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Introducing Systems Thinking in a High School Global Engineering Program

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NJTEA NEW JERSEY TECHNOLOGY EDUCATION ASSOCIATION

Edison VENTURE FUND

STEVENS INSTITUTE of TECHNOLOGY THE INNOVATION UNIVERSITY

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Program Goal

Introduce students to systems thinking concepts and approaches that encourage them to see their design efforts in a larger context

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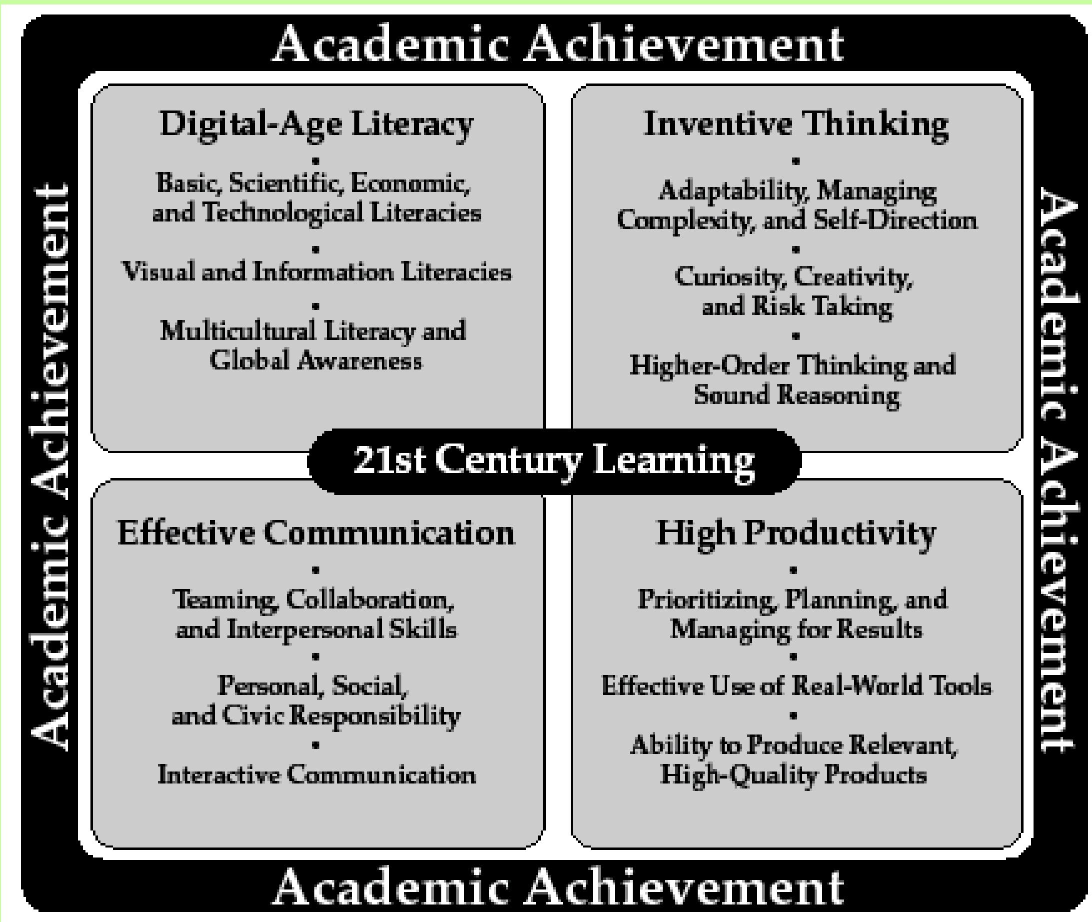

Opportunity for students to design a solution to a complex problem by collaborating with other students world-wide

