

# Billund Builds Music: An Engineering Education Initiative in Danish Kindergartens

Amanda Strawhacker, Amanda Sullivan, and Merredith Portsmore  
 Center for Engineering Education and Outreach, Tufts University,  
 Amanda.Strawhacker, Amanda.Sullivan, Merredith.Portsmore@Tufts.edu

**Abstract - In a recent educational initiative in Billund, Denmark, almost every student between the ages of three to eighteen years participated in Billund Builds Music, a one-week municipality-wide project to explore music and engineering by designing and creating musical instruments. This endeavor was a collaboration between the Tufts University Center for Engineering Education and Outreach (CEEEO), the LEGO Foundation, and Billund's Capital of Children, and LEGO Foundation partner which represents children's voices in civic projects. Approximately 4,000 students and 300 educators from 10 schools across Billund took part in the project. This paper presents preliminary trends and findings from two participating Kindergartens. Results show that in this open-ended Danish Kindergarten setting, 3-5 year-old children were able to build musical instruments and play at least one unique sound on them.**

*Index Terms* – Engineering Education, Music, Kindergarten, Pedagogy

## INTRODUCTION

In the field of child development, questions about what and how young children learn are especially difficult to answer without observing children's physical actions. As we know from decades of research in child-focused clinical interviewing children are far better at demonstrating their ideas through manipulating objects, rather than explaining them with their still-developing verbal skills [1, 2]. Indeed, most researchers agree that physical exploration and play is how children develop new ideas in the first place [1, 3, 4]. Educational interventions that focus on engineering activities offer a fertile ground for observing children's actions as they engage in open-ended problem-solving. In this paper, preliminary findings from the Billund Builds Music project, a one-week curricular and research project, are examined as an exploration into engineering education in Danish early childhood settings.

## BILLUND BUILDS MUSIC

In a recent educational initiative in Billund, Denmark, nearly every student aged 3-18 participated in Billund Builds Music, a one-week municipality-wide project to build, compose, and perform on musical instruments of their own creation. The initiative was a collaboration between the Tufts University Center for Engineering Education and

Outreach (CEEEO), and the Capital of Children, "a unique public/private partnership between Billund Municipality and the LEGO Foundation" that represents Billund children's voices in civic projects [5]. Approximately 4,000 students and 300 educators from across Billund participated in the project. Leading up to Billund Builds Music, members of the CEEEO worked closely with the Capital of Children to offer professional development trainings, online resources, and hands-on engineering education workshops for Billund educators. During the project week in October, researchers, educators, musicians, and other Tufts affiliates traveled to Billund to offer dozens of 1-hour workshops to students (over the age of 6 years), administrators and teachers at all Billund-area schools on various subjects, including the physics of sound and object resonance, music composition, and project-based education implementation strategies. A small research team also collected research in schools to evaluate the efficacy of the project, with regard to student and teacher engagement, and educational content exploration.

Researchers from the CEEEO spent the Billund Builds Music week immersed in four participating schools spanning early childhood through late middle school. During this time the research team collected in-depth observations of the students and teachers, interviews with children and staff, and collected video recordings of the week's work. The research objective of this work was to evaluate the impact that engineering education has on motivation, creativity, and the ability to solve problems in a student-directed context. Additionally, the research team intends to evaluate the successes and areas of improvement of the Billund Builds Music project in order to provide the Capital of Children with suggestions for similar initiatives in the future.

Engineering education has been shown to have positive benefits, especially when introduced in early childhood years [10, 11]. The early childhood context of Denmark presents a unique situation because of its extremely child-directed educational model. Therefore, the current study hopes to see if educational interventions like the Billund Builds Music project might effectively draw the benefits of engineering education in a context of child-directed early years learning. This paper will describe preliminary findings from two early childhood classrooms, and describe the coming steps of analyzing all collected data. Although the early childhood classrooms that are presented in this paper did not participate in workshops with Tufts researchers prior

to the Billund Builds Music week, they did benefit from free curricular resources on the project website in the months leading up to this study. The children in these classes had participated in no formal engineering design activities in their kindergartens prior to the Billund Builds week.

