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Parallel Education: Virtual Teachers for Real Teaching in iSTREAM and iCDIOS

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3. Department of Electrical & Computer Engineering, Rowan University

Contents

1. Background of Education

2. Parallel Education

3. iSTREAM & iCDIOS and Beyond

4. Future Education



What is Education

Learning stems from not only learners' independent exploration and knowledge construction, but also their culture and social interactions



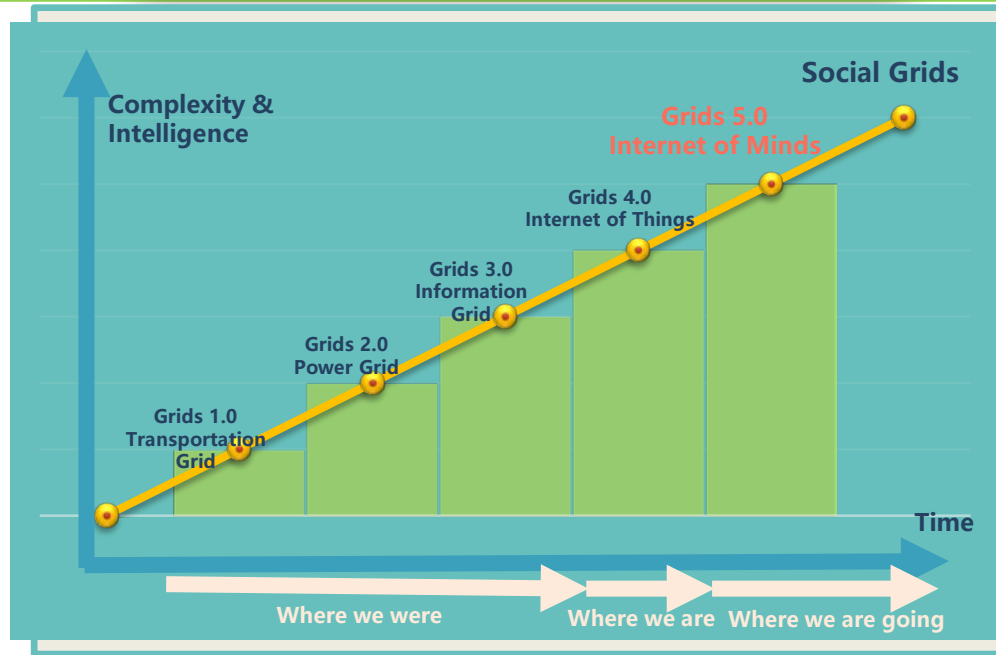
Jean Piaget



Lev Vygotsky

Education is a scientific field of study that examines complex interplay of learning, human attributes and social behaviors

Progress of Technology & Social Infrastructures



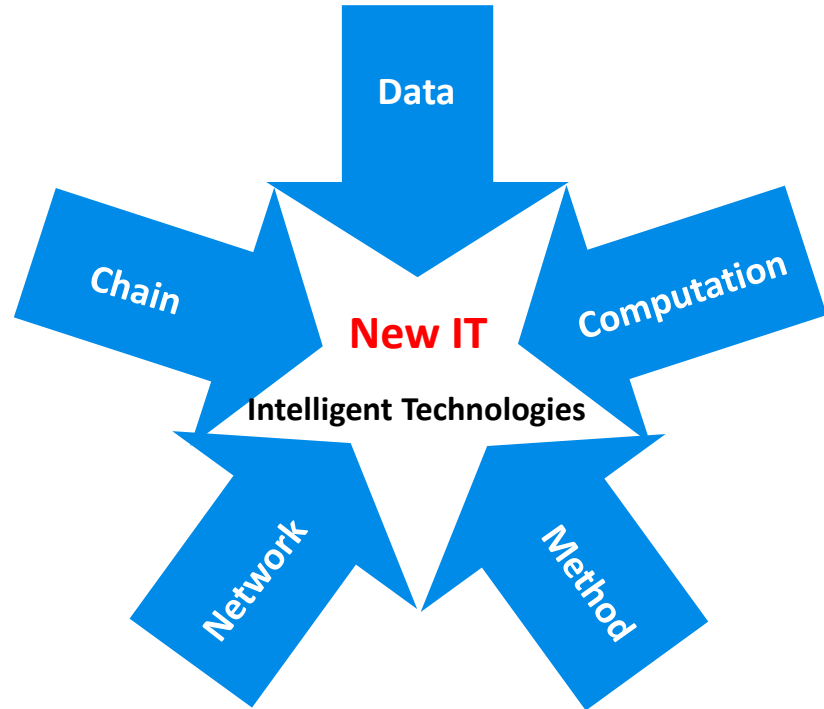
Social Transportation	Social Energy	Social Computing	Social Manufacturing	Social Intelligence
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Social Operations + Shared Economy = Smart Societies

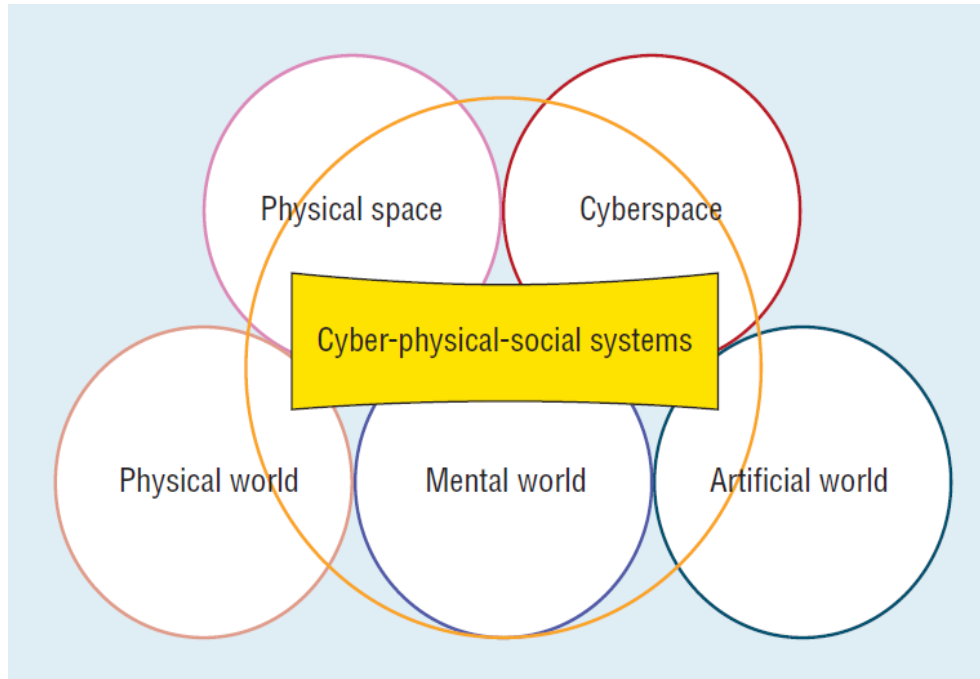


Parallel IT

= “Old” IT → Industrial Technology
+ “Past” IT → Information Technology
+ “New” IT → Intelligent Technology