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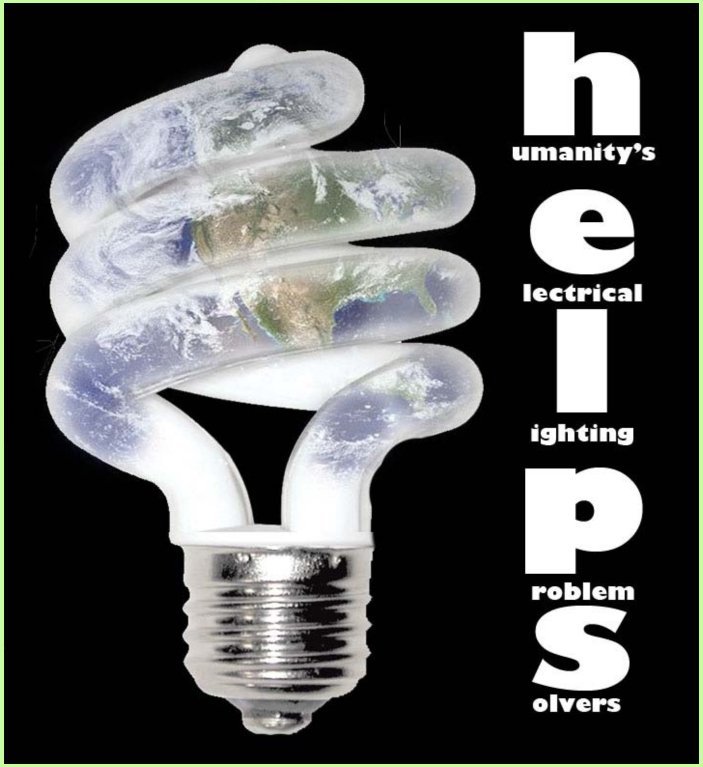
Instructional modules designed to engage students in developing innovative solutions to problems of global significance.



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Major Activities

- Collaboration between K-12 STEM education experts and Stevens systems engineering faculty
- Developed 4 high school level instructional modules
- Provided professional development to pilot teachers
- Piloted materials in classrooms
- Refined each instructional module
- Developed and piloted 5 online short courses for teachers to provide background knowledge and experience in online collaboration

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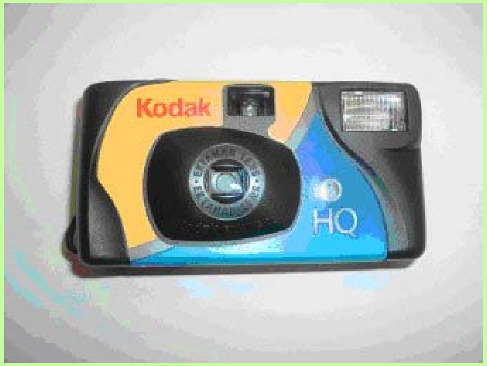
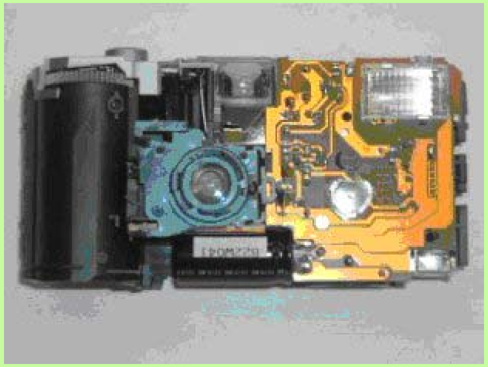
Intro Module:
Core Concepts of Systems Engineering

Reverse Engineering





Students swap reassembly instructions for a product such as a single-use camera

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Focus → Global Sustainability

Biodynamic Farming

Students are challenged to design and operate a system that combines hydroponics (growing plants without soil) and aquaculture (fish farming) to produce food

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Focus → Global Sustainability

Home
Lighting

Integration of LED and solar technologies to produce safe and cost-effective lighting for use in homes that do not have access to the electric grid

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Focus → Global Sustainability

Water Purification

Students develop an understanding of the challenges to provide clean drinking water and develop model systems to meet the needs of people in specific communities

Paradigms for Student Collaboration

Collaboration	Benefit of Interaction
Sharing	Analysis & Comparison
Mentorship	Teaching & Retention
Workflow	Often used in industry
Interdependent Subsystems	Truest systems approach

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Collaboration Central

- Asynchronous online discussion forum
- Documents, engineering files, images, drawings, recordings, links, video are shared
- Letters of introduction posted from each school
- Students exchange ideas, plans, specifications, and provide feedback
- Encourages use of the engineering design process and facilitates shared decision making

Systems Requirement Document

- Served as guiding voice for all aspects of the project
- Classes discussed the product's operating environment and what that meant in terms of materials and design
- Examined target markets and factored into requirements
- Went through several revisions as all schools contributed to and reworked the document into its final form
- Every school brought new, valid ideas to the table, and the value of collaboration was experienced firsthand

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"I was able to witness students collaborating on levels that I had never seen before. The students enjoyed reading and reacting to the daily updates on the Collaboration Central web forum, and working with other schools pushed them to produce work that was clear and to the best of their abilities."

