



UNIVERSITÀ  
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# Integrated Digital Learning Environments: theoretical frameworks and applications

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With the patronage of



# University of Turin

Founded in 1404, the University of Turin is one of the **most ancient and most prestigious Italian universities**.

Hosting about **80000 students**, the University is today **one of the largest Italian Universities**, open to international research and training.

It carries out scientific research and organizes courses in **all disciplines**, except for Engineering and Architecture.





**Digital  
Education for  
Learning and  
Teaching  
Advances  
RESEARCH GROUP**



# Learning Environment

*A place where learning is fostered and supported.*

(Wilson, 1995)



# Learning Environment

5

What elements should be included?



# Learning Environment

6

It includes at least two elements:



learner

setting or  
space  
wherein the  
learner acts



# Ecosystem

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*A complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space.*

Encyclopaedia Britannica

# Digital Learning Environment (DLE)

8

A *learning ecosystem* in which teaching, learning, and the development of competence are fostered in classroom-based, online or blended settings. It is composed of a **human component**, a **technological component**, and the **interrelationships between the two**.



# Components of a DLE

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## Technological component

- Learning Management System
- Integrations for Mathematics
- Tools for communication and collaboration
- Devices
- Digital activities



## Human component

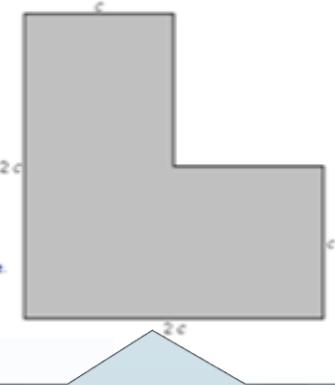
- Teachers
- Students
- Tutors

Osserva la seguente figura

Scrivi la formula che esprime come varia l'area della figura al variare di  $c$   
puoi cliccare sull'icona per visualizzare il grafico della

Risposta:  c  
Risposta corretta:  $3c^2$

Clicca su Verify per controllare la tua risposta e proseguire.



## Interrelationships (methodologies, interactions...)

- Adaptive teaching and learning
- Automatic Formative Assessment
- Problem solving
- Collaborative learning

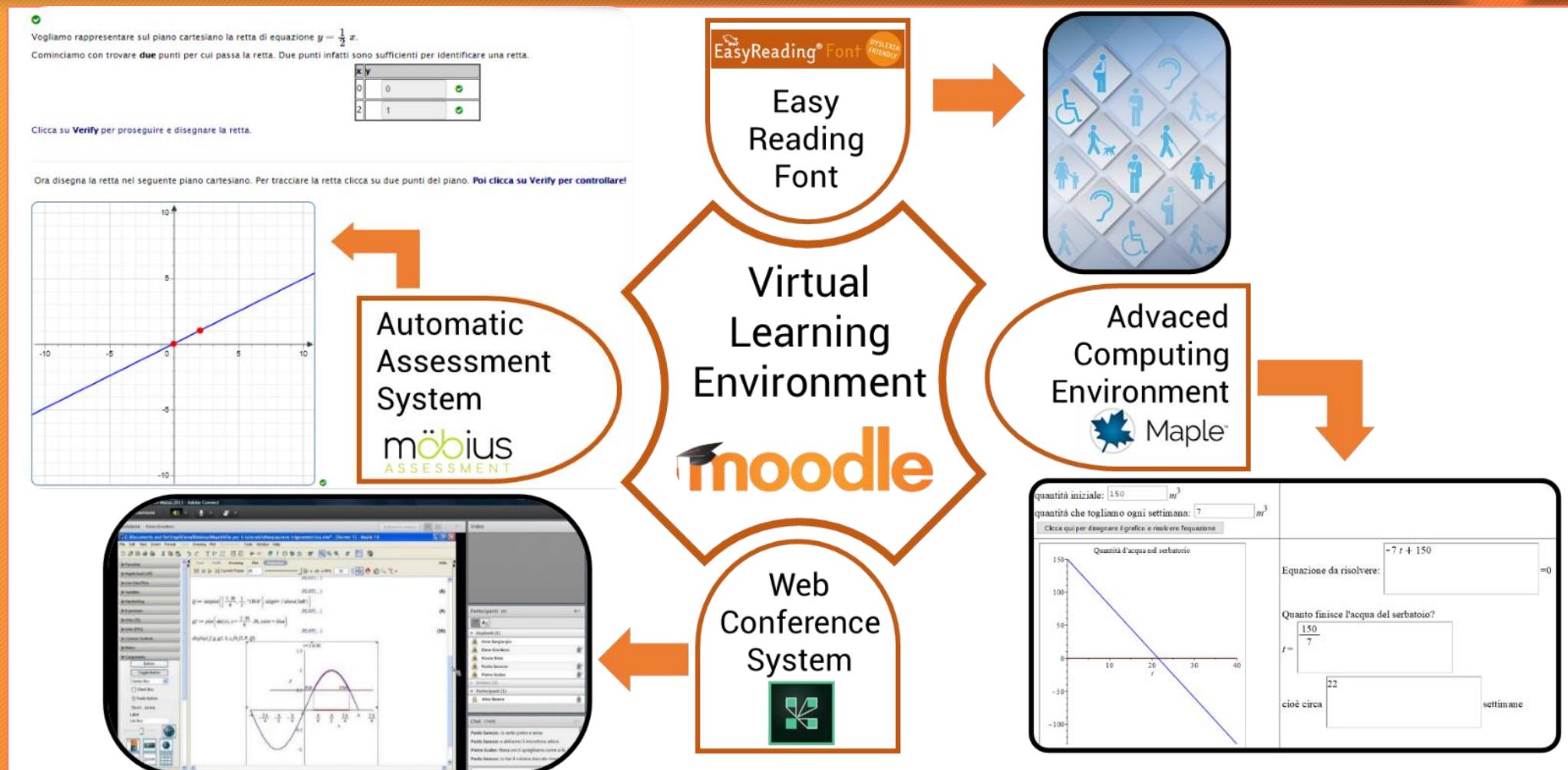
# Components of a DLE

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# Integrated Digital Learning Environment

# Technological components of a DLE for Mathematics



# Virtual Learning Environment



In this Section you will learn how to:

- recognize simple models involving elementary functions
- perform transformations of graphs
- determine domains of functions

## Functions and models

Transcript of the video Functions and models

### 1.1 - INTRODUCTION

Lesson 1.1.1

To do: Go through the activity to the end

### 1.2 - A CATALOGUE OF ELEMENTARY FUNCTIONS

Lesson 1.2.1 (Linear and Power Functions)

To do: View

Lesson 1.2.2 (Exponential and Logarithmic Functions)

To do: View

Lesson 1.2.3 (Trigonometric Functions)

To do: View

Your turn: Explore the following models related to topics explained in Lesson 1.2.2 .

Explore: Population growth

To do: View

Explore: Richter scale

To do: View

Completion Progress

NOW

Select your path into the course

Completed ✓

# Web conference tool

The screenshot shows a web conference interface with a dark header bar and a central workspace.

**Header:** The header includes the Adobe logo, a 'Riunione' button, and a video camera icon. A floating window titled 'Condivisione schermo' (Screen sharing) with the sub-instruction 'Per una condivisione dello schermo più efficace, passate alla modalità Schermo intero' (For a more effective screen sharing, switch to Full Screen mode) is visible.

**Workspace:** The main area contains a 'Maple' application window. The Maple interface has a menu bar (File, Edit, View, Insert, Format, Table, Drawing, Plot, Spreadsheet, Tools, Window, Help) and a toolbar with various icons. On the left, there's a 'Favorites' panel and a 'Expression' panel displaying mathematical expressions like  $a+b$ ,  $\frac{a}{b}$ ,  $\sqrt{a}$ , etc. The central workspace displays a pie chart with two segments labeled 'Concorrente1' (yellow) and 'Concorrente2' (blue). Below the chart, text instructions say 'Inserisci il numero di persone nel pubblico e nella giuria e muovi gli slider per vedere come varia il risultato!' followed by fields for 'Pubblico in studio' (100) and 'Giuria di esperti' (49), and sliders for 'Percentuale di voti del pubblico del primo concorrente' (set at 28) and 'Percentuale di voti della giuria del secondo concorrente' (set at 48). Below these are two bullet points: 'Voti totali primo concorrente: 49' (percentuale: 35%) and 'Voti totali secondo concorrente: 91' (percentuale: 65%).

