages 16 to 18, tackle the vexing problems afflicting today's kids: from the mundane (cleaning up after the dog and clearing the dinner dishes) to the mischievous (constructing an automatic snowball-making machine) to the altruistic (creating an automated recycling system for a school). The big life lesson: while the motivation to automate a task might be driven by one's lazybone, solving a challenge takes creative thinking, trial and error, and an understanding of science, math, and engineering. In short, there's nothing lazy about it.

Throughout the series, two teams compete, using their problem-solving skills to design, construct, and test challenges proposed by the LAZYBONES audience. The show's host, who has used his or her knowledge of engineering to create a domain that would make Rube Goldberg proud, keeps tabs on the contestants. Injecting the show with humor and wit, she or he offers viewers a running commentary – pointing out the successes and pitfalls of each team's engineering endeavors.

Behind all this fun lies a serious educational purpose (1) to teach kids to learn about engineering by using science and technology to solve real-life problems; (2) to help bridge the critical years for keeping kids interested in science and math, and; (3) to improve the public image of engineering, especially among girls and minorities.

An extensive educational outreach campaign and web site will deliver LAZYBONES activities to places where kids congregate, including after school programs, schools, the Internet, and shopping malls. The plan is to build partnerships among informal educators, professional engineers, public television stations, and classroom teachers and provide them with an Educator's Guide and trainings so that they can use the allure of LAZYBONES to increase their students' awareness, curiosity, and knowledge of engineering and the design process. The Web site will further this mission by giving kids simplified versions of the show's challenges that they can do at home, keeping them involved in the popular culture of the series, and expanding their notions of engineering. Further, WGBH will work closely with public television stations so that they can successfully host LAZYBONES mall events around the country.

Addressing the Need

LAZYBONES will be one of only a few programs targeting kids aged 10 to 14, thus addressing an often-underserved age group in educational programming. Although public broadcasting is world-renowned for its outstanding children's programming, much of that programming is aimed at children in preschool and early elementary school. By reaching kids at this critical age, the goal is to stimulate their interest in math, science, and engineering before they lose enthusiasm as they advance from grade to grade. The need for programming for this age group is even more apparent in light of a recent study published by Children Now. Their findings showed that, over the past five years, the number of children's shows in one major U.S. market has decreased by almost half.[5]

LAZYBONES, as reality-based programming, will greatly appeal to its target audience. An analysis of the viewing data of network television demonstrates that kids in the target age group are primarily watching live-action adult programming. In October 2002 through June 2003, with

kids ages 9 to 11, 24 percent of the top 100 network shows and 40 percent of the top 10 were reality-based. The popularity of these programs has prompted broadcasters to re-version adult shows specifically for a kid audience (for example, *American Juniors* is a spin-off for kids of the number one rated *American Idol* and *Trading Spaces: Boys vs. Girls* is a spin off of the popular program *Trading Spaces*). Since this genre has proven so popular for the target audience, the goal is to use it to appeal to kids who wouldn't necessarily tune into an engineering TV show, awakening a curiosity about engineering that might otherwise remain dormant.

LAZYBONES will be as hands-on as television can be. Viewers will see the LAZYBONES players taking raw materials, and with very little adult intervention, transforming them into workable solutions. The series will present kids doing a wide range of activities and will provide viewers with the motivation to do the activities on their own. These projects will have a scale and complexity that will excite the viewing audience. So unlike other children's series, where most of the activities happen on a table using low-tech materials (such as scissors, tape, and cardboard) the kids on LAZYBONES will use modern technology (such as computers, electronics, and machine tools) to solve bigger challenges.

In addition, LAZYBONES will rely on the remarkable way kids emulate and imitate other kids, especially older ones. To reach the target age of 10- to 14-year-olds, WGBH will cast players aged 16–18. This age group will both appeal to a younger viewing audience and possess the skills and content knowledge needed to tackle the engineering challenges. To ensure that the challenges are of interest to the audience, during pre-production, we will solicit kids' ideas through the ZOOM Web site. While the engineering problems on the TV show will be for kids older than the LAZYBONES audience, there will also be more accessible versions delivered through outreach activities and a Web site.

