LEARNING PRODUCTS: PEDAGOGICAL DESIGN, ASSESSMENT, STAKEHOLDER DIALOGUE

TASOS HOVARDAS
RESEARCH IN SCIENCE AND TECHNOLOGY EDUCATION GROUP
UNIVERSITY OF CYPRUS, HOVARDAS@UCY.AC.CY

This course is co-funded by the STE(A)M IT and Scientix 4 projects, funded by the EU’s ERASMUS+ programme (GA 612845-EPP-1-2019-1- BE-EPPKA3-PI-FORWARD), and EU’s H2020 research and innovation programme (GA 101000063) respectively. The content of the document is the sole responsibility of the organizer and it does not represent the opinion of the European Union or the Education, Audiovisual and Culture Executive Agency, which are not responsible for any use that might be made of the information contained.
LEARNING PRODUCTS AND PEDAGOGICAL DESIGN

- Learning product (physical or digital): Artefact created by students during a learning activity; usually students are supported by tools, templates or scaffolds.

- Examples of learning products (physical or digital): Drawings; concept maps; hypotheses; experimental designs; data collected in datasheets; graphs; tables; models, videos created by students, etc.

- A sequence of learning activities may be reconstructed as a sequence of learning products, where each learning product of a former learning activity is needed as necessary input for processing an upcoming learning activity.

- Learning products present a key point for all state-of-the-art learning approaches.

- They determine the duration of learning activities and class arrangement (if learning activities are to be undertaken by individual students, groups of students or if these are whole-class activities).
EXAMPLES OF LEARNING PRODUCTS
LEARNING PRODUCTS AND ASSESSMENT

- Learning products reflect knowledge and skills which are necessary for their creation: If students do not possess this knowledge and these skills, they would not be able to create these learning products.

- Learning products can be stored in portfolios to be retrieved and reused (reworked, revised, compared): In this regard, learning products can be used to restructure student navigation and performance in the learning environment.

- Learning products can be used for assessment purposes:
  - Summative assessment: Learning products stored in portfolios; certification of skills and competences);
  - Formative assessment: Teachers can focus on learning products to diagnose student performance and provide on-the-fly feedback; no need for other instruments which are external to the learning activity sequence.
  - Peer assessment: Students can assess the work of their peers in reciprocal peer assessment arrangements (each student will undertake the role of peer assessor and peer assessee).
STUDENT PORTFOLIOS

OPTIMIZATION OF LEARNING PRODUCTS
Posters (text and pictures)
Our designs are perfect for student life and/or outdoor life. Our houses are built on the customer's ideas in mind. Our houses are low cost, and we can
Designs
Physical models
Physical models
Data sets and graphs

![Image of data sets and graphs]

Table 2. Results of the proportionality between illuminance and distance.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Illuminance (lx)</th>
<th>I^2<em>d (lx</em>m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>5200</td>
<td>332</td>
</tr>
<tr>
<td>0.70</td>
<td>3500</td>
<td>493</td>
</tr>
<tr>
<td>0.75</td>
<td>3000</td>
<td>605</td>
</tr>
<tr>
<td>0.80</td>
<td>2700</td>
<td>499</td>
</tr>
<tr>
<td>0.90</td>
<td>2200</td>
<td>421</td>
</tr>
</tbody>
</table>

The illuminance E is given by the equation:

\[
E = \frac{k}{d^2}
\]

where \( k \) is a constant. Taking Log of both sides, we have:

\[
\log(E) = \log\left(\frac{k}{d^2}\right)
\]

or

\[
\log(E) = \log(k) - 2\log(d)
\]

The graph shows a straight line, indicating the proportionality of illuminance to distance squared.

4) Are all the data in agreement with the relationship found? If there are discordant data try to give a reason.

All the data are totally in agreement with the empirical relationship when using the average value for \( k \) (600 lx*m²). All the data set between the maximum and minimum values, that's between the...
School garden
LEARNING PRODUCTS AND STAKEHOLDER DIALOGUE

- Stakeholders can structure a constructive dialogue focusing on learning products.
- Teachers can use learning products for increasing the coherence and showcasing the strengths of their pedagogical design; teacher collaboration.
- When educational interventions have been designed with reference to concrete learning products, students reveal increased self-regulated learning and metacognition.
- Learning products have been found to foster inter-contextual transfer of knowledge and skills (transfer tasks).
- Learning products can be used to scaffold students work in the form of partially worked examples.
- Ministries of Education can use learning products for exemplifying curriculum development and analysis: Collections of learning products as the curriculum under development (learning progressions).
- Industry partners can use learning products for highlighting desirable skills.