Class Letter of Introduction

Hello, we are from NVOT Regional High School. This class is level one Innovations and Inventions, section two, grades nine through twelve. Northern Valley Regional High School at Old Tappan is located in Old Tappan New Jersey. Our latitude and longitude is 41.01001 and -73.974414. Our school strengths come from sports. Our Varsity baseball program 2007-2008 won the sectional three State Championship. Also, we have a 100% graduation rate and our school was the 18th ranked public high school in New Jersey out of 314 schools according to the New Jersey Monthly magazine. However, one of our weaknesses this year is that our network has failed on us multiple times. At times there is no access to the network, Internet, etc. Our classroom has 24 Mac G5's, containing Photoshop, Vector Works, and Google Sketchup. Our technology classroom has a dedicated workshop. In this workshop we have a variety of hand and machine tools. Moreover, to this effort we can contribute clear and thorough sketches, enabling vivid pictures and concise directions for rebuilding the camera. Our goals in participating include working on projects as engineers do in the real world, improving our communication skills through sketching and learning about system engineering, so we can apply it to our next project. From this first meeting, we wish to learn others weakness's and try to help them with the problem they have. Also from this project, we would want to see how other schools conduct their own projects. In closing, we look forward to this upcoming project, meeting and sharing our ideas to work through this experiment.

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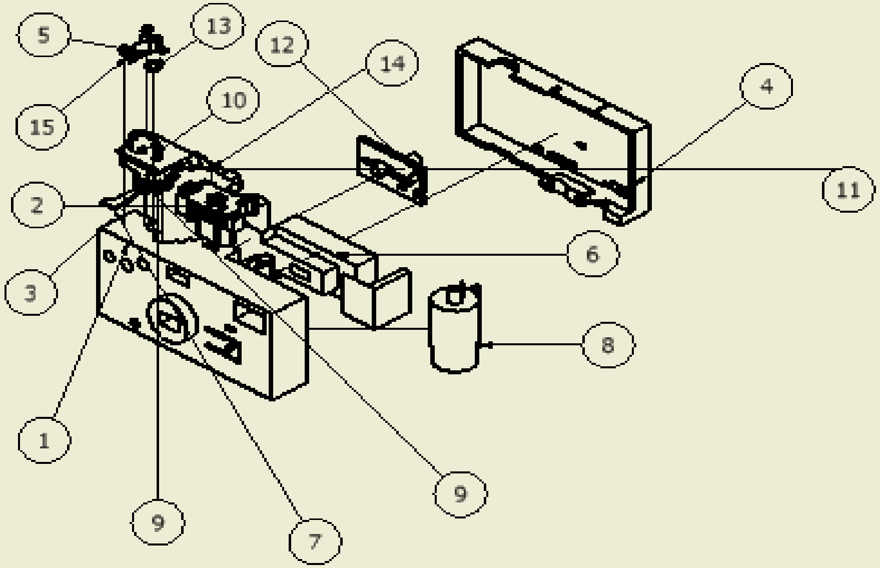

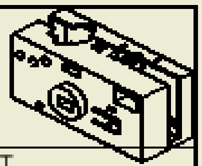

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ITEM	QTY
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2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	2