Education → Cyber-Physical-Social Education

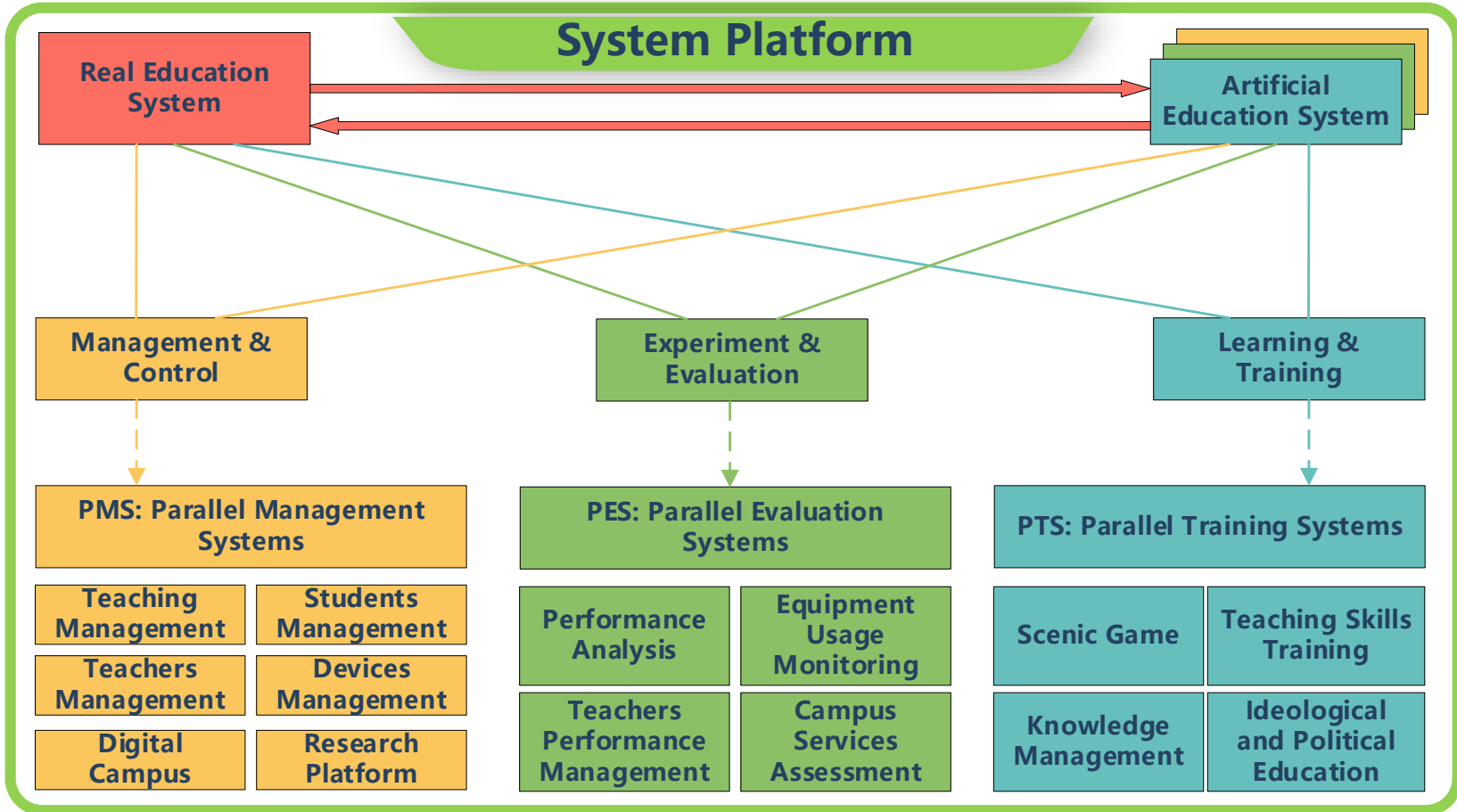


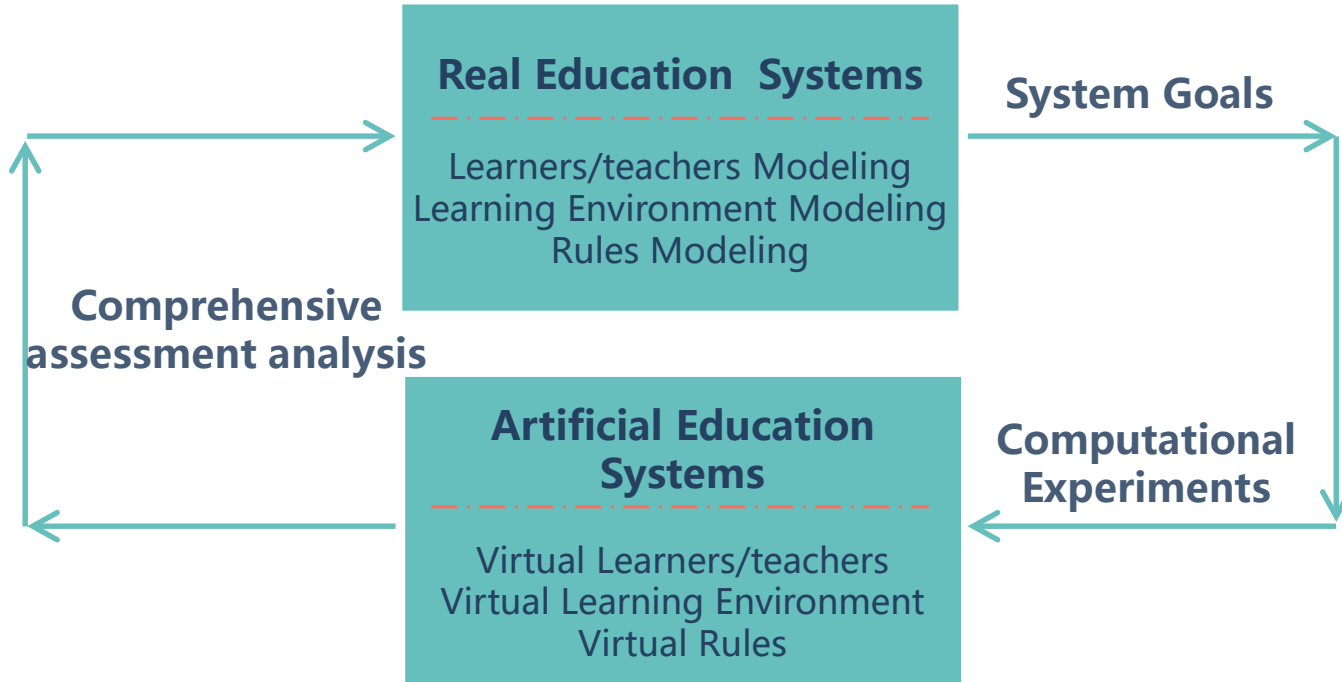
Contents

1. Background of Education
2. Parallel Education
3. iSTREAM & iCDIOS and Beyond
4. Future Education



Parallel Intelligence in Education





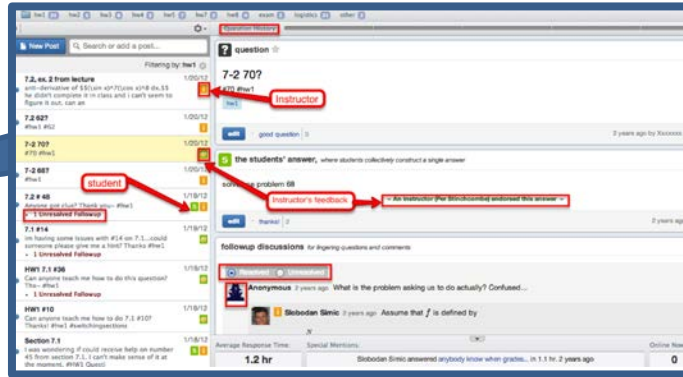
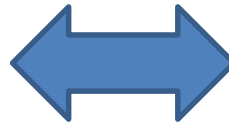
Based on learning modeling, environment modeling, and interactive modeling, artificial education systems are built to conduct computational experiments.