**Right Sidebar:** The sidebar includes a 'Video' button, a 'Partecipanti (2)' section listing 'Cecilia' (Relatore attivo) and 'Francesco' (Ospitante), and a 'Chat (Tutti)' section showing messages from participants: Rosalba, Alice, Marinella, and Sara.

# Advanced Computing Environment (ACE)

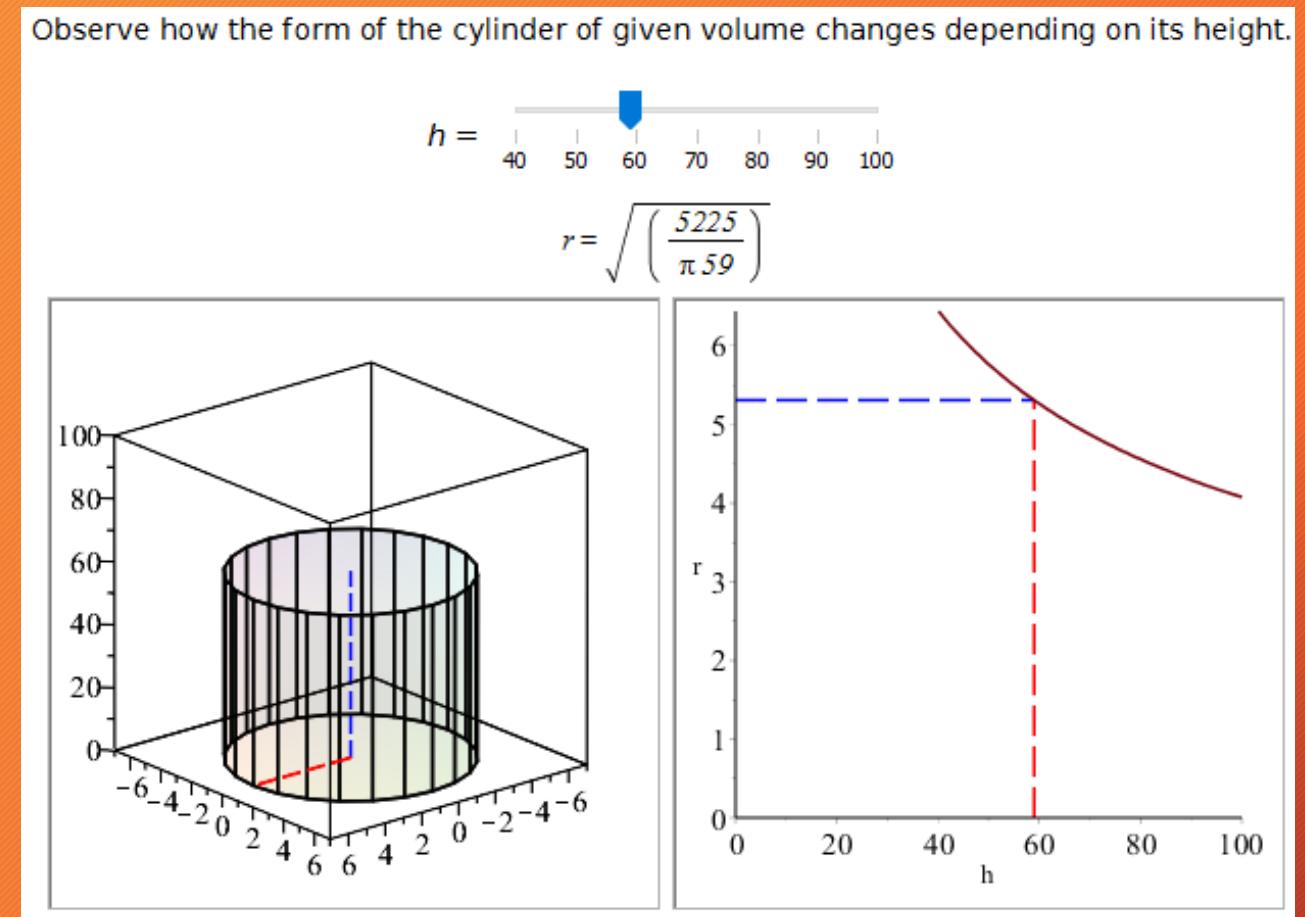
15

System which allows to embed in a single worksheet:

- text
- numeric computations
- symbolic calculus
- geometric visualizations
- interactive components
- algorythms and procedures



FLEXIBLE TOOL FOR STEM



# Advanced Computing Environment (ACE)

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## ACTIVE USE of the ACE

- Students actively use the ACE to solve problems

## INTERACTIVE USE of the ACE

- Teachers create interactive worksheets and make them available to students through the DLE

Thanks to the integrated platform, the worksheets can be uploaded in the platform and visualized without having the software installed, maintaining the **interactivity**.

- To overcome difficulties
- To boost Math competence
- To develop Problem Solving skills
- To study, review, understand theoretical concepts

# Automatic Assessment System

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Question 3: Score 1/1

Question type: Mathematical Formula

Quali sono i vertici dell'ellisse di equazione  $\frac{x^2}{9} + \frac{y^2}{16} = 1$ ?

Elenca tutti i punti separati da ;

Esempio: (0,1); (1,0); (1,1)

Your Answer: (0,4);(0,-4);(3,0);(-3,0)

Correct Answer: (3,0); (-3,0); (0,4); (0,-4)

Comment:



Question 4: Score 0/1

Your response

Trova lo zero della funzione

$$f(x) = \frac{\ln(x-1)}{x}$$

$$x = 0$$
 (0%)

Total grade:  $0.0 \times 1/1 = 0\%$

Comment:

Question 5: Score 1/1

Question type: Maple-Graded

Scrivi l'equazione della circonferenza di centro (0, 0) e raggio 3.

Your Answer:  $x^2+y^2-9=0$

Correct Answer:  $x^2+y^2 = 9$

Comment:



Adaptivity

Grade

Refresh

Close

Immediate feedback

Algorithm based questions

Open Math answers

Find the value of  $k$  for which  $(1+k)x - 4ky - 2 = 0$  is a line parallel to the x-axis.

$$k = -1$$

Write the equation of the sheaf of lines which corresponds to the value of  $k$  that you have found.

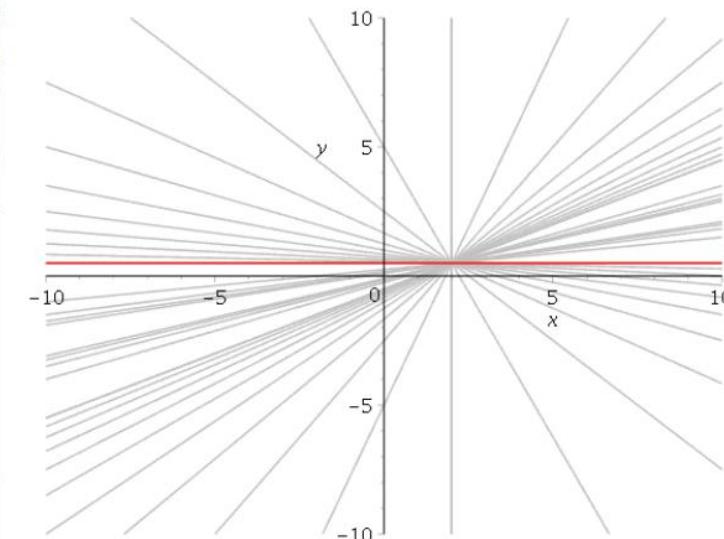
Then, click on the P icon to visualize the graphic of the line and to check that it belongs to the sheaf.

Equation Editor

$a^b$   $\sin(a)$   $\frac{\partial}{\partial x} f$

$$y = \frac{1}{2}$$

Preview



Close

# Automatic Assessment System

18

 Look at the following equality:  
$$\left(\frac{1}{4}\right)^{-4} = \frac{1}{4^4}$$

Is it correct or incorrect?