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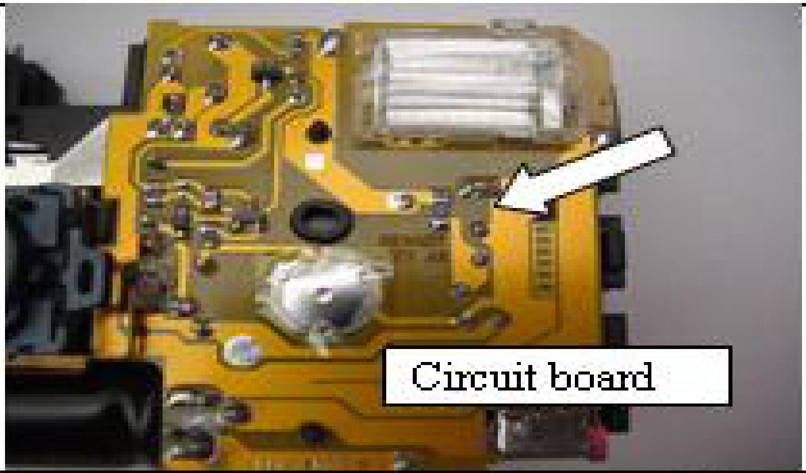
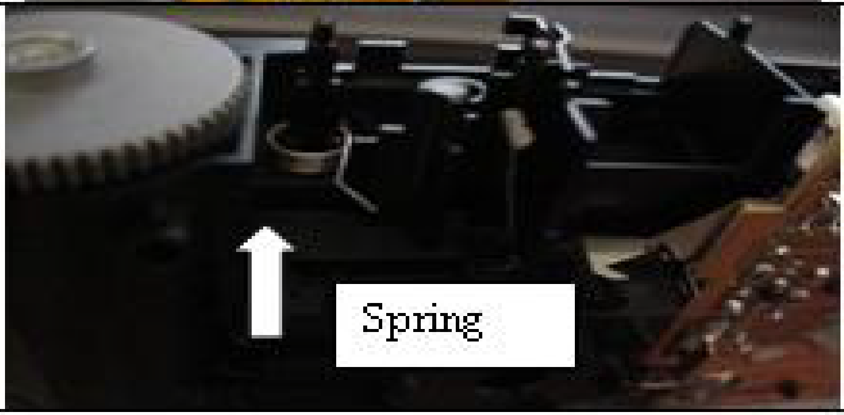
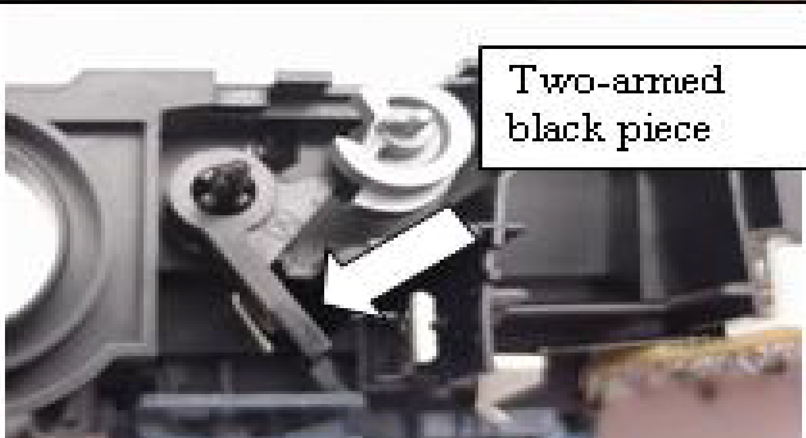
KODAK CAMERA ASSEMBLY

1	Place circuit board on the frame	
2	Put the spring inside the camera	
3	Place the two-armed black piece on top of the spring.	