Real Classroom



e-Virtual Classroom



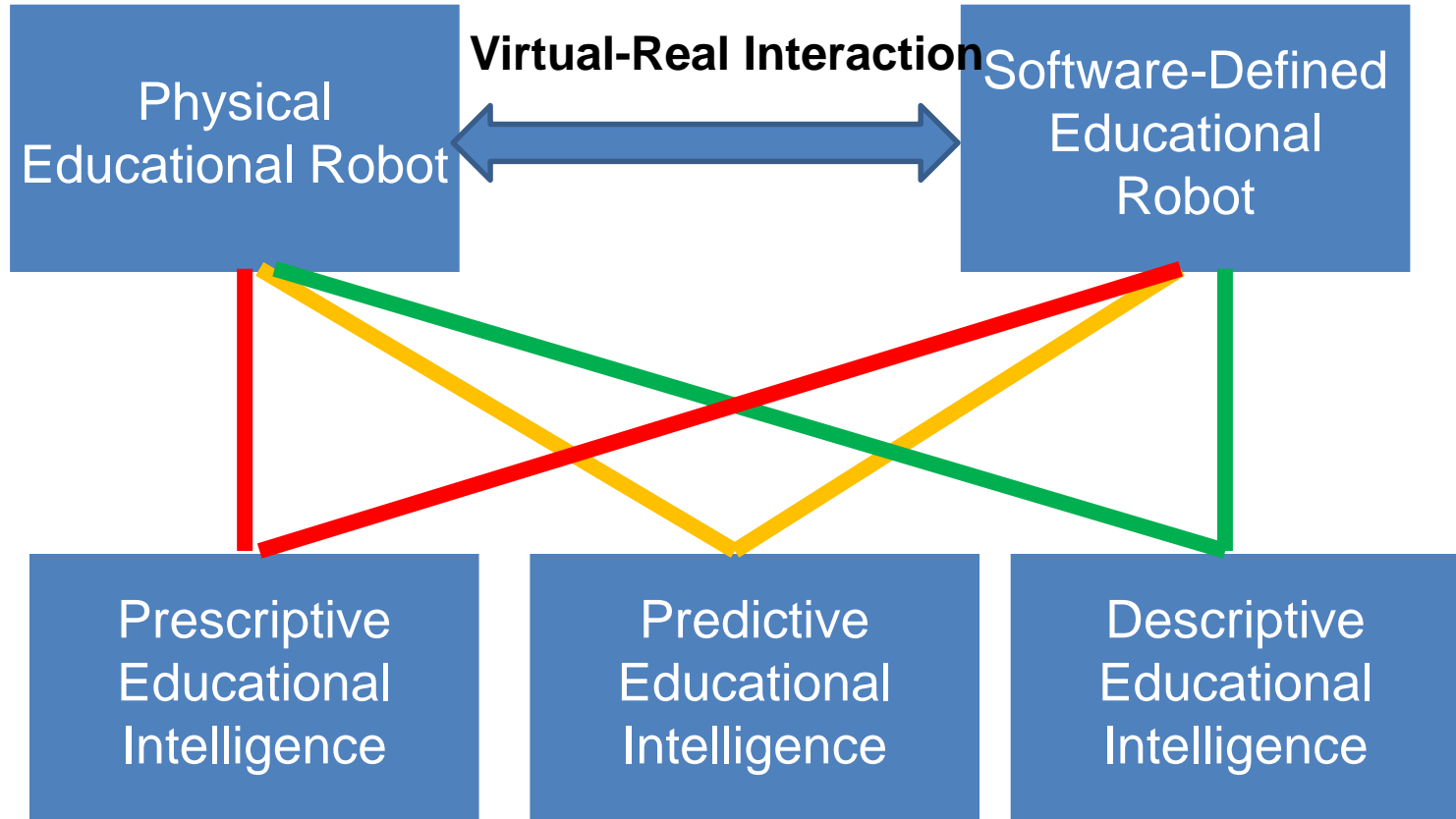
e-Collaboration Platform



AI-based Virtual Personal Assistant



Parallel Educational Robots Framework



Roles of Robots

□ Robot as a teacher or tutor

- Provide direct learning support through hints, tutorials, and supervision



□ Robot as peer

- Offer advantages over tutor-to-student interaction

□ Robot as novice

- Provide the opportunity of learning by teaching

Roles of Software-Defined Robots

□ Instructor Robot

- Mirror a physical instructor with the intelligence resulted from big data, AI and practical experiences of many excellent real teachers



□ Collaboration Robots

- Learning companion that does not know all answers, but a learner on the side of the player, there to help him or her learn, and in so doing, learn how to learn better
- The companion can be a competitor of the player, or another learner that needs more help from the player



Roles of Software-Defined Robots

□ Knowledge/Descriptive Robot

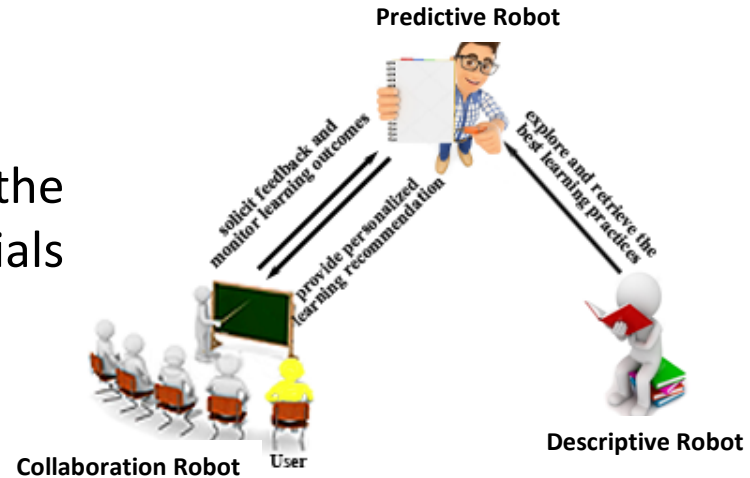
- Has the concepts, facts, rules, problem-solving strategies of the domain in context

□ Predictive Robots

- Solicit feedback from learners regarding the effectiveness of specific learning materials and learners' difficulties
- Monitor learning outcomes continuously

□ Prescriptive Robots

- Personalize learning materials based on the individual's responses to the e-Classroom environment



