Pre-service Science Teachers' Interdisciplinary Understandings of Design Technology

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Design is the approach engineers use to solve engineering problems—generally, to determine the best way to make a device or process that serves a particular purpose.

Through out the K-12 grades, students should be given the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core areas

(From A Framework K-12 Science Education)

Why Design Technology?

"Engineering and technology are featured alongside the natural sciences(physical sciences, life sciences, and earth and space sciences) for two critical reasons:

(1) to reflect the importance of understanding the human-built world
(2) to recognize the value of better integrating the teaching and learning of science, engineering, and technology"

(From A Framework K-12 Science Education)

The Importance of Design Technology

Engaging in the practices of science gives students an appreciation of the wide range of approaches that are used to investigate, model, and explain the world, likewise, engaging in the practices of engineering helps students understand the work of engineers, as well as the links between engineering and science.

(From A Framework K-12 Science Education)

Three Major Dimensions in New NSES

(A Framework for K-12 Science Education)

- ◆Scientific and engineering practices
- ◆Crosscutting concepts that unify the study of science and engineering through their common applications across fields
- ◆Core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and the applications of sciences

(National Research Council, 2012)

Scientific and Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

(National Research Council, 2012, p.42)

The Challenge:

Today's Students need to think and work across disciplinary boundaries, but it is unclear what interdisciplinary thinking means and how we can best assess it.

Research Goals:

(A) To analyze pre-service teachers' application of interdisciplinary knowledge in a design technology context
(B) To investigate pre-service teachers' understanding of design technology processes and cycles
(C) To investigate pre-service teachers' understanding of design technology through case-based pedagogy
(D) To understand how pre-service teachers might engage their future students in design technology

Methodology

(A) Design-based Research Methods

A means of studying innovative learning environments in naturalistic settings with the goal of developing a better theoretical understanding of the learning phenomena of interest

Sandoval,W.A. & Bell,P. (2004). Design-based Research Methods for Studying Learning in Context: An introduction

(B) Participatory Action Research

Phase I: Pilot Study

"Crazy Candy Factory"

(Designing a model hand)

- Design Task: Participants were asked to design a model hand and use it to pick up candies of various sizes and shapes.
- Participants: Five students enrolled in a secondary science teacher preparation course during their student teaching semester
- Storyline : a candy store employs a large number of people with special needs who are physically challenged. They need a mechanical hand to help them sort the candies.

Participants		Content Expertise
Group1	Chuck	Biology, Forensics
	Mark	Physical Science, General Chemistry, Organic Chemistry, Conversation
	Haley	Marine biology, Zoology
Group2	Daisy	Vertebrate Biology, Ornithology
	Sam	Genetics, Biology

Procedures and Data Collection/Analysis

(a) Research team develops the "Crazy Candy Factory" design task.
(b) Pre-service teachers are provided with an overview of design technology and its role in the NSES
(c) Introduction to the "Crazy Candy Factory"
(d) Audio and video-recording of pre-service teachers' design planning and testing session
(e) Individual student written post-reflections
(f) Focus group discussion
(g) Analysis and interpretation

Test Table

- There are various candies arranged on the test tables.
- Two groups compete to pick up candies, with the goal of obtaining the highest point value.
- Each type of candy has a different point value, depending on size, surface and other factors.