LAZYBONES will also provide role models for girls and minorities by casting children from a range of racial, ethnic, and socio-economic backgrounds. When viewers watch LAZYBONES, they will see kids, like themselves, who are actively involved in engineering. WGBH has had great success with casting for ZOOM and will apply lessons learned from this experience to the casting of LAZYBONES. In the seasons that ZOOM has been in production, there has always been a 4 to 3 ratio of girls to boys. In addition, a little more than half the kids (16 out of 28) cast have been minorities and five have been native Spanish speakers. These casting decisions have a measurable impact. Ratings show that almost twice as many girls as boys aged 6 to 11 watch ZOOM. And compared to their distribution in the US population, African American families are 23% more likely to watch ZOOM and Latino families are 39% more likely.

The television series, combined with outreach and Web activities, will reach millions of kids every week. Much of the work that is being done in engineering education, although exemplary, is currently reaching only small pockets of kids. Television, with its all-pervading presence in kids' homes, can extend this reach. But LAZYBONES will be more than just a television series. It will be a multimedia project with outreach, web and partnerships. Through these various arms, WGBH can create an umbrella under which to bring the activities of various engineering associations and other existing outreach programs and find new opportunities to promote mutual goals.

An Example of a Design Challenge

WGBH felt it was necessary to test the feasibility of the LAZYBONES concept. The team had to be sure that 16- to 18-year-olds could design the machines effectively, safely, and within a day (since this has a strong effect on production costs). MIT undergraduates working in Undergraduate Research Opportunities Program developed and tested several possible design challenges including a scrambled egg cooking machine, a bedroom surveillance system, and an electric shopping scooter.

The most thoroughly tested design challenge was the automatic scrambled egg cooking machine. The challenge was to create a machine that could make scrambled eggs at the push of a button. The undergraduate research assistants developed two very different solutions to the problem as depicted in Figure 1.

In one machine (on the left in Figure 1), the eggs initially rested on a screen. When the button was pressed, a weighted circular arm smashed the eggs. The shells were separated from the egg by filtering through a screen. The egg liquid was collected in a chute and flowed down toward the pan. On the way down the chute, the egg liquid was mixed by beaters. The multiple events required were coordinated by a programmable microcontroller.

The other machine (on the right in Figure 1) was conceptually very different. It worked akin to a guillotine in reverse – dropping a weighted egg within a tube onto a blade. This concept relied on the shell breaking into two fairly coherent halves. The egg flowed through a coarse strainer into a pan where it was stirred by a rotating blade just above the pan's surface.