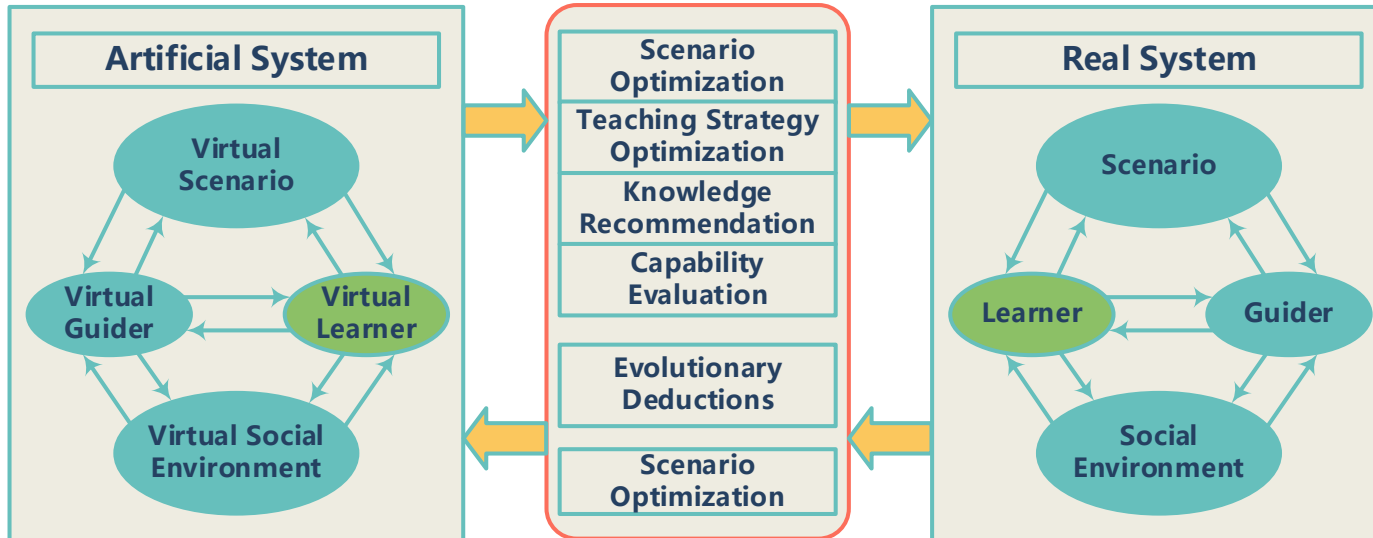
Robot Support

Technologies

- ✓ synergy of human and machine intelligence
- ✓ Learner-centered
- ✓ Adaptive and Personalized

Support for

- ✓ Multidisciplinary Integration
- ✓ CDIO (Conceive-Design-Implement-Operate) Engineering Education
- ✓ Constructivism Learning Theory
- ✓ Exploratory Education



Contents

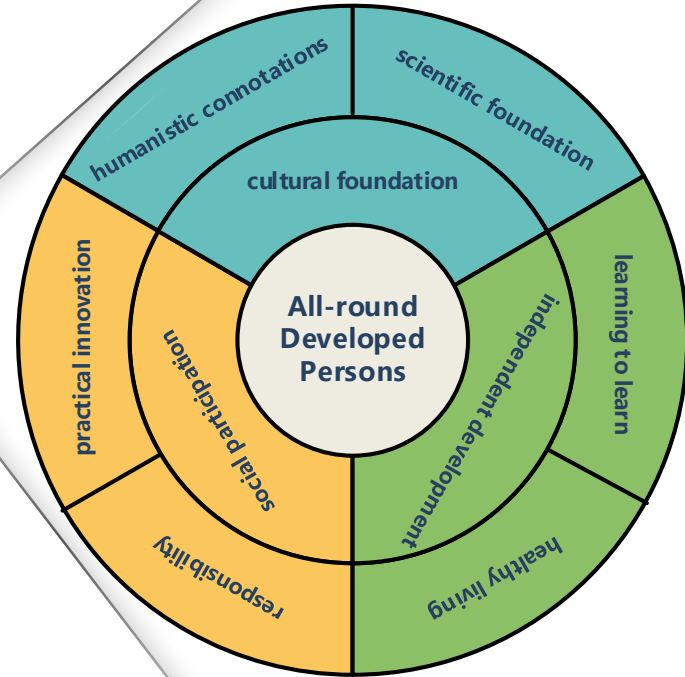
1. Background of Education
2. Parallel Education
3. **iSTREAM & iCDIOS and Beyond**
4. Future Education



Core Competencies and Values for Student Development



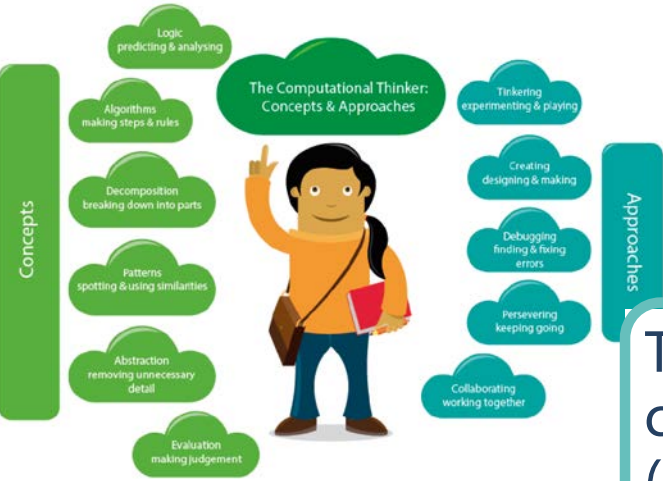
- ▶ Cultural foundation
 - Humanistic connotations
 - **Scientific foundation**
- ▶ Independent development
 - **Learning to learn**
 - Healthy living
- ▶ Social participation
 - Responsibility
 - **Practical innovation**



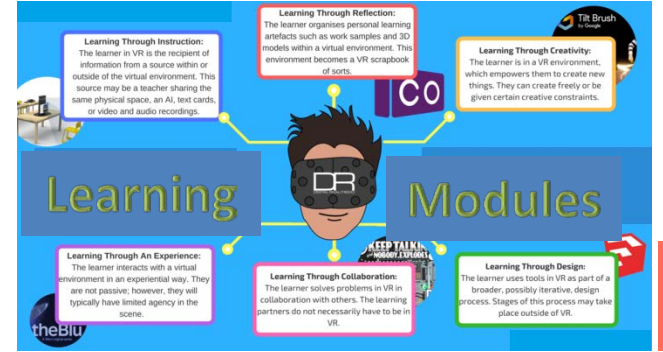
Core Competencies and Values for Student Development

“授之以鱼，不如授之以渔” Give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime

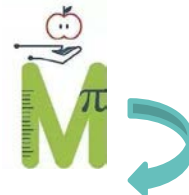
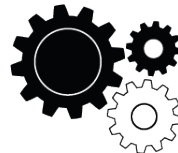
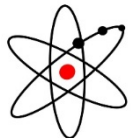
Traditional Contents (STEM) + no-traditional content in Artificial Intelligence (i), Robotics (R) and Art (A)



Innovative delivery methods – virtual reality, augmented reality, serious games to **think** computationally and **act** computationally



