# Integrated Crayons for Adaptive Needs

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***Abstract*— Education is an inherent right for all individuals. In addition, all individuals no matter what their cognitive level or physical abilities, have a right to be able to experience and participate in educational activities just as their same aged peers do. It is the job of the professionals who work with these individuals to ensure that they have access to the tools that will allow them to be the most independent and experience the most joy and success when attempting these tasks. It is the goals of the Integrated Crayons for Adaptive Needs (ICAN) project to achieve this through the use of a customized adapted crayon that has been made using recycled materials. ICAN achieves not only the goal of access and inclusion for individuals with disabilities, but it integrates innovative practices in biomedical engineering, inclusive practices in education and assistive technology, and the environmental practices of recycling and community involvement.**

***Keywords—Tribology, Green Economy, Project-Based Learning, Service Learning, Hermeneutic***

## I. INTRODUCTION

The scholarship of Engagement is one component of the Boyer's model [1]. Described by Boyer as "…connecting the rich resources of the university to our most pressing social, civic and ethical problems, to our children, to our schools, to our teachers and to our cities..." [2] traditionally, the scholarship of engagement, is not pursued very often in research-oriented institutions. At Gannon University service to the community is part of the University's mission [3]. This work illustrates the latest partnership between the Occupational Therapists from the Elizabeth Lee Black (ELB) School at the Barber National, and Gannon University for the integration of service, teaching and research. The Barber National Institute (BNI) is an institution devoted to serving children and adults with intellectual disabilities and behavioral health challenges. The present research is focused on pre-kindergarten individuals with intellectual disabilities. The BNI has an approved private school in Erie (PA) which provides a structured environment for children to engage in educational activities that allow them to practice new skills and develop to their fullest potential. An educational task that develops both cognitive and fine motor skills is coloring, which also is an enjoyable and highly engaging activity for many children that they can be successful in. The common tools utilized for coloring are Crayola pencils (Crayons). Crayons are small paraffin wax cylinders that come in various colors but limited shape. One of the main problems for children with fine motor delays is how to properly grip the Crayons. Children with more developed motor skills are able to perform a tripod grasp using thumb, index and medium finger [4]. On the other hand children that have not reached this particular level will tend to grasp the Crayons using a power grasp [5]. Power grasps are usually utilized to grasp objects with the whole hand such as a ball on the handle of a hammer. These particular grasp do not allow for a good control of the crayon. The Department of Education at Gannon University, which actively partners with The Barber Center for their student field experiences and student teaching, has proposed an activity that addresses an educational need, engages the ERIE COUNTY school communities in crayon collection and recycling, and utilizes the expertise of the Biomedical Engineering (BME) Program requiring redesigning and fabricating a new generation of Crayons to be utilized and enjoyed by children with disabilities at the ELB school.

The Integrated Crayons for Adaptive Needs project (ICAN) strategically combines project-based learning [6] and service-learning [7]. A set of compartmentalized projects can take place within a variety of classes that are part of the biomedical engineering curriculum. The first course to be involved in this activity is the course of Tribology. Tribology is the study of contact mechanics between surfaces. Crayons can be easily melted at the temperature of 105 C and therefore they can be reshaped by means of a mold. In order to fabricate a compatible mold numerous engineering problems must be addressed. Specifically the material that is used for the fabrication of the mold needs to withstand high temperature. Furthermore, the mold's material needs to be non-toxic in order to not leave any dangerous residual that would be harmful for the children if ingested. What is more, the fabrication of the process to make the crayons needs to be a simple process without any specialized equipment. The fabrication process must not require complicated procedures and should be put in place by using simple household tools. Students of the tribology class were asked to design the mold making sure that proper extraction of the crayons from the mold could take place minimizing the adhesion of the paraffin wax to the mold. The service of crayon collection and recycling, along with the production and donation to the Barber Center will be continued through the Education student

organizations ensuring that this innovative process can continue and be sustained.