It is correct.  
 It is incorrect.

**Correct response:**  
It is incorrect.



 The equality is incorrect.  
To simplify the power, we need to use the following property:  
$$\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$$

**Correct response:**  $\left(\frac{b}{a}\right)^n$

Use the symbol / to write a fraction. E.g.: a/b

Thus the result is the following:  $\left(\frac{1}{4}\right)^{-4} = \left(\frac{1}{4}\right)^4 = 256$

**Correct response:**  $4^4 = 256$

**Correct response:** 256

Use the symbol ^ to write an exponent. E.g.: 3^2

Step-by-step solving processes

# Automatic Assessment System

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✓ A mountain spring constantly feeds a tank with  $5 \text{ m}^3$  of water each week. Today the tank contains  $160 \text{ m}^3$  of water and a village starts getting  $9 \text{ m}^3$  of water each week.

Complete the following table with the number  $n$  of  $\text{m}^3$  of water that the tank contains in function of the number  $t$  of weeks, starting from today.

$t$ (weeks)	$n$ ( $\text{m}^3$ )
0	160
1	156 ✓
2	152 ✓
3	148 ✓
4	144 ✓

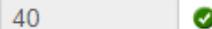
✓ Write an expression representing the number  $n$  of  $\text{m}^3$  of water that remain in the tank, in function of the number  $t$  of weeks.

$$n(t) = 160 - 4t$$

Correct response:  $160 - 4t$

After how many weeks will the tank be empty?

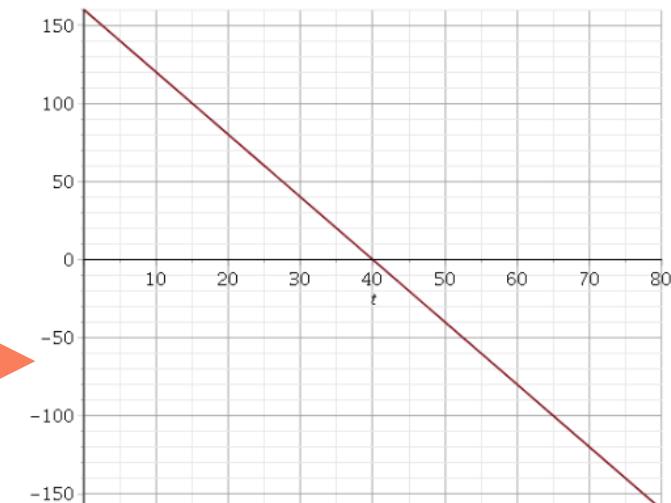
40



Multiple representations

Real-world problems

Preview



Close

# Integrated virtual learning environment

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Modular structure

The screenshot shows a module titled "Module 1" which reviews concepts about fractions and operations with fractions. The module structure includes:

- 1.1 Fractions**: Includes "EXPLORE equivalent fractions" and a "TEST" section with three items checked.
- 1.2 Operations with fractions**: Includes "COMPARE fractions and decimal numbers generated by fractions" and two "TEST" sections, both with three items checked.
- Solve the problem!**: A section with one item checked.
- FINAL TEST ON FRACTIONS**: A section with one item checked.

Checkmarks are present in the "TEST" sections and the "Solve the problem!" section. A legend indicates that green checkmarks represent completed tasks, while blue checkmarks represent pending or partially completed tasks.

Review of  
the theory

Explorative  
interactive  
activities

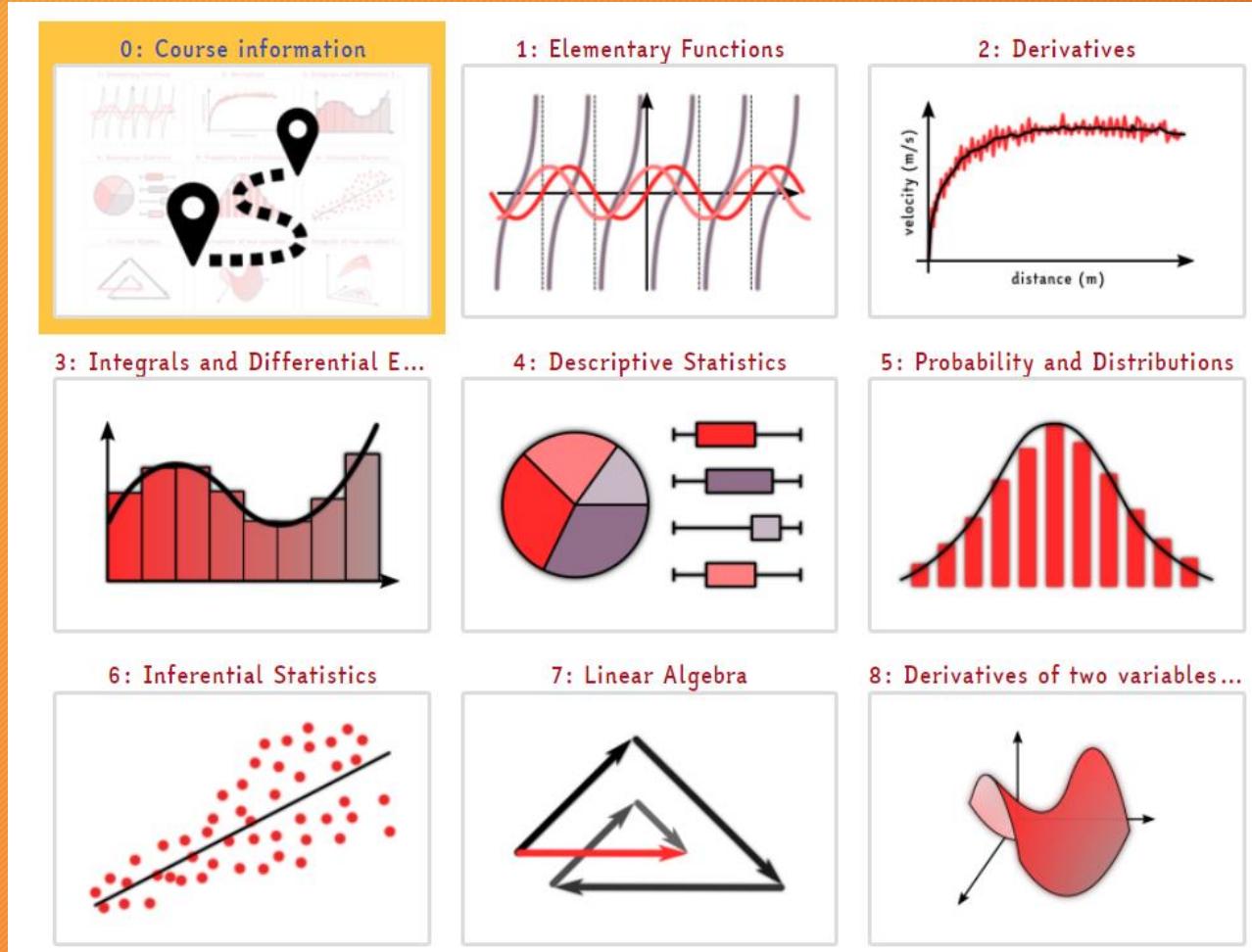
Automatic  
assessment

Final tests

Problem  
Solving

# Integrated virtual learning environment

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## ACTIVITIES

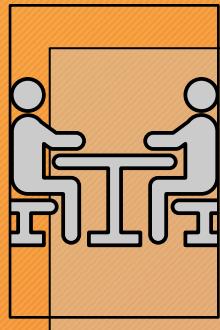
- Interactive files
- Quiz
- Forum
- Glossary
- Submission of assignments
- Online meeting
- ...

## RESOURCES

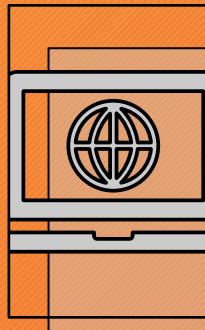
- Static pages
- Pdf files
- Videos
- Podcast
- Url
- ...