STEAM → iSTREAM



i S T R E A M

Intelligence

Science

Technology

Robotics

Engineering

Arts

Management

Learning by Making



CDIO → iCDIOS



i

Intelligence



C

Conceive



D

Design



I

Implement



O

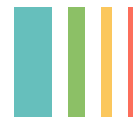
Operate



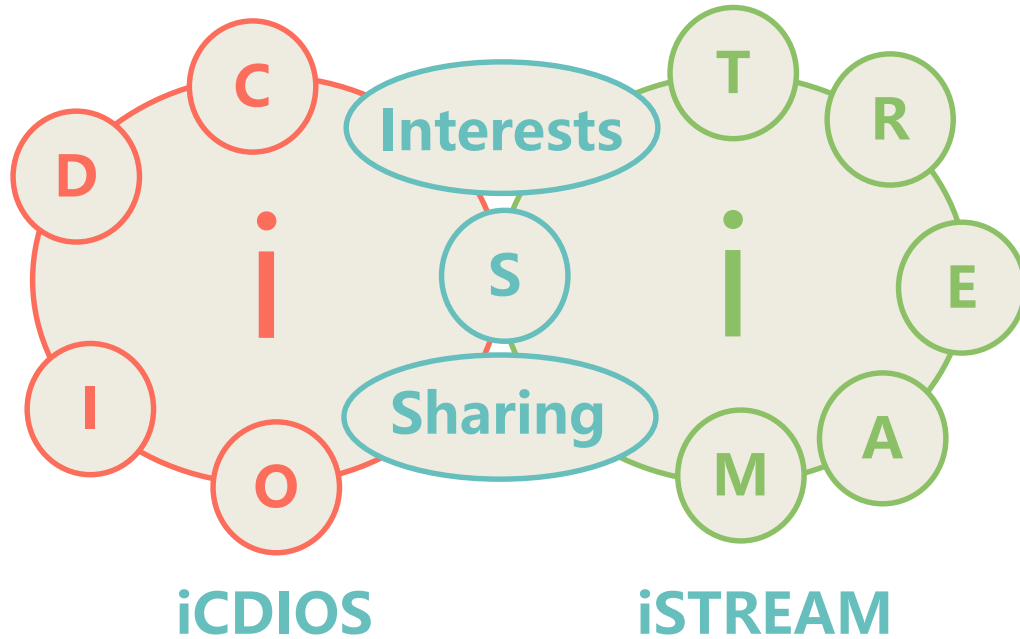
S

Services

Making by Learning



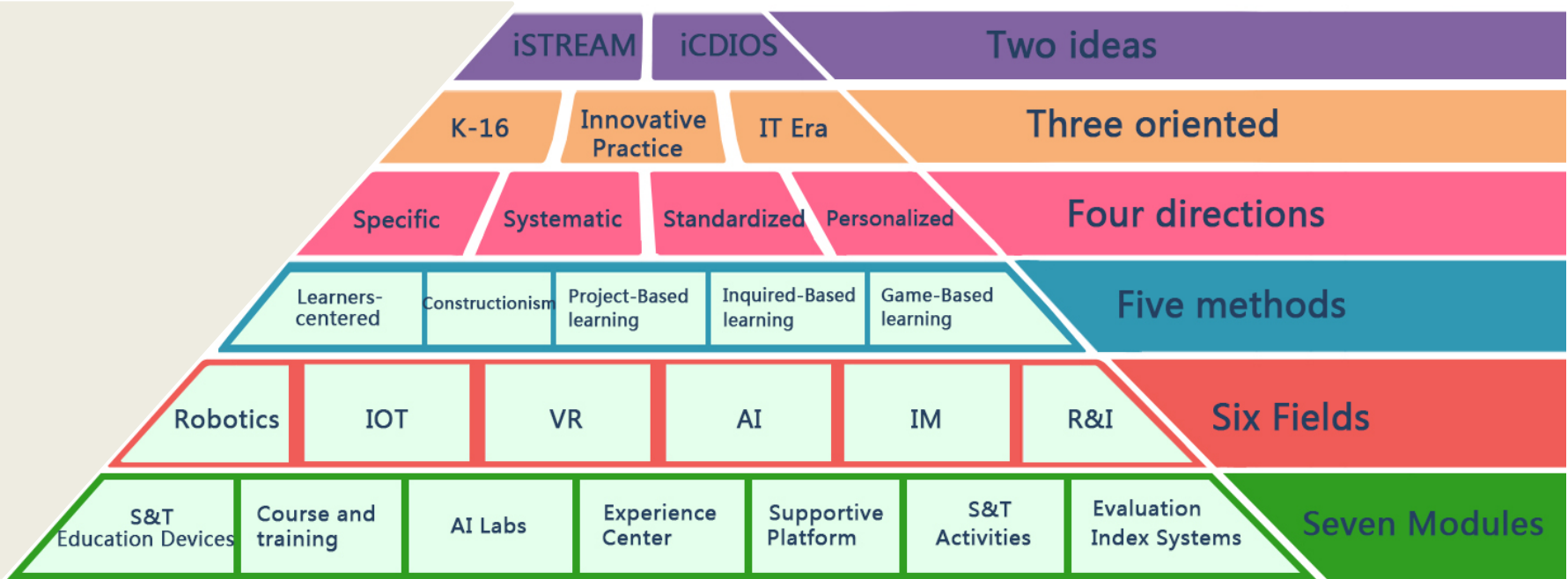
□ “i” –intelligence, innovation, inspiration



□ “s” –service, security, sustainability

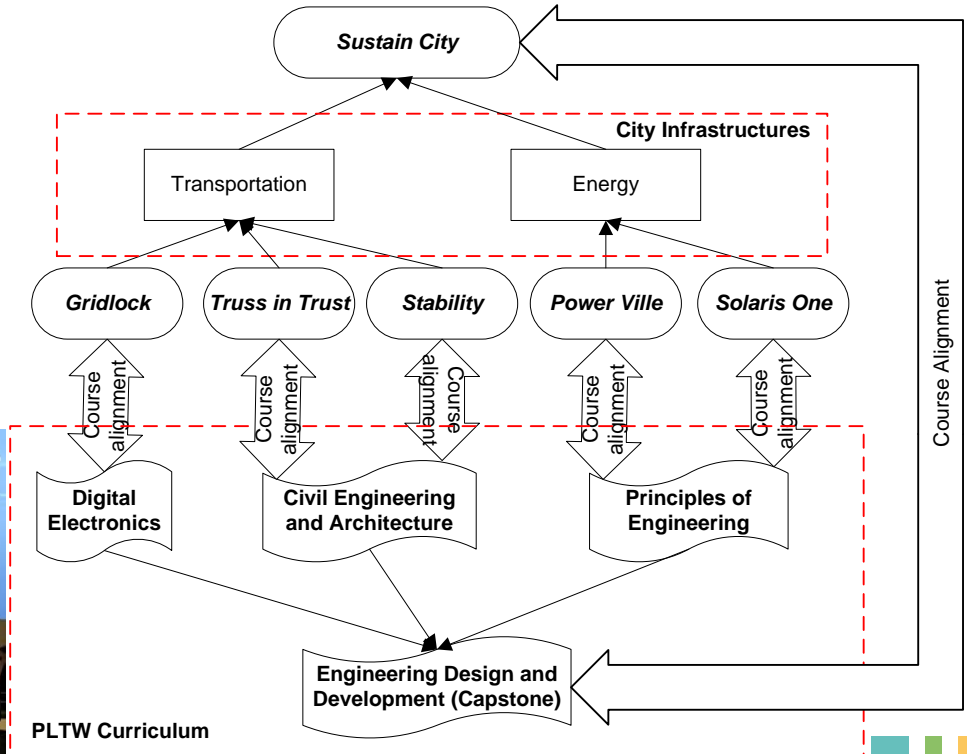


iSTREAM + iCDIOS Education Innovation



Integration of Game Mechanics w/ Learning

- Sustaincity** is such a system that involves a series of virtual reality games aligned w/ Project-Lead-The-Way curriculum





Integration of Game Mechanics w/ Learning

□ Design challenges encountered essentially boil down to three topics

- Narrative-Learning Synthesis
 - ▶ *Motivation by embedding a learning experience into a narrative*
 - ▶ *Balancing learning content and entertaining aspects*
- Supplemental Feedback
 - ▶ *Motivation through sufficient rewards and punishments based on performance*
- Scaffolding for Game Navigation
 - ▶ *Should the player fail to grasp the subjects, provide help tailored specifically to the player's skill set*

□ Narrative Learning Synthesis

- **Transformative learning** - the expansion of consciousness through contextual understanding, critical reflection on assumptions, and validated meaning by assessing reasons
 - ▶▶ *Sustain City is an exquisite combination of interacting systems (infrastructures) to be designed and analyzed using engineering and scientific principles*
 - ▶▶ *Sustain City provides students an opportunity to
 - learn what it means to be a scientist, engineer, or mathematician who helps design and maintain an eco-city
 - see the interconnection between their courses as a progression of increasing design complexity*



☐ Solaris One



- The instructional goal is to demonstrate the basic laws of thermodynamics and their applications in the real world

$$Q = m * C_p * \Delta T$$
$$P = \frac{Q}{\Delta T}$$
$$P = K * A * \frac{\Delta T}{L}$$
$$K = \frac{Pl}{A * \Delta T}$$



- The players takes the role of a power engineer to restore a solar energy harvesting facility located at the asteroid back online



Integration of Game Mechanics w/ Learning

□ Game succumbs not just to repetition, but variation across repetitive operations

- *Solaris One* consists of a series of mini-games that provides a cohesive narratives with obvious stepping points and an end goal.