## II. Adaptive Device

The new crayon design was developed based off of feedback that was provided from the Occupational Therapists detailing what their students' needs were, what was currently being used, what was lacking in these current tools, and what they would like to see incorporated into a new crayon design. Their input was that it was more ideal for a student to be able to pick up and use a crayon "as is" as opposed to having to add on to it with a pencil grip or other device in order to achieve a correct or functional grasp. One of the main problems that this project tried to solve was the creation of a crayon that would invite children to transition from a power grip to a tripod grip (Fig. 1B). The shape has been designed to give the possibility to practice a modified power grip for users with low motor skills and a tripod or pinch grasp for users with intermediate and unimpaired motor skills. As described before children with lower motor skills would tend to grasp the crayon using a power grip. As the fine motor skill develops the grip is switched to a finger grip (Fig. 1A) and a modified tripod grip (Fig 1C).

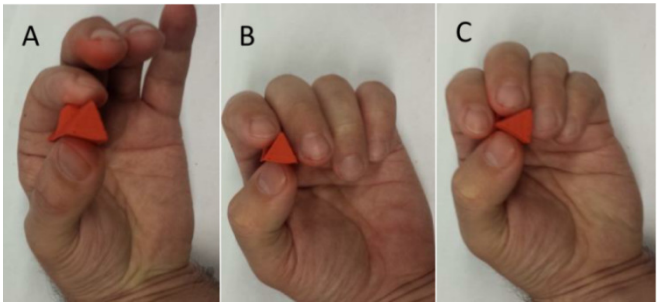


Fig. 1. Example of grips:A) Finger grip, B) Tripod grip, C) modified tripod grip.

We created the crayon with a standard triangular shape so that it would invite a tripod grip. The introduction of a stopper surface (Fig. 2AB) was necessary in order to limit the movement of the finger when the children are pressing on the paper. When the user has an intermediate motor skill level, the crayon is pinched only with the fingers and pressed on the surface. In this condition a traditional crayon tends to slip between the fingers. Introducing a physical barrier between the tip of the crayon and the finger halts the slippage of the finger and allows the user to maintain a finite distance between the paper and the fingers. With regular crayons this cannot be enforced.

The stopper and the symmetry of the crayon are critical features. Symmetry minimizes the chances that uses would pick up the crayon in the wrong way. By having a symmetric object gripping one end or the other is irrelevant thus the occupational therapist does not have to intervene by taking the crayon out of the hand of the user and reposition it in the correct configuration. Thus the adapted crayon facilitates independence. Users with lower motor skills prefer power grips like those necessary to grab a ball. In this case the stopper allows the user to grab the crayon towards the tip and pull it in toward the palm as shown in Fig. 2CD. This movement increases the stiffness of the hand thus improving motor skills [8]. This allows a firm grip and an increased stiffness of the hand that gives higher control during writing.

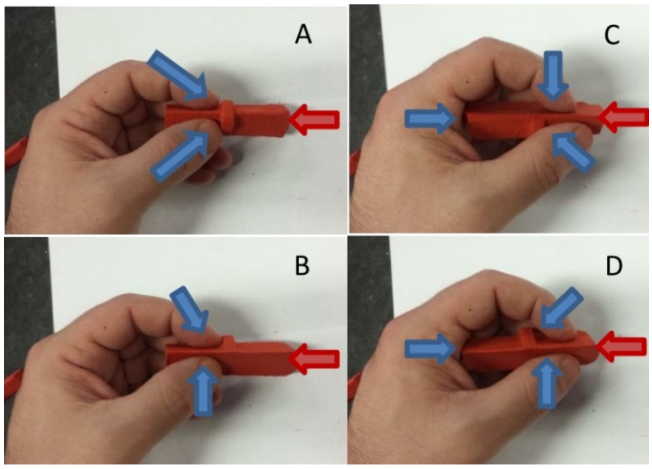


Fig. 2. Example of grips with different orientation of the crayon:A- B) Tripod grip, C-D) modified power grip

Once the initial idea for a design was agreed upon, two tasks within this project-based learning component began. Students in the Education Department began the task of engaging the school community in the crayon collection and students in the Engineering Department began researching the process to be used to create the crayons.