# Teaching and learning modalities in a DLE

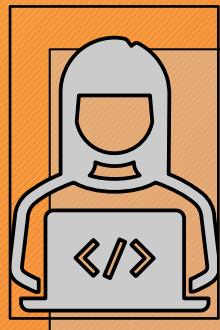
22



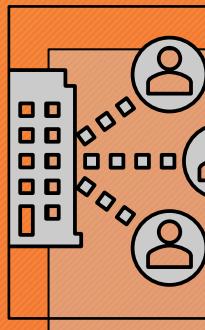
Face-to-face



Online



Blended



Hybrid

# Time of the activities in a DLE

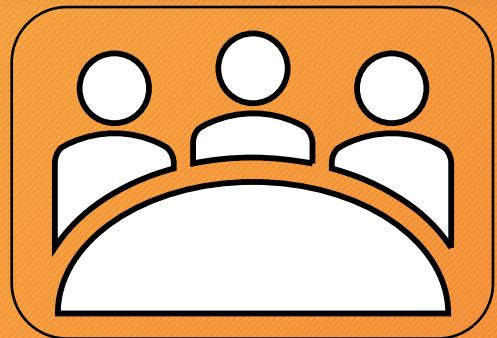
23

Synchronous

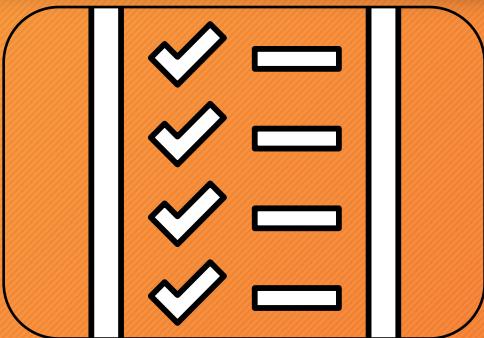
Asynchronous

# Asynchronous activities

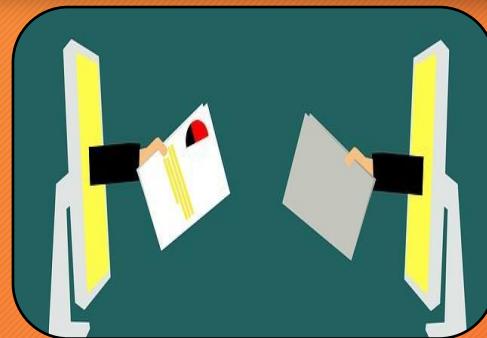
24



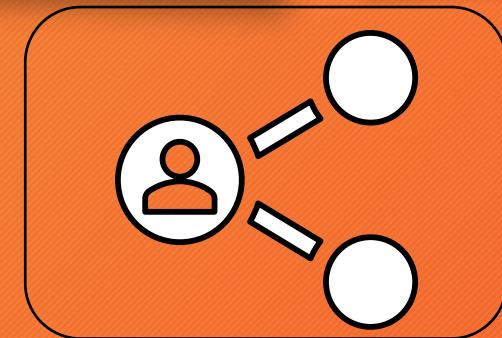
Discussions



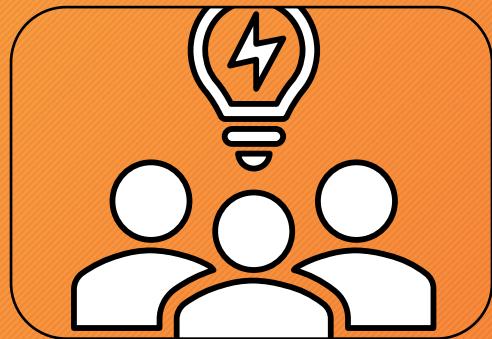
Automatic assessed tests



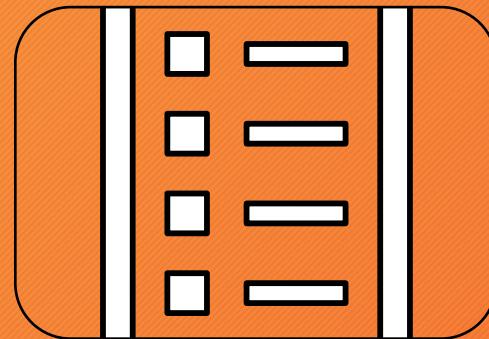
Submission of assignments



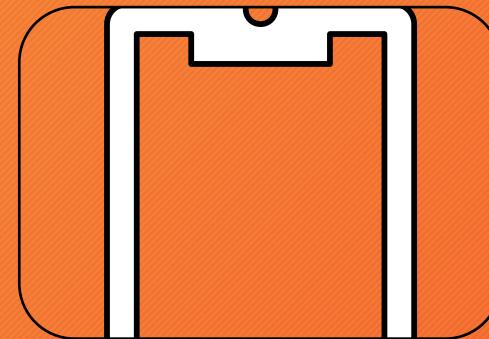
Shared materials



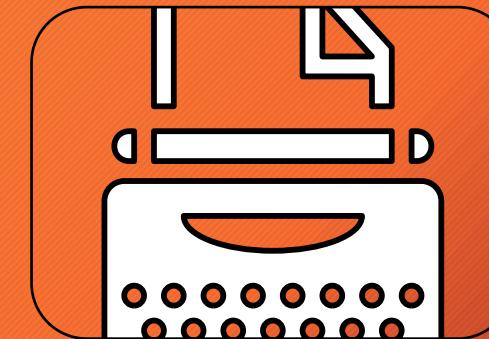
Workshops



Questionnaires



Surveys



Logbook

**Creating and managing courses and activities**

**Delivering and displaying activities and resources**

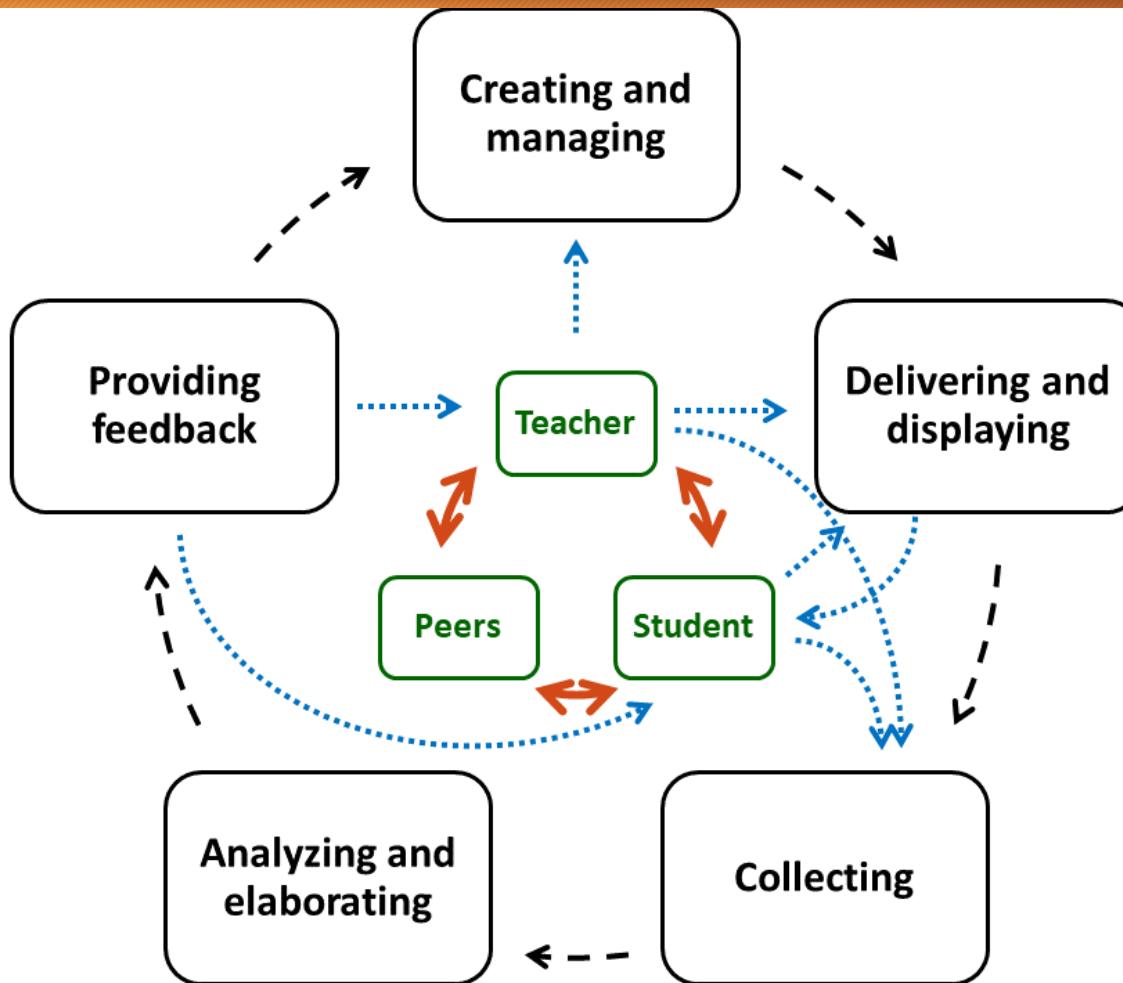
**Collecting qualitative and quantitative data**