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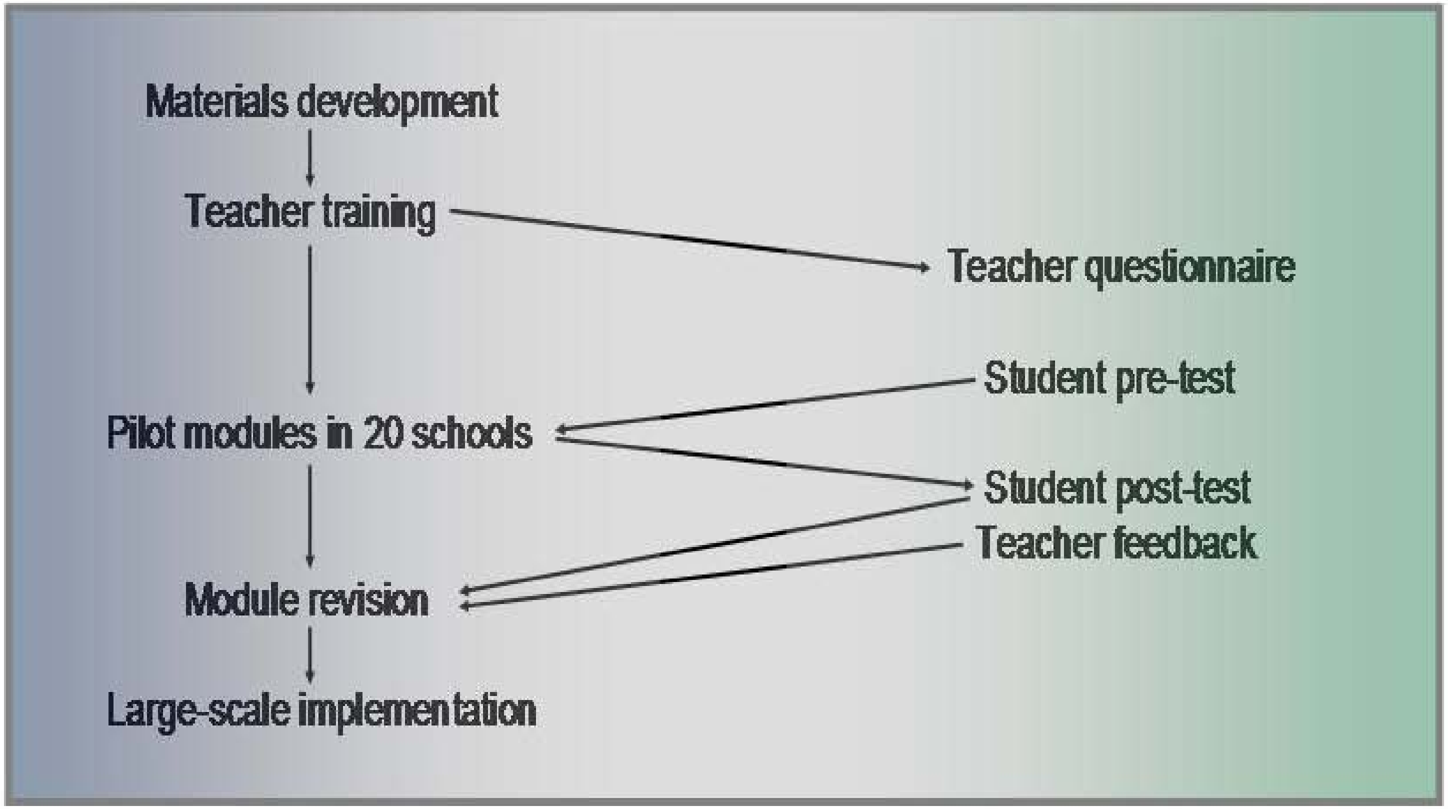
Implementation and Evaluation Strategy



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Pilot Test of Intro Module

- 16 high school teachers implemented in classroom
- Pre and post tests collected from students in 12 classes; 271 students
- Teacher survey

Student Assessment

- Pre and Post Tests: Measured knowledge of and ability to apply systems engineering concepts
- Developed by Stevens Systems Engineering faculty, HS educators, and assessment specialist
- 23 multiple choice Items
- Items at different cognitive levels

Level	Type	Count
1	Recall	12
2	Application	9
3	Analysis	2

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Student Performance on Assessment by Teacher ID

Significant Positive gains achieved by half the classes

Significant Negative gain by one class; review suggests reversal of answer sheets

Teacher ID	No. of Students	Mean Gain
1	24	0.35
2	56	2.13**
3	32	0.20
6	19	3.00**
7	17	0.20
8	18	0.98
9	18	-2.68*
12	25	3.71**
15	15	2.04*
18	6	0.55
19	22	2.62**
23	19	2.83**
Total	**271**	**1.48****

*$p < .01$. **$p < .001$.

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Student Performance as a Function of Cognitive Level (N=253)

Items	Maximum Possible Score	Mean Raw Score		Significance
		Pre-test	Post-test	
All	**25**	12.81	14.59	< .001
Level 1	**12**	6.46	7.59	< .001
Level 2	**10**	4.93	5.65	< .001
Level 3	**3**	1.42	1.35	- .079

Significant gains, overall, and for levels 1 & 2 (recall of systems engineering concepts and their application)

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Teacher Survey Results

- Amt. of time spent on project varied widely; Avg was approx. 6.5 class periods of 42 min
- Teachers reported that the most valuable part of the training was the detailed overview of systems engineering
- Teachers new to using online collaboration were more likely to report challenges
- Majority reported they were very likely to use module again

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Lessons Learned

- Require that all classes use intro module prior to undertaking more complex modules
- Extend time for project implementation and class deliverables
- Online short courses beneficial but difficult to schedule. Have incorporated readings, videos, and other instructional materials in tutorial format imbedded in modules

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For More Info

www.stevens.edu/ciese/sage

Thank You!