## III. Service Learning

There is numerous research that supports project based learning's positive effects on students. Students with little previous content knowledge as well as average to low verbal ability were shown to learn more in project based learning classes than in traditional classes [9, 10]. It was found that students involved in project based learning emerge with real-world content knowledge that can be applied to a wide range of tasks [11]. In addition to increased content knowledge and applicable skills, student also demonstrated high levels of engagement [12, 13]. The benefits are numerous and incorporation of project based learning into higher education coursework will only serve to produce students that have increased skills in collaboration, management, initiative, as well as empathy.

Students in Gannon's Education Department engaged in service driven project based learning. Local schools in Erie County were approached and asked if they were interested in collecting crayons for the project. The schools were informed that the intent of the project was to recycle and reuse all collected crayons to create the new adapted crayon for students at the BNI. A total of over 300 pounds of crayons were collected from October 2015 to February 2016 during those short four months. While elementary and middle school students were engaged in a community recycling effort to benefit the environment as well as to benefit students with diverse needs, Gannon's pre-service teachers were engaged in creating educational activities that involved some of the students from the Barber Center.

Individual tasks were created with the recycled crayons incorporating the educational aspects of color identification and sorting. Through this activity the students from the Barber Center can be involved in their own way within the project.

## IV. Project-Based Learning

The course of tribology is a technical elective course that is usually listed among engineering programs. It can be taken as an advanced senior course for students in the biomedical and mechanical engineering program. It is also listed as a basic engineering course for the Master in mechanical engineering and engineering management. Tribology studies the contact properties of the materials and requires basic knowledge of chemistry, material science and fluid mechanics. The course is divided in 6 modules: 1) introduction 2) friction 3) wear 4) lubricants 5) Reynold's equation 6) application of tribology. Students are required to present a project at the end of the course illustrating a specific application of tribology to either the biomedical or mechanical engineering field.

From the tribology stand point, the choice of the material for the mold is paramount. The mold needs to resist at a high temperature and at the same time it is required to guarantee proper extraction of the crayon without damaging the final product. Thus, in the absence on an extraction mechanism the mold needs to be flexible in order to be deformed during the extraction. Furthermore the material must inhibit the adhesion of paraffin wax to the surface of the mold.

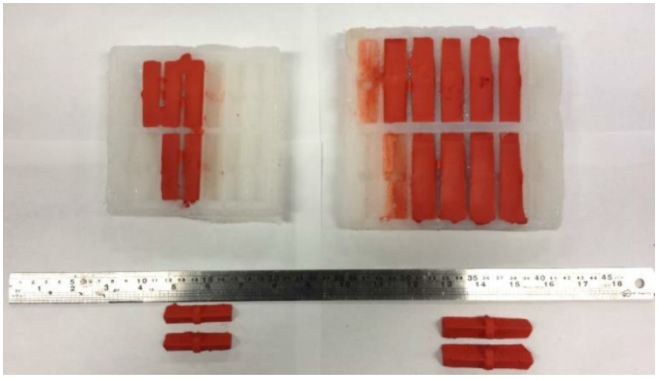

Fig. 3. Example of molds and dimensions of various crayons' sizes

The choice of silicone is very important. Silicone has a set of physical and chemical properties that allows it to resist high-temperature (205 C) before decomposing. One of the main problems to be addresses when using silicone is the time of curing. The first tentative to create a mold required about 7 days for curing the resin completely. Acceleration for the curing can be obtained using dispersant additives. Dispersants are commonly used as additive in lubricants in order to provide lower surface tension and therefore increased tribology properties. The addition of commonly used hand-soap into uncured silicone resin allows two main results. Firstly, it decreases the curing time form 7 days to about 20 minutes. Secondly, it reduces adhesive properties of silicone so that the melted paraffin wax will not stick to the mold.

The process utilized to melt the crayons is also very important for the identification of the proper mold's material. Crayon's melting can be obtained simply by using an electric or gas heater and a heat-resistant container. The liquid wax is than poured into the mold and allowed to cool. This process is indicated if numerous crayons of the same color are available to be processed at once. On the other hand we also looked at a process that allows creating a limited amount of crayons from time to time. This is obtained by using a microwave oven as source of heat. Few crayons of different colors can be deposited within the mold cavities and the whole mold can be inserted in the oven where the crayons melt using the mold as a crucible. Silicone has superb chemical properties and does not decompose in the presence of microwave and/or high temperature. To fulfill the constraint of using the mold as a crucible the mold must have one open surface (Fig. 3).