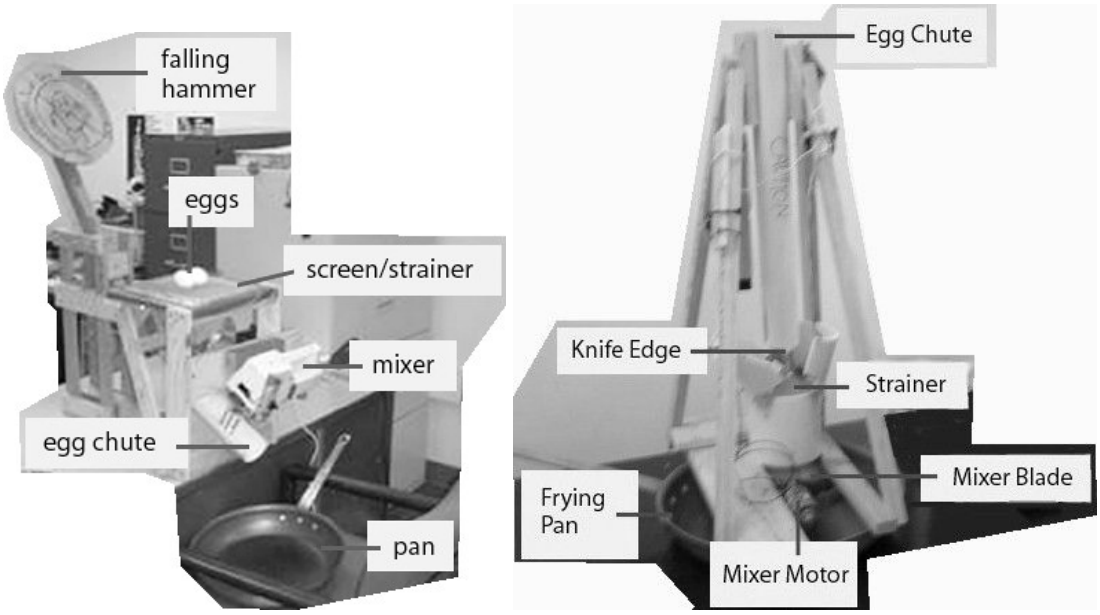

Figure 1. Two different solutions to the automatic scrambled egg cooking challenge.

Based on the work of the undergraduate research assistants, WGBH and MIT decided the task would be feasible for a team of four 16- to 18-year-olds. The decision was made to attempt a

"dry run" (doing the complete task with kids in the target age group, but without a professional film crew). Two teams of four kids aged 16-18 were given identical kits of materials, components, and tools. The two solutions helped determine the materials and components needed. The kits included some fairly high technology items such as microcontrollers and servomotors as well as basic items like wood, metal, and fasteners. Some basic machine tools such as band saws and drill presses were also made available to the teams.

No previous training was supplied to the teams. A few adults were on hand to provide supervision and to help students who got stuck on technical tasks. (For the television program, there will be a technology familiarization day prior to the shooting day. By that means, the contestants can more independently and quickly complete the challenges.)

The dry run was successful in that both teams implemented feasible solutions within a single day. As hoped, the kit was rich enough to enable very different solutions to the task. Not only were the machines constructed by the two teams of teenagers different from one another, they were also different from the ones developed by the MIT undergraduates. For example, one of the teams sliced the egg open rather than cracking it. The teenagers developed some delightfully creative features such as a stacked series of servos to simulate the spatula motion of a short order cook.

Based on the success of the feasibility study, the team completed a pre-pilot shoot. A group of eight players were cast from Boston area high schools and universities. A single episode was filmed based on the scrambled egg challenge. The majority of the television program is footage of the design teams at work. To tie the show together, two hosts explain the challenge and then interact with the players as they design, build, and test their systems. Animations and graphics may also be added to illustrate technical concepts.

Summary and Future Work

Data on college enrollments demonstrate a need to encourage more young people to pursue engineering as a profession. In addition, experts agree that the US must improve technology literacy and the public understanding of engineering as a profession. The National Academy of Engineering has called for the popular media to participate in addressing these problems. WGBH is in a good position to answer that call given its experience developing successful children's programs such as ZOOM. To complement the skills of the WGBH team, faculty and students at MIT and independent experts on game design have joined the development effort.

Under an NSF planning grant, the team has developed a concept for a new television program called LAZYBONES. The target audience is kids aged 10 to 14, thus addressing an often-underserved age group in educational programming. The program will follow the popular reality television format. The program will feature teams of 16- to 18-year-olds working to automate common everyday tasks in whimsical ways using modern engineering technology.

The team has conducted a feasibility study by developing several design challenges and testing one of the challenges with teams of 16- to 18-year-olds. The test revealed that small teams of

teenagers can complete the design tasks successfully and safely within a day. Based on the success of this test, a pre-pilot episode was filmed.

WGBH is seeking funding for the program from the National Science Foundation and from various foundations and corporations. If successful, the next steps will be to shoot 13 episodes.

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Biographical Information

Daniel D. Frey is an Assistant Professor of Mechanical Engineering and Engineering Systems at MIT. He conducts research on robust design and teaches undergraduate courses on mechanical design and graduate courses on statistics and systems engineering.

Marisa Wolsky is a producer at WGBH. As Science Producer of ZOOM, Marisa is responsible for developing science and math content. She is also a producer on the NSF-funded preschool science series, PEEP AND THE BIG WIDE WORLD.

Nathan Ball is a junior in Mechanical Engineering at MIT. Nate loves to build machines and can be seen zipping around the halls of MIT on all sorts of conveyances of his own design.

Derik Thomann is a junior in Mechanical Engineering at MIT. Derik loves modifying existing machines from cars to computers, and plans to study electromechanical control.