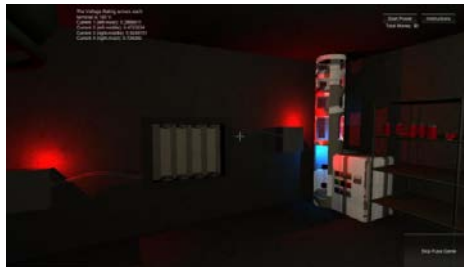
➤ Rocket Launch



➤ Pipe Energy Games



➤ Fuse Game



□ Supplemental Feedback

- *Experiential Consequentiality and Various Rewarding*
 - *The game must be designed such that there are various degrees of accomplishment and that the outcomes can directly affect **the game world** and, by extension, the **player's experience***
 - *reward for success, and punish for failure*
- Example – **Power Ville** that educates students about four energy choices –Coal; Wind; Solar; and Nuclear
 - *Built-in systems tally to rank student's performance across a number of mini-games and quizzes*
 - *Provides the student with an end score*

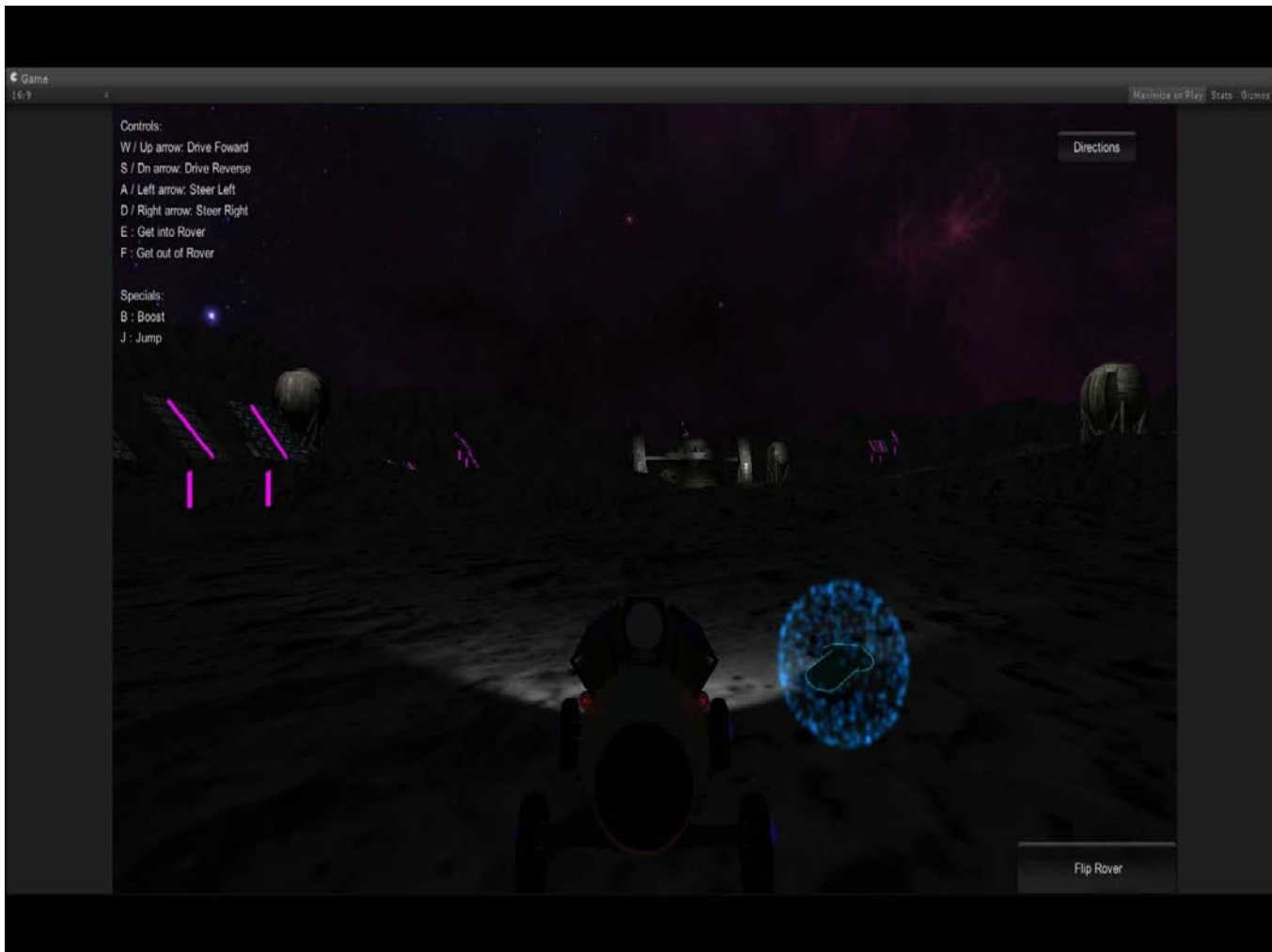




□ Supplemental Feedback

- Example – *Solaris One* where a money model to reward players throughout the game for upgrading the rover w/
 - *Performance Improvement*
 - *Flight*
 - *Aesthetic additions*





□ Scaffolding for Game Navigation

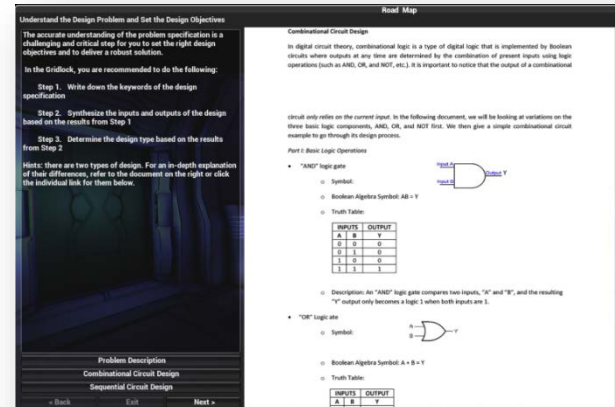
- Educational games are particularly complicated in guiding game play because students are different
 - *Guide the player through frustration in educational aspects*
 - *Guide the player through environments or surrounding game play (A more traditional problem seen in all games)*
 - *Challenges lie in identifying where a player has difficulty and delivering precisely the help they need*



Metacognitive Interventions

- *Road Map* --- Study guides

- ▶▶ Task list to guide students to navigate through game assignments and retrieve important information
- ▶▶ A set of suggestions designed to lead students through a problem solving process by directing attention to key ideas and suggesting the application of proper skills



Metacognitive Interventions (cont.)