SCIENTIX
The community for science education in Europe

STEAM IT
An interdisciplinary STEM approach
USING LEARNING PRODUCTS FOR ASSESSMENT PURPOSES

INSIGHTS FOR DEVELOPING NON-LINEAR THINKING
BACKGROUND AND RATIONALE

- Systems thinking, non-linear phenomena
- Ecology: Population level; biocommunities, where populations of different species interact (e.g., prey–predator systems); ecosystems
- Develop non-linear reasoning
- Non-linear reasoning diverges substantially from linear reasoning
- Linear interactions between variables: Proportional or inversely proportional relationships; one-way, unidirectional causality

- Non-linear relationships in ecological systems are not proportional and imply two-way, bidirectional causality
- The latter type of causality is a crucial characteristic of feedback loops observed in ecological phenomena
- Main questions to be addressed:
  - (1) Good practice in pedagogical design to develop non-linear thinking
  - (2) How to use learning products within the frame of formative assessment for securing the developing of non-linear thinking
  - (3) Implications for learning and instruction
## Game Simulation and Computer Simulation

### Learning Activity Sequence Focusing on a Game Simulation of a Prey-Predator System (Hovardas, 2016; Hovardas & Zacharia, 2019)

<table>
<thead>
<tr>
<th>Learning Activity (Serial Number)</th>
<th>Time to Complete; Class Arrangement</th>
<th>Learning Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliciting Initial Ideas (1)</td>
<td>10min; individual</td>
<td>Text addressing an introductory scenario</td>
</tr>
<tr>
<td>Comparing Initial Ideas with Scientific Data (2)</td>
<td>10min; individual</td>
<td>Text focusing on the comparison at task</td>
</tr>
<tr>
<td>Playing the Game (3)</td>
<td>20min; group</td>
<td>Table with number of prey and predator individuals</td>
</tr>
<tr>
<td>Constructing a Graph (4)</td>
<td>20min; group</td>
<td>Graph presenting prey and predator population trends</td>
</tr>
<tr>
<td>Interpreting the Graph (5)</td>
<td>10min; group</td>
<td>Text focusing on the interpretation of the graph</td>
</tr>
<tr>
<td>Comparing Graph Interpretation with Initial Ideas (6)</td>
<td>10min; group</td>
<td>Text focusing on the comparison at task</td>
</tr>
<tr>
<td>Discussing the Comparison of Graphs with Initial Ideas (7)</td>
<td>15min; whole-class</td>
<td>Table which includes similarities and differences</td>
</tr>
<tr>
<td>Predicting Prey and Predator Population Sizes in a New Learning Context (8)</td>
<td>10min; individual</td>
<td>Text addressing the new scenario</td>
</tr>
<tr>
<td>Revising the Game to Address the New Scenario (9)</td>
<td>15min; individual</td>
<td>Text which includes revised rules for the game</td>
</tr>
</tbody>
</table>

### Learning Activity Sequence Focusing on a Computer Simulation of a Prey-Predator System (Hovardas, 2016; Hovardas & Zacharia, 2019)

<table>
<thead>
<tr>
<th>Learning Activity (Serial Number)</th>
<th>Time to Complete; Class Arrangement</th>
<th>Learning Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructing a Model of the Prey-Predator System (1)</td>
<td>20min; individual</td>
<td>Structural model of the prey-predator system</td>
</tr>
<tr>
<td>Inserting Equations of Population Dynamics (2)</td>
<td>10min; individual</td>
<td>Equations describing the prey-predator system</td>
</tr>
<tr>
<td>Simulating the Prey-Predator System (3)</td>
<td>10min; individual</td>
<td>Graph depicting prey and predator population trends</td>
</tr>
<tr>
<td>Interpreting the Graph (4)</td>
<td>10min; whole-class</td>
<td>Text which focuses on the interpretation of the graph</td>
</tr>
<tr>
<td>Constructing a Scatterplot with Prey and Predator Populations (5)</td>
<td>10min; individual</td>
<td>Scatterplot</td>
</tr>
<tr>
<td>Interpreting the Scatterplot (6)</td>
<td>20min; whole-class</td>
<td>Text which focuses on the interpretation of the scatterplot</td>
</tr>
<tr>
<td>Exploring Model Behaviour for Different Initial Population Sizes (7)</td>
<td>15min; group</td>
<td>Scatterplot with multiple curves</td>
</tr>
<tr>
<td>Predicting Prey and Predator Population Sizes in a New Learning Context (8)</td>
<td>10min; group</td>
<td>Text presenting a new scenario</td>
</tr>
<tr>
<td>Revising the Model to Address the New Scenario (9)</td>
<td>15min; group</td>
<td>Revised model</td>
</tr>
</tbody>
</table>
BUILDING BLOCKS OF LEARNING
SCENARIOS: FOCUS ON LEARNING PRODUCTS

GAME SIMULATION OF THE PREY PREDATOR SYSTEM: FOCUS ON LEARNING PRODUCTS (YELLOW RHOMBUSES)
GAME SIMULATION

Rules of the game:

1. Each wolf consumes one deer in each time unit.
2. Each deer consumed is “transformed” into a wolf.
3. All wolves consume deer.
4. If a wolf cannot find a deer to feed on, it is “transformed” into a deer.