**Analyzing and elaborating data and answers**

**Providing feedback to students and teachers**

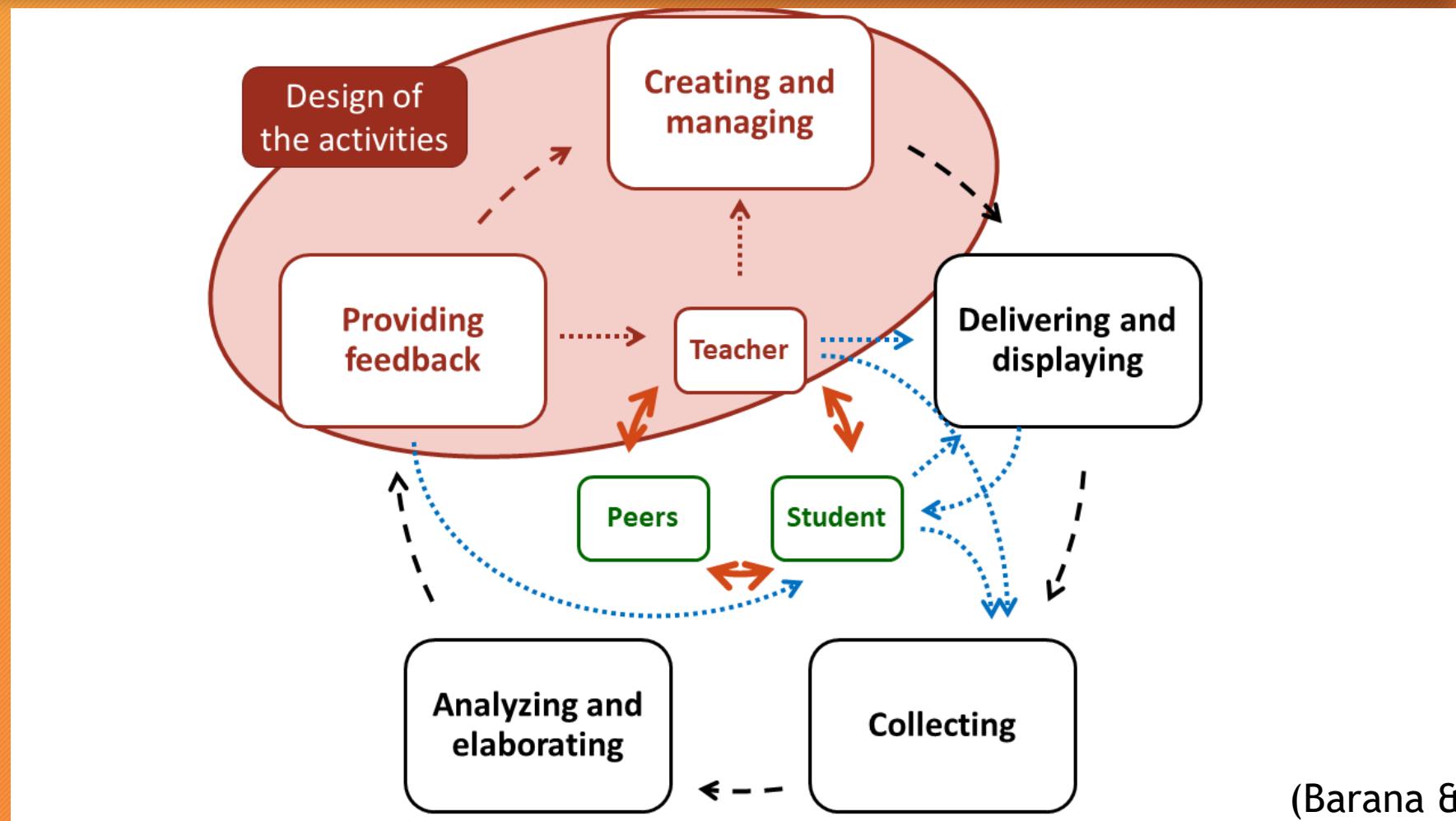
# Modelling interactions in a DLE

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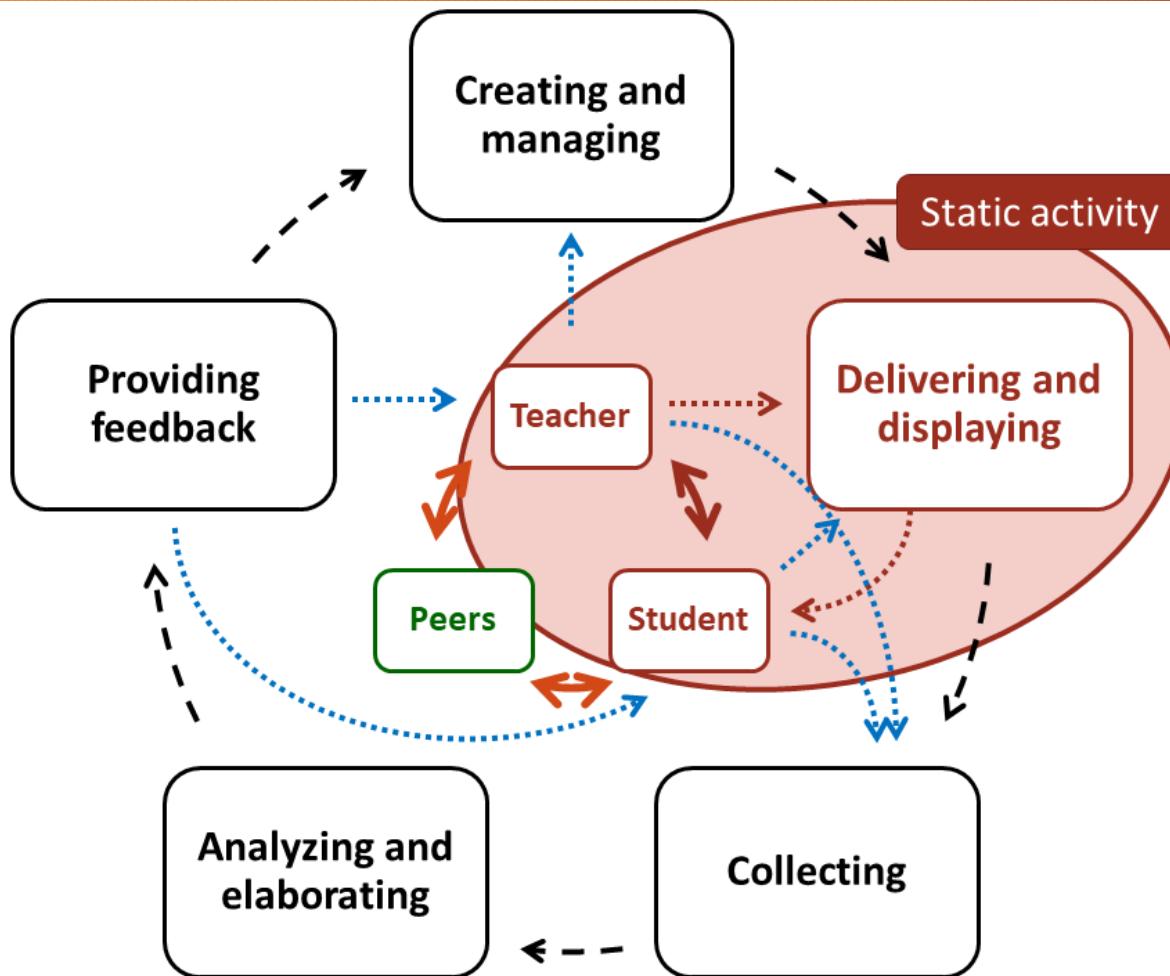
# Modelling interactions in a DLE