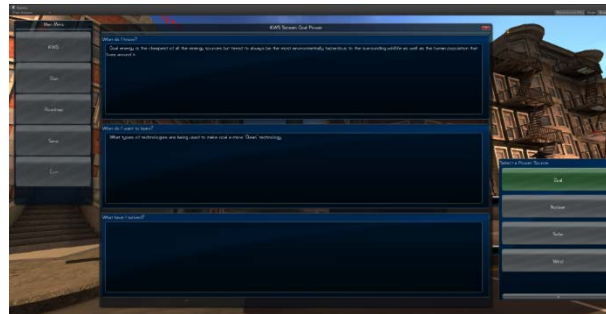
- What I **K**now, What I **W**ant to Know and What I Have **S**olved (KWS)--
- provides a 3-column chart structure to:
 - ▶▶ Activate students' prior knowledge
 - ▶▶ Motivate students to think
 - ▶▶ Review what part of the problem has been resolved

KWS

A 2-bit synchronous counter design

What Do I Already K now	What Do I W ant To Know	What Have I S olved?
<ul style="list-style-type: none">• I/O : reset, enable, clock, 2-bit output• Sequential machine• State machine method	<ul style="list-style-type: none">➤ How to test the counter design	<ul style="list-style-type: none">✓ A state machine for the counter✓

Fig. 2: A sample KWS worksheet



1. What is the difference between a Sequential circuit and a Combinational Circuit?

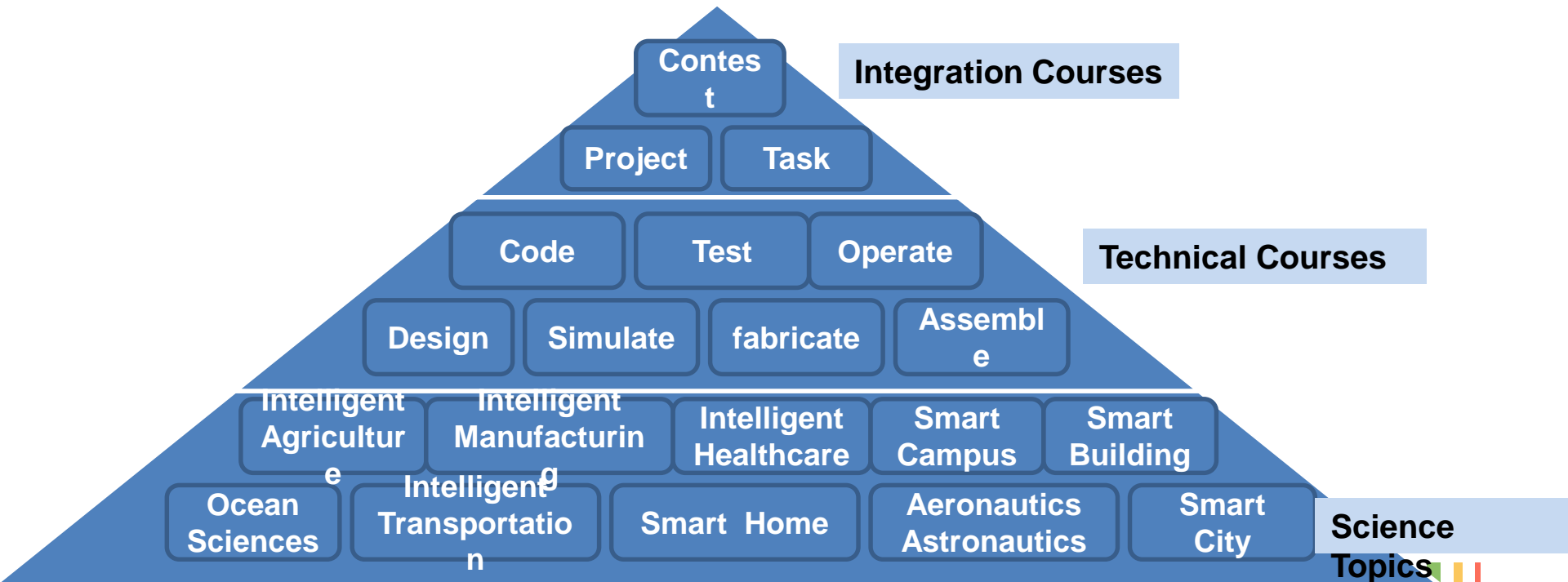
- a. They are the same.
- b. The sequential circuit has storage elements to store binary information, called a state, and determine outputs based on the current state and inputs. Combinational circuits do not have memory.
- c. The combinational circuit has storage elements to store binary information, called a state, and determine outputs based on the current state and inputs. Sequential circuits do not have memory.
- d. None of the above

□ Learning to learn + Thinking about thinking

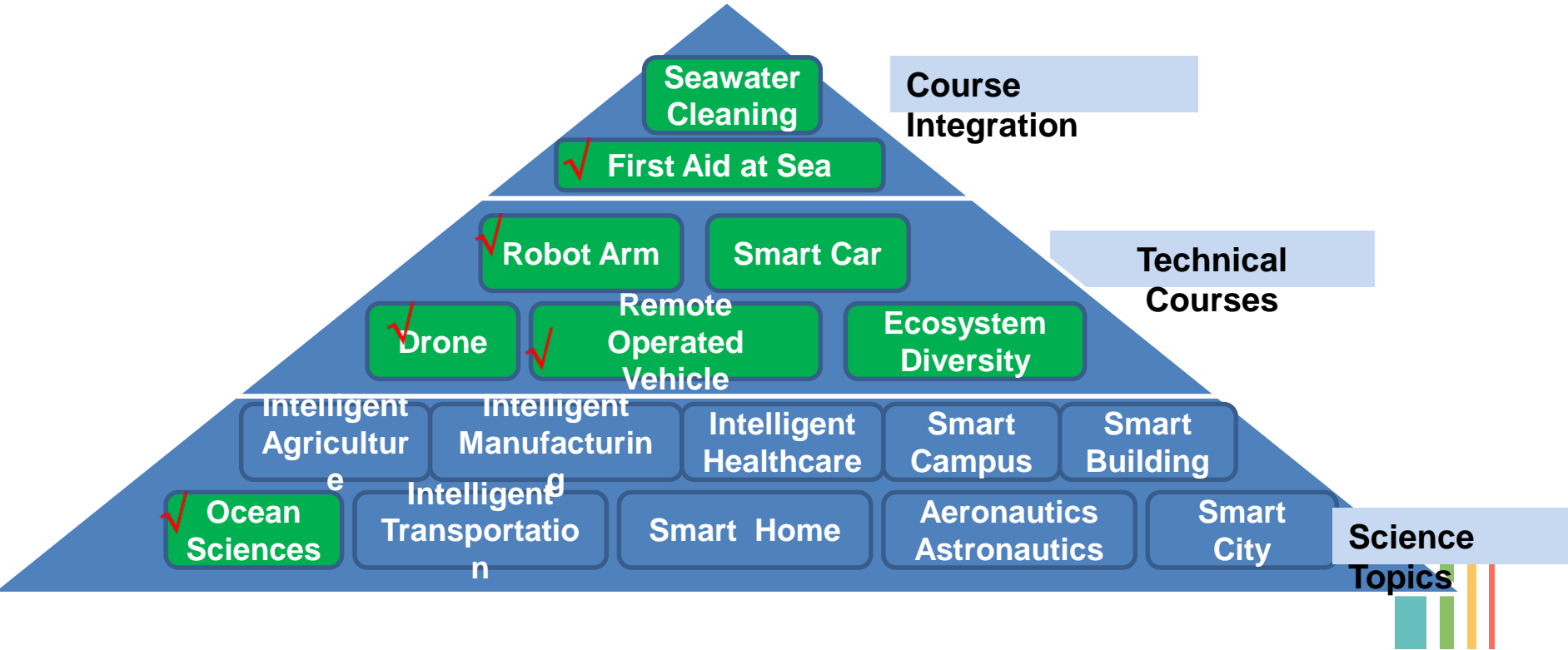
- *“The more realistic the scenario, the better I enjoy working on real-world problems because I feel it better prepares me than simply designing a circuit that performs some random function”, and “I thought the movement in the game encouraged me a little more to make it work”.*
- Road Map was the most popular tool, since road map, in their words, *“kept reminding me what I did and what I have to get accomplished”, and “hints necessary concepts”.*