<table>
<thead>
<tr>
<th>Time unit</th>
<th>Number of wolves</th>
<th>Number of deer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>
Initial predictions of students are based on an assumption that prey-predator interaction would evolve as a linear, monotonous trend; however, the prey population does not disappear.

Some students describe population trends as “inversely proportional.”

Regression to linear thinking.

Learning products: Graph; graph interpretation.

“*When the one population increases, the other population decreases. When wolves increase in number, deer decrease. We can see that populations of wolves and deer relate in an inversely proportional way (Participant no 51).*”
If participants had identified maximum and/or minimum values in population curves or if they had observed the temporal pattern of oscillations of prey and/or predator populations, they were significantly less likely to resort to linear, unidirectional reasoning.

DATA ANALYSIS BASED ON LEARNING PRODUCTS (TREE MODEL)

If participants had observed maximum and/or minimum values of population curves during graph description they had most probably progressed to non-linear reasoning.

Those who recorded maintenance of both wolves and deer but depicted population trends as “inversely proportional” were most probable to not have progressed.
Concrete aspects of concrete learning products provide clear evidence of learner progression, stagnation, or even regression (formative assessment).

Students who concentrated on the space delineated by maximum and minimum values of population curves interpreted trends as “inversely proportional.”

However, proportionality in our case would be only possible to ascertain, if prey and predator population sizes would have been plotted the one against the other, for example in a scatter plot.
The powerfulness of linear heuristics might reach to the point of distorting novel information.

Linear heuristics are quite powerful and might re-surface even when targeted by instruction.

There is the possibility that schooling itself might be contradictory and that the curriculum may promote divergent objectives.

Linear thinking in physics; non-linear thinking in ecology.

Using graphing to approach only linear and proportional relationships might be counter-intuitive for addressing non-linear reasoning.

Graphs and graph descriptions might be instrumental in either challenging or perpetuating linear reasoning.

Curriculum design and development should incorporate a comparison among scientific fields/domains.

Such a perspective could very well match with nature of science (NOS) approaches in science education.
REFERENCES


QUESTIONS TO BE DISCUSSED

LEARNING PRODUCTS: PEDAGOGICAL DESIGN, ASSESSMENT, STAKEHOLDER DIALOGUE
QUESTIONS TO BE DISCUSSED

- Can traditional assessment instruments (e.g., multiple choice items) be employed to effectively evaluate learning outcomes in integrated STEM education?
- Can we use learning products instead?
- How easy would it be to base pedagogical design and implementation of integrated STEM education on collections of learning products?
- Can we use learning products to describe learning progressions?
- Can we use learning products to describe curriculum standards?
- Can we use learning products to describe desirable skills and competences?
- Can we use learning products for certifying skills and competences?
- Can we use learning products (digital) to facilitate a transition from the “traditional” classroom to a “digital” classroom?
LEARNING PRODUCTS AND LEARNING PORTFOLIO

NIKOLETTA XENOFONTOS
UNIVERSITY OF CYPRUS
Mechanical engineer

Software engineer

Researcher

Publications

Web applications and traffic analytics

Video demonstration
LEARNING PORTFOLIO

A COLLECTION OF STUDENT WORK THAT SHOWCASES STUDENT’S PROGRESS, ACHIEVEMENTS AND COMPETENCIES
WHY LEARNING PORTFOLIO?

Provides **aggregated information** about student learning

Showcases **evidence** of what specific learning goals student achieved

Allows teachers to **monitor** student progress and provide formative assessment

Allows student to **reflect** on their learning

It can be presented to **parents**

It can be given to the **next teacher** (following grade)

It can be scored based on **rubrics** (match of the intended learning goals with the assessment criteria)

Students are involved in the creation of their learning portfolio (**self-regulated learners**)

Allows student **self-assessment** and **peer-assessment**
EXAMPLES FROM THE STE(A)M IT INTEGRATED STEM TEACHING AND LEARNING SCENARIOS

LEARNING PORTFOLIOS AND ASSESSMENT
THE SOLAR SYSTEM AND THE EARTH: WHERE COULD HUMANS LIVE INSTEAD OF THE PLANET EARTH?

**Subjects:** Science, Technology, Mathematics and Language (Primary education)

**Learning goals** (Lesson 2 - Science)

1) name other planets (and comets or meteorites) of the Solar system

2) interpret gravity as a factor that makes Earth habitable

3) argue on the factors that make Earth habitable compared to other planets

4) argue on the habitability of other planets in relation to Earth
Learning goals (Lesson 5 - Language)

1) argue on where humans could live in case living conditions on Earth become less friendly for humans by writing an article

2) reflect upon their article based on certain (con)textual and structural criteria
Learning goals (Lesson 5 - Language)

1) argue on where humans could live in case living conditions on Earth become less friendly for humans by writing an article

2) reflect upon their article based on certain (con)textual and structural criteria
LEARNING PORTFOLIO

Critical thinking and problem solving skills:
Analyze, interpret, compare and evaluate different data to seek and validate evidence.