### **EDUCATION AND PEDAGOGY IN DENMARK**

Education in Denmark is generally government-funded, free of charge, and open to all. “Basic” education is compulsory until age 16, with 15.6% of all children at this level attending private schools supported by a voucher system. After basic education, Danish higher education is divided into academic and vocational tracks. All of the early childhood educators who participated in our study were trained in a vocational line of work called Pedagogy, a specifically-Danish education concept. The professional expertise of a pedagogue implies both theoretical and practical knowledge of children’s development, play, friendship and conflicts [6]. It is important here to distinguish between teachers, who are academically trained educators, from pedagogues, as these two professions are fundamentally different and involve unique training paths. Although pedagogues are not limited to working in early childhood settings, Danish Kindergartens are exclusively taught by pedagogues. There are 60,000 pedagogues in Denmark, who work to create learning settings characterized by supportive experiences to foster children’s development and play [6].

Danish “Kindergartens” refer to early child development centers akin to American preschools and daycares. The Kindergartens, which serve children under six or seven years of age, are not a part of the formal educational system [6]. Instead, the Kindergartens are considered a safe space (not associated with school or formal education) where children can participate in child-directed activities under the guidance of a pedagogue. Danish early childhood settings do not follow any traditional curriculum or subdivision of classes and subjects [6]. While many learning activities are initiated by the pedagogues, children are also encouraged to initiate their own play, learning, and inquiry. Unlike the formal school settings that begin in later years, activities in Danish Kindergartens typically have no set time constraints and can vary from short sequences to weeklong sustained play.

### **ENGINEERING EDUCATION**

The education movement towards building objects and engineering solutions is rooted in the tradition of

constructivism, a theoretical perspective that emphasizes the learning affordances of physical, virtual, and mental building and tool use, to construct ideas and understand problems [7, 1]. Beginning in early childhood, children are curious about how the human-made world around them works. By introducing children to practices of scientific inquiry and engineering, they can better ask questions and improve how they define problems [8]. The Engineering Design Process involves practices: posing a problem or question, doing research, planning, developing a prototype, testing, redesigning, and sharing solutions that help structure the process of moving from problem to solution [9]. Applying this design process to building activities can allow children to formulate a process of independent learning and problem solving.

Research shows that there are also a range of long-term benefits to introducing children to engineering curricula from an early age, such as fewer gender-based stereotypes regarding STEM careers [10, 11] and fewer issues entering technical fields later in life [12, 13]. Engineering education initiatives can be integrated into many learning domains, including architecture [14], robotics and computer programming [15, 16, 17], environmental sciences [18], and the arts [19].

### **RESEARCH METHODS**

Approximately 4000 students across Billund participated in this project. The team collected data from N=4 classrooms (2 Kindergartens and 2 middle school classes) and n=80 children as case examples of the project. In this paper, we provide preliminary findings from the two Kindergartens. In addition to exploring what these children learned through engineering, the research team is also interested in how the pedagogues chose to structure the music and engineering activities with their students. The pedagogues in this study were not given rigid lesson plans to follow. Instead, they were provided with resources and encouraged to design their own implementation of a musical instrument building activities. CEO researchers were paired with Danish research assistants from nearby Aarhus University, who aided in translations and data collection. In each Kindergarten, photographs, video data, and field notes were collected daily throughout the week during music and instrument building activities. These data are currently being analyzed, and preliminary findings are presented below in Table 1.

## PRELIMINARY RESULTS

The two Kindergartens (called K1 and K2 here to distinguish between schools) in our study each interpreted the project in unique ways, and demonstrated different types of building and constructing processes with their 3-5 year old students. While pedagogues introduced the building challenges in a structured way, both Kindergartens allowed for a child-directed experience where children interpreted the project and guided their own experience. No explicit directions or instruction about engineering, building, or even music were typically observed as part of these sessions. In order to look more deeply at the Billund Builds experience their own implementation of a musical instrument building activities. CEEO researchers were paired with Danish research assistants from nearby Aarhus University, who aided in translations and data collection. In each Kindergarten, photographs, video data, and field notes were collected daily throughout the week during music and instrument building activities. These data are currently being analyzed, and preliminary findings are presented below (See Table 1).