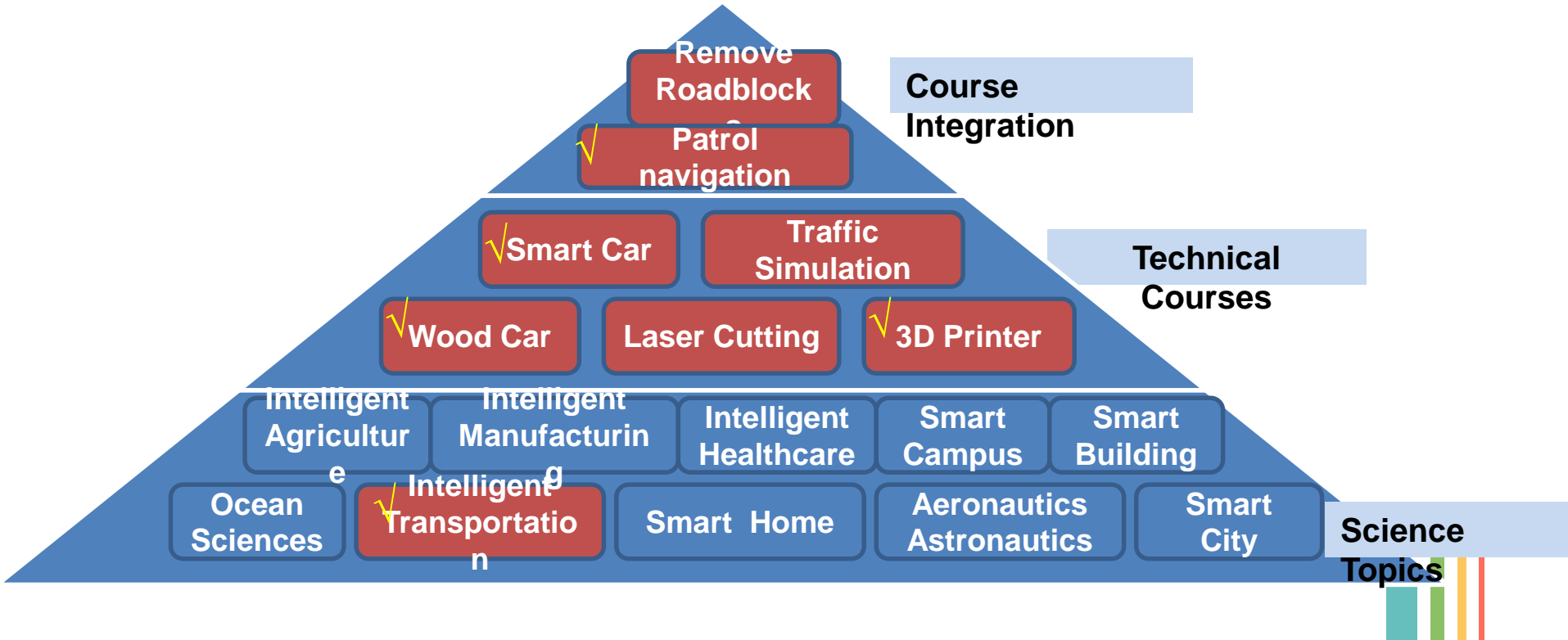
iSTREAM Curriculum Template



Curriculum Personalization



Curriculum Personalization



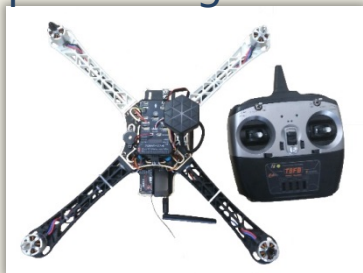
Curriculum Development



Educational Equipment



Graphical Programming Drone



Water Sampling Drone

Intelligent Robot



VR



Robotic Fish



3D Printer



Underwater Robot



Innovative Labs

Robotics Labs
IOT Labs
VR Labs
3D Printing Labs
Drones Labs



iSTREAM Education Base



Since its opening in September 2016 to December 31, 2017, **iSTREAM Education Center** has welcomed more than 8,500 Teachers and students from 35 schools.



iSTREAM Experience Center



Located in Qingdao CBD, close to Wusi Square, iSTREAM Experience Center has welcomed more than 2000 teachers and students from China.

Shandong provincial Party committee Secretary Mr. Jiayi Liu visited iSTREAM educational center.



Qingdao municipal Party committee Secretary Mr. Jiangting Zhang visited iSTREAM educational center.



Schools Served



● **17 Primary schools in Shinan District:** Jiangsu Road Primary School, Taiping Road Primary School, Shinan New Century Primary School, Nanjing Road Primary School, Hong Kong Road Primary School, Ningxia Road Primary School, Badaxia Primary School, Beijing Road Primary School, Dexian Road Primary School, etc.

● **37 Primary Schools in Shibe District:** North New Century Elementary School, Beizhong Road First Primary School, Taizhan Road Primary School, Shanghai Zhilu Primary School, Liaoyuan Road Primary School, Shangqing Road Primary School, Dongsheng Road Primary School, Lingxian Road Primary School, Beizhong Road Primary School 2, Shouguang Road Primary School, etc.

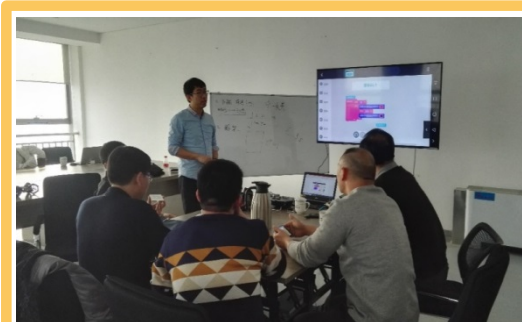
● **20 Middle Schools:** Yucai Middle School, 39th Middle School, 9th Middle School, Chaoyin Middle School, 15th Middle School, 6th Middle School, 50th Middle School, 53rd Middle School, 51st Middle School, etc.



Activities



Summer Camps



Teachers Training



Science Fairs



Lectures

Welcome to iSTREAM Education Base



Schools Visited iSTREAM Education Base in Qingdao



Contents

1. Background of Education
2. Parallel Education
3. iSTREAM & iCDIOS and Beyond
4. Future Education



01

> **Scientific** games and cartoons

02

> **Pervasive** simulation and imitation

03

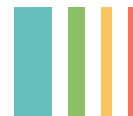
> **Digitalization** of knowledge and experience dynamically in real time

04

> **Personalization and diversification** of education

05

> **Self-taught and lifelong learning**



Future Directions



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