Cooling time is also important. The surface exposed to open air should be quite large allowing the crayon to cool faster. An enclosed mold would maintain a higher temperature for a long time. Since silicone is not thermally conductive several minutes would be required for the wax to solidify. A longer cooling time should be expected when using the mold in the microwave as the whole mold will act as a thermal mass.

The creation of an open mold is quite simple once a specific form is created. The desire form was engraved using either a nylon or wood board. Specifically nylon is a solid lubricant and allows for an easy extraction from the mold to the form. Wood had the advantage of providing a natural texture to the mold so to obtain a nice grip surface for the crayon when produced. Extraction was facilitated by spraying the wood with canola oil.

## V. Discussion

ICAN incorporates cross discipline collaboration, project-based learning as well as service learning. Faculty from Gannon University's Education department, Biomedical Engineering program, and Occupational Therapists from the Elizabeth Lee Black School at the Barber National Institute collaborated together to create a new design for the crayons. The occupational therapists conveyed that when their students pick up a regular crayon, their hand slips down as well as it is very difficult to achieve a proper grasp with the current size and shape of typical crayons. Ideas for a new design were developed among the team members and a number of new structural features were used with the new design. The crayons were design to be triangular and symmetric. A stopper has been introduced to the middle of the crayon to help the user with the grip.

Courses within the Biomedical program that can be potentially involved in this project are Tribology, Biomedical robotics, and Biomechanics. From a Tribology standpoint, the decision of how the crayons would be melted as well as the choice for the material of the mold is paramount. The mold needs to resist a high temperature and at the same time it is required to guarantee proper extraction

of the crayon without ruining the final product. Thus, in the absence on an extraction mechanism the mold needs to be flexible during the extraction. Furthermore, the material must inhibit the adhesion of the crayon to the surface of the mold. It was decided to make the mold with silicone in order for the crayons to be easily extracted. Research was conducted on a silicone additive for accelerated curing and easy extraction as well as the material safety. It was important for the material to be easily procured as well as safe to handle.

### A. *An integrated pedagogical approach*

Through innovation in design and process, promotion of the use of recycled materials and environmental sustainability, community outreach and involvement, and incorporation of educational best practices, a customized assistive technology tool has been created that will benefit diverse learners of all abilities. Education and Engineering are complimentary and connected disciplines in that they both strive to create improved experiences and outcomes for the individuals they serve. Whether they design the tool or directly support and instruct the individual on how to use it, they both are integral in helping to provide that individual have an enhanced quality of life.

It is important to look at the motivational aspects of this project: we know that engagement is a crucial part of learning. Students are less interested in a rote learning approach (What am I doing?) and relate more to the motivation for which they are learning something (Why am I doing this?) [14]. In this activity the motivational part for the student has been an important aspect of the whole project.

### B. *Can you do this? Will it work? Is it worth it?*

If the student reply is yes to all the aforementioned questions the individual is empowered [15]. Students become critical thinker and “experts”. Project based learning builds on the basic knowledge that students already have (knowledge of the action) and are asked to make inferences on the application of such knowledge (understanding of consequences). To do so, students are required to exercise their critical thinking. This way, students learn that their actions are bound to the consequence that they produce. The question “is it worth it” stresses the effect of the consequence of the student work: “learning is not a process of mere acquisition, but of construction of meanings: it is intrinsically a hermeneutic activity that goes on by means of, according to and with the goal of meaning.” [14]. Helping others is one of the main motivators [16]. Students found a personal connection with the idea of making a difference in the action that they can take. Through the ICAN project, learning a new topic with the specific intent of doing it for a higher goal has transformed the attitude of the students toward learning.

The project is an example of innovative practice as it exposes students to all the components of a “green economy” (i.e. environmental, societal, economical) which are often considered separately. The environmental component lies in the recycling of the petroleum based wax used for fabricating the crayons. A strong social component is emphasized by the creation of specific shapes that children with special needs can use. Finally the optimization of the fabrication process emphasizes the economical aspects. It clearly accomplishes the objectives of innovation in design, action research, service learning, environmental sustainability and literacy, and collaboration across disciplines.

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