While Billund Builds Music was described as a weeklong program to the participating schools, K1 children did not spend all week working on the music project. Instead, students were brought in small groups to a special room called the “experimentation room,” dedicated to exploration and science inquiry. Here, children were invited to create instruments with one to three pedagogues present for approximately one hour. Craft and recyclable materials were neatly organized by size and type, and children were instructed to first select a large object (such as a box, tube, or tub) and decorate or fill it with small objects (such as beads, nuts, and string).

In K2 on the other hand, students spent approximately one hour each day exploring a different music building challenge in their regular classrooms and outdoors. Each day was spent tackling a new type of instrument or a new concept; children did not iteratively apply the engineering design process to refine the same instruments throughout the week, although they did continuously explore the same musical and building themes. In all instances, children did not typically apply the planning or research phase of the engineering design process to their creations, except in some rare instances when they asked to see pictures of real-world instruments.

In both Kindergartens, children spontaneously designed predominantly percussive instruments such as shakers, drums, and rhythm sticks (see Figure 1). In K2, children’s instruments began to evolve as the week progressed. With prompting and time, some students began to explore stringed instruments and wind instruments rather than simply percussive creations (See Figure 2). With these instruments, children explored the “testing and improving” phase of the Engineering Design Process by listening to the sounds the different constructions yielded.



FIGURES I AND II

STRING INSTRUMENT FROM K2 AND PERCUSSIVE SHAKER FROM K1

## CONCLUSIONS AND NEXT STEPS

This research provides preliminary evidence that in a child-directed Kindergarten setting, children were able to build and play musical instruments that made at least one sound. In general, the instruments that children made were percussive drum and rattle style instruments. In order to explore more complex creations, the students required guidance from the pedagogues and researchers, which was not typical of the student-directed activities that usually take place in Danish Kindergartens. Future work will analyze video and audio from the Kindergarten classrooms in order to determine how aligned the Billund Builds project was with Danish Pedagogy perspectives and values of play, open exploration, and student-directed learning [6]. This analysis will also help determine best practices for encouraging more engineering design practice while still keeping the Danish principle of child-directed play in Kindergartens.

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#### AUTHOR INFORMATION

**Amanda Strawhacker**, Doctoral Student, Department of Child Study and Human Development, Tufts University  
**Amanda Sullivan**, Doctoral Candidate, Department of Child Study and Human Development, Tufts University  
**Merredith Portsmore**, Director of Center for Engineering Education and Outreach, Tufts University. Research Assistant Professor, Center for Engineering Education and Outreach.

TABLE I  
TRENDS IN PROJECT IMPLEMENTATION ACROSS TWO KINDERGARTENS

Class	Time Management	Exploration of Music	Exploration of Building and Engineering	Instruments Created
K1	Children were pulled in small groups at one point in the week to build an instrument	Limited discussion of sounds and music	Limited planning/imagining of creation	Children made mainly percussion instruments (shakers, drums, etc.)
	Children spent approx. 1 hour building	Some modeling of real world instruments and non-traditional sound sources Instrument performance on last day of week	Used hot glue guns and tape with adult supervision Pedagogues accepted of a variety of solutions Limited iterative rebuilding and refining of creation within 1 hour timeframe	Some children built non-musical creations (animals or jewelry)
K2	The entire Kindergarten worked on building instruments for all 5 days of the week	Limited discussion of sounds and music	Hands-on building with arts, crafts, recycled materials	Children started out making mainly percussion instruments (shakers, drums, etc.) Children explored making instruments that created more than 1 sound
	Children spent approx. 1 hour each day	Some discussion of modeling real-world instruments	Used hand-saws, glue, and tape	
	Although the music and building themes were consistently revisited, children did not iteratively refine instruments, instead creating new ones each day.	Singing and instrument performance on last day of week	Use of natural materials children collected on nature walk	With time, some children were able to explore string and wind instruments