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# Modelling interactions in a DLE

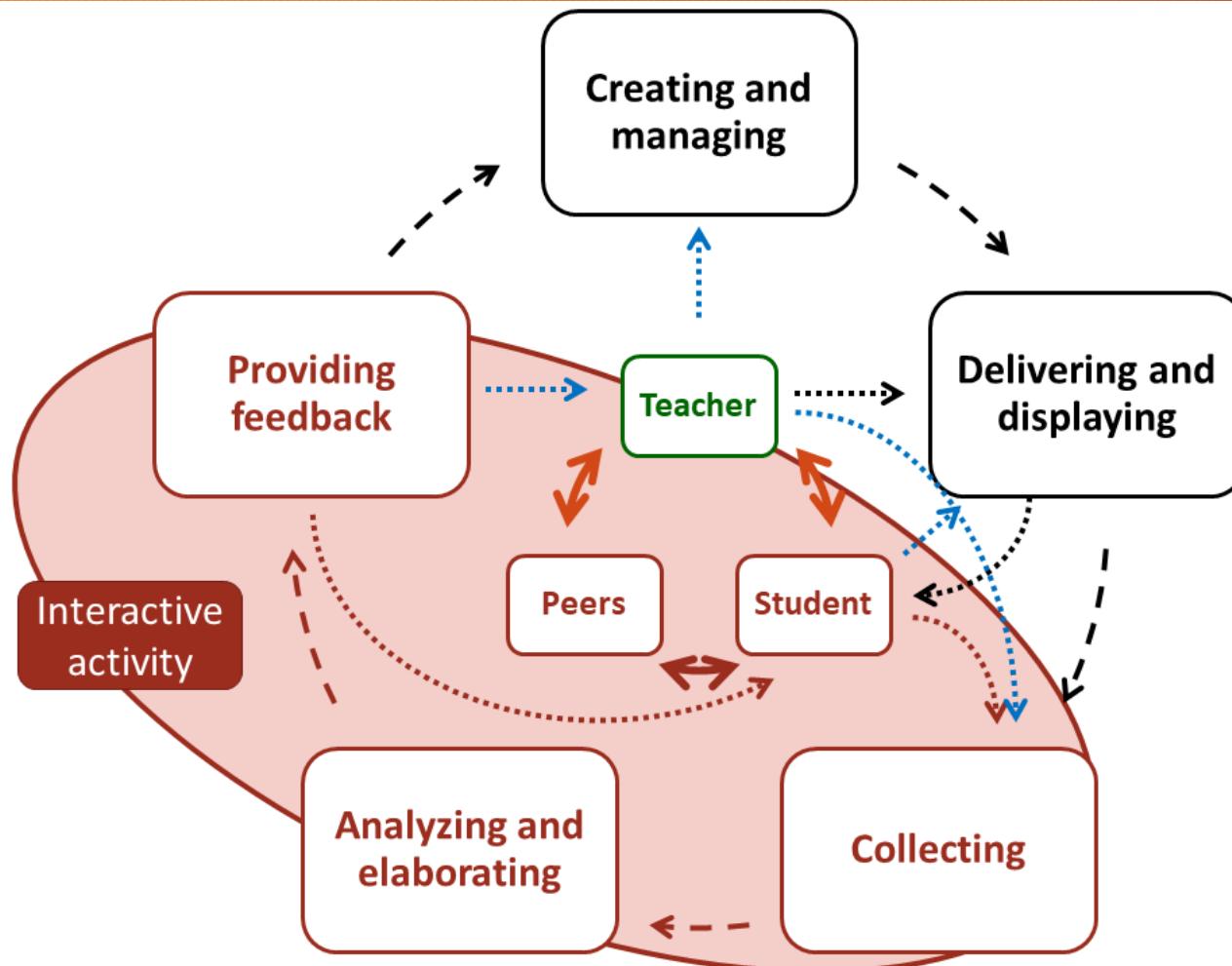
28



(Barana & Marchisio, 2022)

# Modelling interactions in a DLE

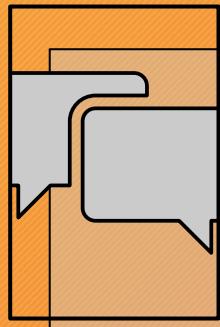
29



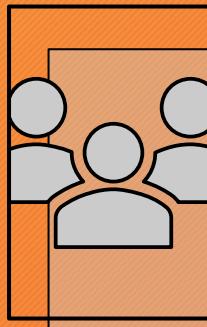
(Barana & Marchisio, 2022)

# Outcomes of an integrated DLE

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To Create an Interactive Learning Environment



To Support Collaborative Learning



To Promote Formative Assessment

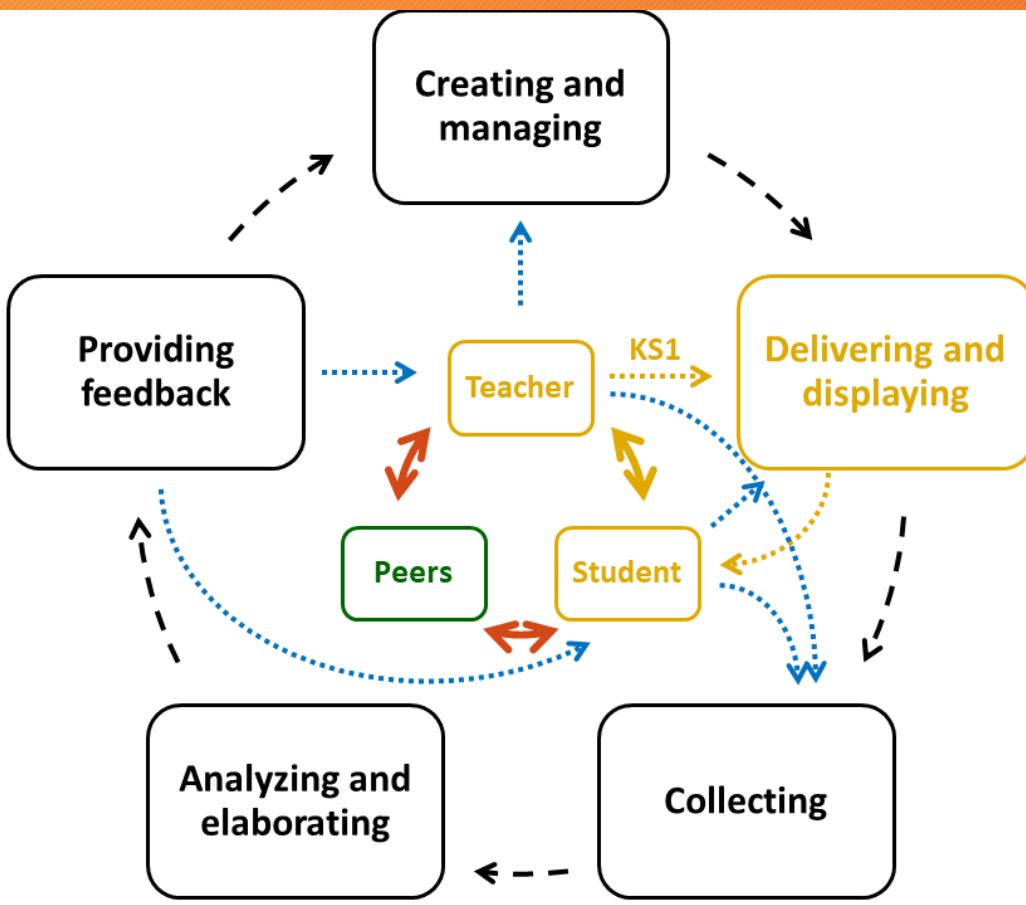
# Example

31



“Look at this figure. Write the formula which expresses how the area of this figure varies when  $a$  varies. That is, how long is this side?”