Findings from Phase I Pilot Study

1. **The two groups utilized different design strategies.**

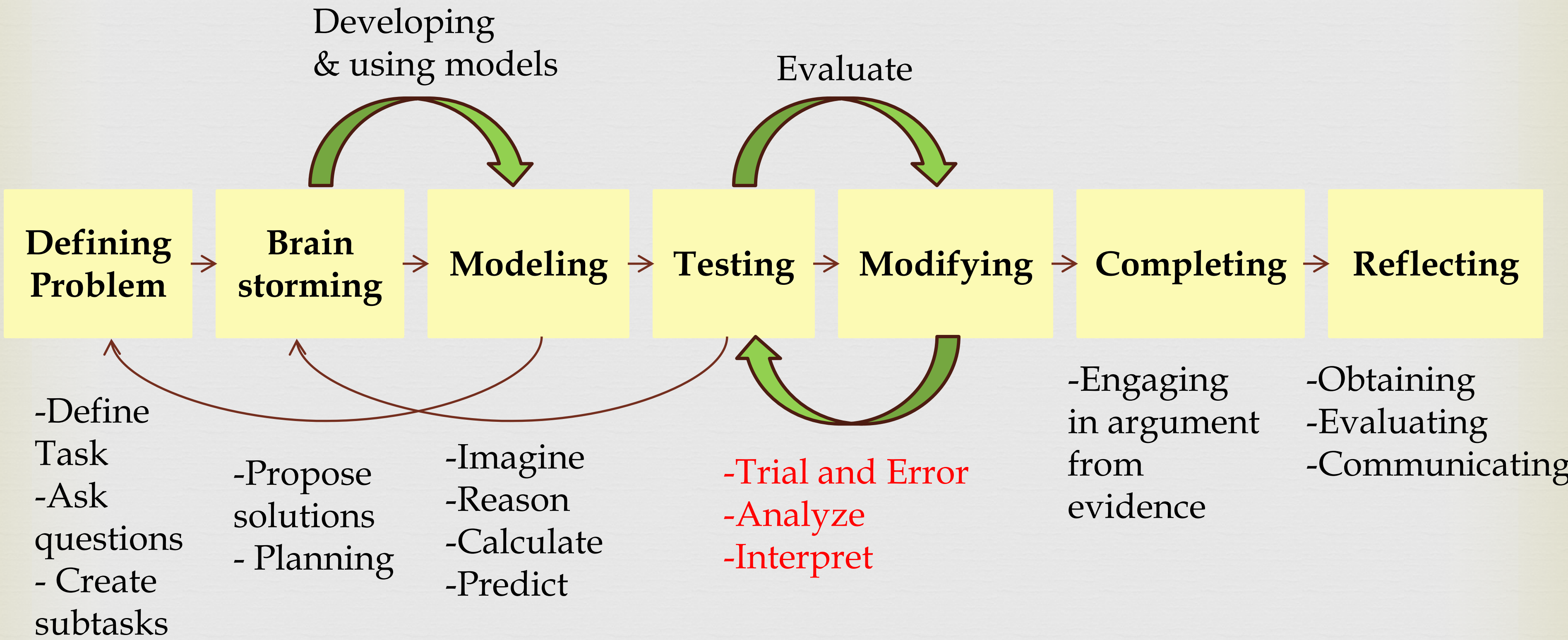
❖ Group 1 : Process

- Group 1 took a decomposing approach. They broke the hand design challenge into a set of problems, or design cycle, one for each finger (e.g. ejector finger, shoveling finger, and a chopstick finger). This enabled them to pick up a diverse range of candies.
- Group 1 used "trial and error" within each design cycle, continuously developing and modifying their ideas.
- Group1 tested their design continuously and systematically throughout the process.

❖ Group 2 : Process

- Group 2 started with a mental model of an Eagle's claws and tried to make a model based on this image.
- Group 2 utilized a holistic approach, viewing the whole hand as a design cycle. They attempted to design and test a model of the whole hand (they did not focus on each finger).
- During the design process, they designed three different hand models. When one model did not work they discarded it and started it again.
- Group 2 struggled to pinpoint the problems in their design (Why they were not able to successfully pick up candies)
- Group 2 tested their model hands only on a few occasions near the end of the allotted time.

Sample Design Cycle; Group 1



2. Drawing on interdisciplinary knowledge

- Group 1 drew on knowledge from physics (surface area), anatomy and physiology (e.g. human hand, joints), and geometry (e.g. numbers of joints, angle between the thumb and forefinger, rotations of joints)
- Group 2 drew primarily on knowledge of form and function of biology and anatomy (e.g. zygodactyl feet, eagle claw)

3. Nature of the Group Learning Environment

- Group 1 : Haley appeared to be marginalized as a legitimate contributor and participant in the model hand design technology task. Haley's ideas were not accepted, When she tried to express her ideas (i.e. about animal claws), Chuck and Mark dismissed then, even though they eventually used some of her ideas without giving her credit for them.
- Group 2: There was little argumentation between Daisy and Sam. Frequently, when one proposed a solution, the other agreed immediately, with little discussion of its relative merits.

Some Questions to Consider for Phase II:

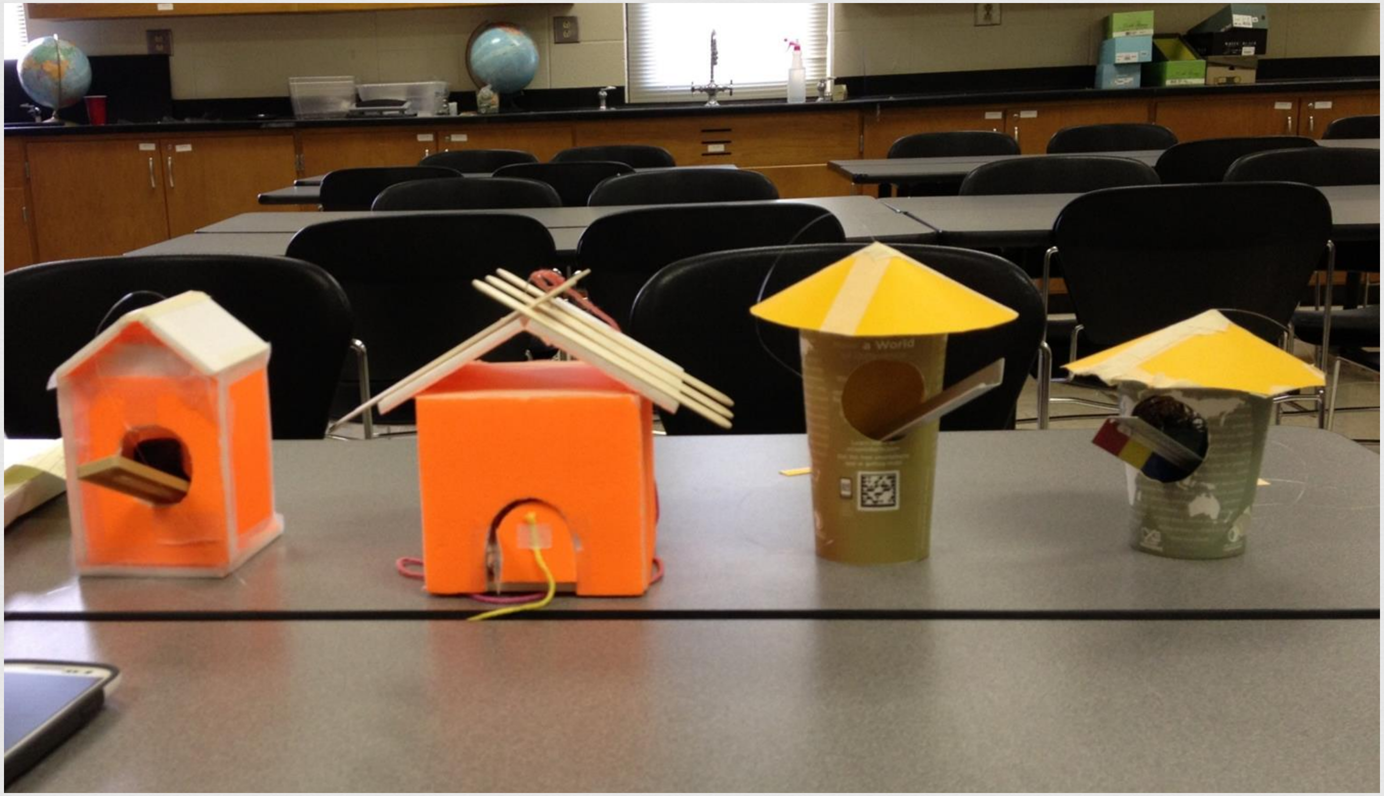
- Should we scaffold the design process in the future?
- How can we foster more argumentation as part of the design process?
- What kinds of experiences with design do pre-service teachers bring to the class with them?

Phase II:
Design an Earth Friendly Birdhouse

- Design Task: Participants will be asked to design an Earth-Friendly birdhouse that meets specific criteria.
- Participants: Eight students enrolled in a required elementary science teacher preparation methods course during their junior year.
- Storyline: Build a birdhouse that will attract a bird in your neighborhood. Your birdhouse most be rain proof, wind proof and well insulated.

Procedures and Data Collection/Analysis

(a) Research team develops the "Earth Friendly Birdhouse" design task.
(b) Pre-service teachers complete a survey about their experience with design technology.
(c) Pre-service teachers are provided with an overview of design technology and its role in the NSES.
(d) Pre-service teachers read and write a written reaction to the case, "A Learning about Newton's Third Law through Linguine"
(e) Introduction to the Earth Friendly Birdhouse design task
(f) Audio and video-recording of pre-service teachers' design planning and testing sessions
(g) Group discussion and sharing of drawings depicting the design cycle used by the group.
(h) Paired interviews with the eight participants
(i) Design technology Lesson Plans.



❖ Our project team's samples of Birdhouses (for opening of design task)

Where do we go from here?

Analysis of transcriptions and other data using the IT^3 framework. This framework will be used to analyze participants interdisciplinary understandings in terms of four intellectual dimensions:

A) Integration (linking knowledge across disciplinary boundaries)
B) Translation (explaining discipline-specific terms in ways that can be understood by individuals from other disciplines.
C) Transfer (applying models and concepts from one discipline to another)
D) Transformation (creating a new physical or conceptual system by applying a model or concept from one discipline to another)

Thank you
for allowing us to present.

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