Creative-thinking skills:
Ability to use new knowledge derived from their analysis, comparison and evaluation of different data to write a scientific article and argue in which planet humans could live, in case living conditions on Earth become less friendly for humans.
LIGHT UP FUTURE HOMES

Subjects: Technology, Physics and Art (Secondary education)
LIGHT UP FUTURE HOMES

These learning products can be stored in an electronic learning portfolio:

- **Local storage**
- **Cloud storage, e.g.**:
  - Google drive
  - One drive
  - Dropbox

3D design files
Video and/or images of a real model
Website
ASSESSMENT BEHIND LEARNING PRODUCTS

COLLABORATIVE TASKS
Example of a collaboration rubric teacher may use to evaluate each student’s collaboration skills.

If it is too hard to complete this rubric for every student, then train students to do it by themselves …
ASSESSMENT OF COLLABORATION AND COMMUNICATION SKILLS

... For example:

RIDE Assessment tool from Go-Lab (www.golabz.eu)
COVID-19 CHALLENGE

Distance and online learning
Real or electronic learning products

E-Learning portfolio
Storage of electronic files

Synchronous collaboration
Online collaboration and communication

Useful tool: Go-Lab ecosystem: www.golabz.eu

Learning analytics apps
Export to E-book (i.e., e-portfolio)

Apps for collaboration and communication
Images used in this presentation are under Creative Common Licences from:

http://alphastockimages.com/
https://pxhere.com/
https://pixabay.com/
https://www.needpix.com/
https://commons.wikimedia.org/
INTEGRATED STEM LEARNING SCENARIO IN THE CONTEXT OF EDUCATIONAL ROBOTICS – FOCUS ON PEER ASSESSMENT

NIKOLETTA XENOFONTOS
UNIVERSITY OF CYPRUS
GINOBOT PROJECT

Funded by the Cypriot Research and Innovation Foundation

Consortium: ENGINO.net Ltd and University of Cyprus

Pedagogical Approach:
GINOBOT

BUILD-IN PERIPHERALS

1. 2x DC Motors
2. 5x Proximity Sensors
3. 2x Color Sensors
4. 1x Ultrasonic Sensors
5. 1x Buzzer module
6. 4x RGB LEDs

Optional add-on electronics

Compatible with:

- Arduino
- micro:bit
- Raspberry Pi

SCIENTIX
The community for science education in Europe

HEXAPOD  EXCAVATOR  CRANE  HUMANOID  GRIBBER

STEAMIT
An interdisciplinary STEM approach
MARS CHALLENGE

BUDDLE OF THREE LESSONS
LEARNING SCENARIO – SUMMARY

Main Idea: The GINOBOT scans an unexplored, unknown surface in Mars and identifies the location of areas of interest or concern (i.e., rocks to be avoided and dusty hills to be explored).

Subjects: Computer Science, Technology and Mathematics

Lesson 1: Students have to find a way to make their robot move over the entire surface and, at the same time, use the sensors of the GINOBOT to screen the surface and identify rocky areas (represented as red cells on a grid) and dusty hills (represented as green cells on a grid).
LEARNING PRODUCT – KEIRO FLOW DIAGRAM (1)
**LEARNING SCENARIO – SUMMARY**

**Lesson 2:** After screening the Mars surface (grid), students must draw a line for robots to move on the Mars surface (grid) in order to avoid rocky areas (red cells) but pass over dusty hills (green cells), where the GINOBOT will stay for some seconds for further exploration.

Line follow examples
LEARNING PRODUCT – KEIRO FLOW DIAGRAM
Lesson 3: Students are assigned the role of peer assessors and peer assesseses. Each group evaluates if the identification of the location of the red and green cells by another peer student group was correct. Moreover, they evaluate if the line-follow program of the assessee group worked correctly. The peer assessment process gives the opportunity to the students to improve their work. The lesson concludes with the creation of a short documentary video about their mission and a reflection on the possible next steps for continuing the Mars’ challenge.
PEER ASSESSMENT

A reciprocal process during which learners provide feedback to each other, based on a set of assessment criteria.

Type of collaborative learning

Self-reflection

Metacognitive awareness

(Bohlen et al., 2017; Hovardas et al., 2014; Tsivitanidou et al., 2011)


THANK YOU

Nikoletta Xenofontos
ReSciTEG, University of Cyprus
xenofontos.nikoletta@ucy.ac.cy