It's  $a$ .



## DLE:

- LEARNING COMMUNITY: teachers and students
- TECHNOLOGIES: IWB, computers, LMS integrated with an AAS for Mathematics
- INTERRELATIONSHIPS: formative assessment, classroom discussion

MODALITY: face-to-face

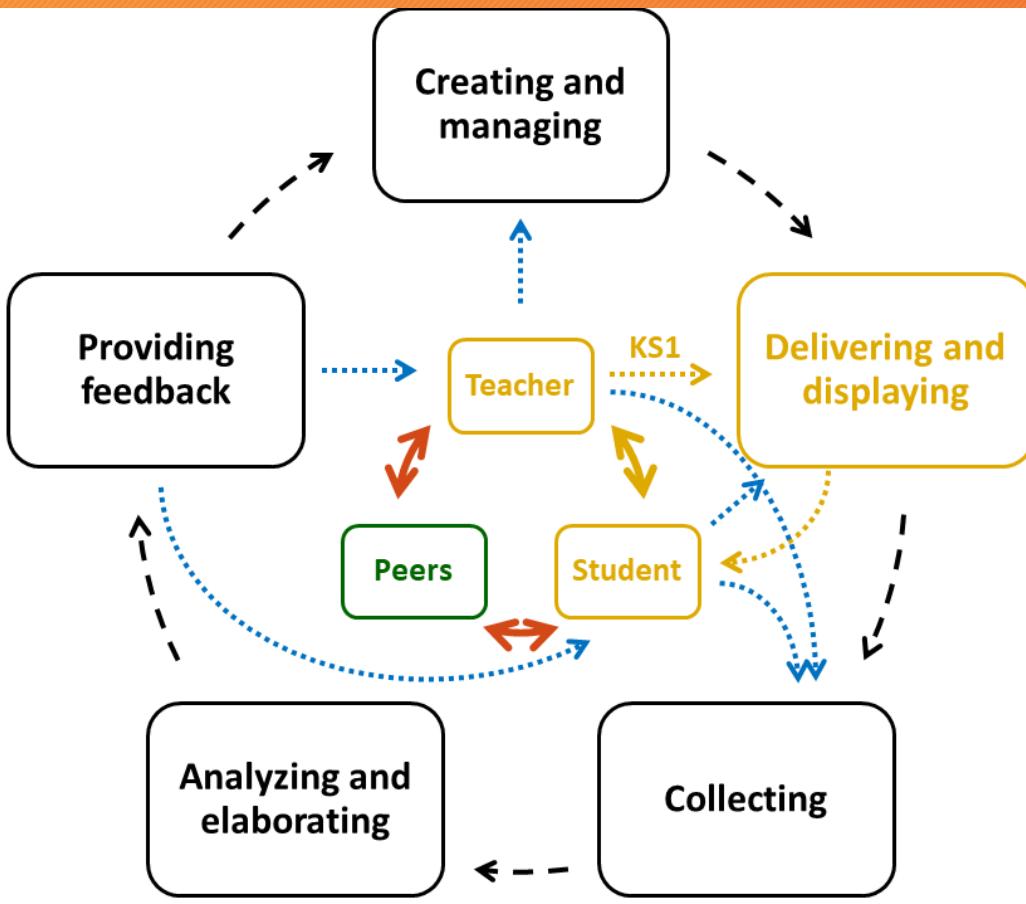
# Example

32



Well, you have to compute the area of this figure using  $a$ . Those sides measure  $a$ . What does it mean? What is  $a$ ?

A variable.



## DLE:

- LEARNING COMMUNITY: teachers and students
- TECHNOLOGIES: IWB, computers, LMS integrated with an AAS for Mathematics
- INTERRELATIONSHIPS: formative assessment, classroom discussion

MODALITY: face-to-face

# Example

33



We have to compute the area, but we don't have any data!

But we have  $a$ .

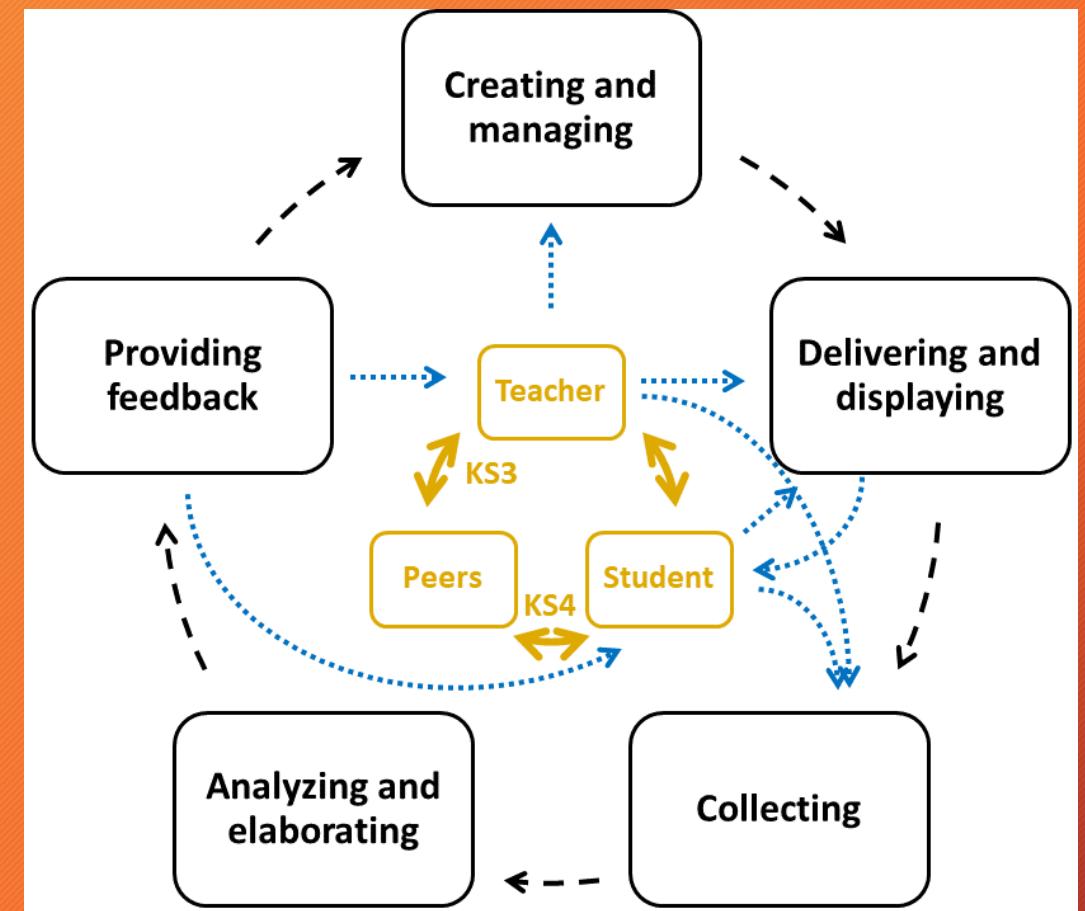
But  $a$  is not a number!

Ok, but we can compute the area using  $a$ .

Teacher, how can we compute the area without numbers? Can we use a?

Yes, it is like a generic number.

We have to write a formula using  $a$ , isn't it?

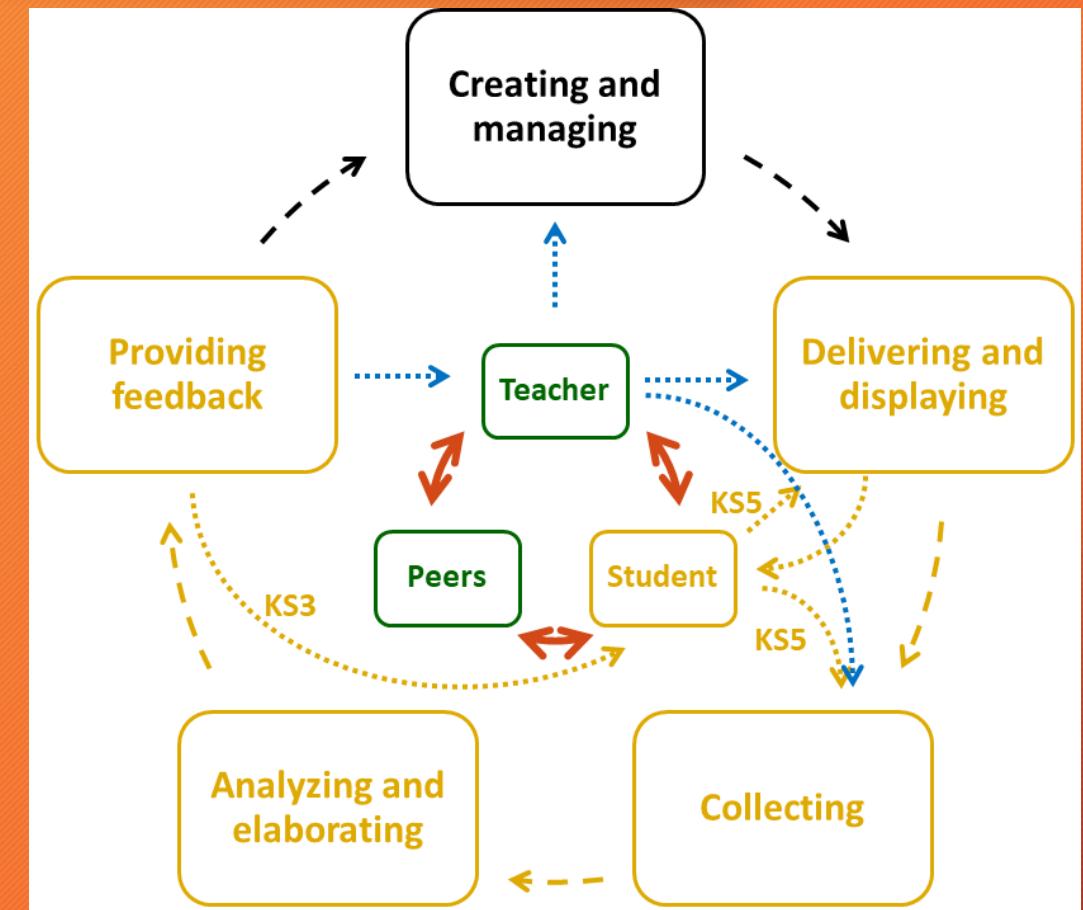


# Example

34



$$\text{Area} = ((a + a) \cdot (a + a)) - \sqrt{a^2 + a^2} \cdot \sqrt{a^2 + a^2}$$



# ACTIVITY - PART 1

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Think about a learning situation in a Digital Learning Environment that you experienced in your career. Try to model the DLE and the interactions occurring through the given framework.

## COMPONENTS:

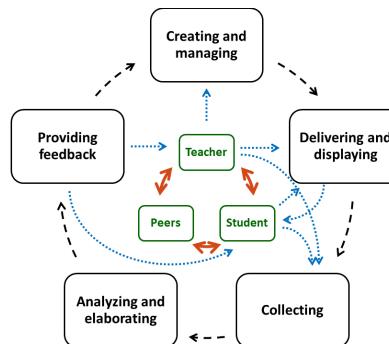
- ✓ Learning community: \_\_\_\_\_
- ✓ Technologies: \_\_\_\_\_
- ✓ Methodologies/interactions: \_\_\_\_\_

MODALITY (face-to-face, blended, online, hybrid): \_\_\_\_\_

## DIAGRAM OF THE INTERACTIONS:

### WHAT OUTCOMES HAVE BEEN ACCOMPLISHED?

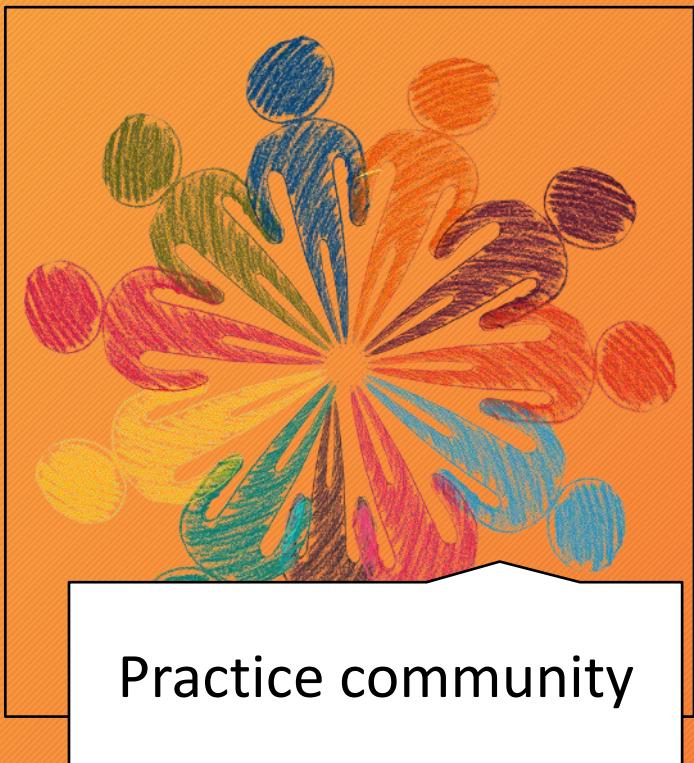
- To Create an Interactive Learning Environment
- To Support Collaborative Learning
- To Promote Formative Assessment



# Advantages of using a DLE

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For teachers...



Practice community



Adaptive teaching

Vogliamo rappresentare sul piano cartesiano la retta di equazione  $y = \frac{1}{2}x$ . Cominciamo con trovare **due** punti per cui passa la retta. Due punti infatti sono sufficienti per identificare la retta.

Clicca su **Verify** per proseguire e disegnare la retta.

Ora disegna la retta nel seguente piano cartesiano. Per tracciare la retta clicca su due punti del piano. Poi

A screenshot of a digital math worksheet. It shows a Cartesian coordinate system with x and y axes ranging from -10 to 10. A blue line is drawn through the points (0,0) and (2,1). To the left of the graph, there is a table with two rows:

x	y
0	0
2	1

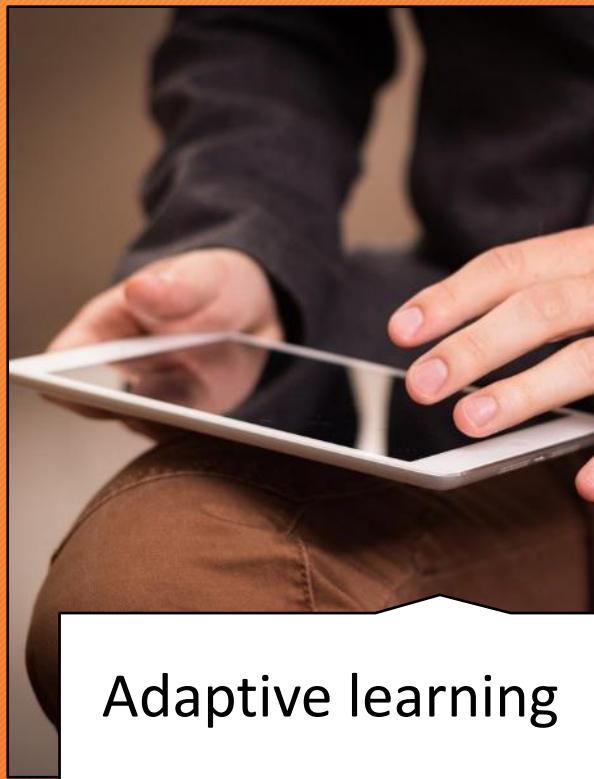
The word "Poi" is partially visible at the bottom right of the worksheet area.

Automatic formative assessment

# Advantages of using a DLE

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For learners...



Frazioni

- Domanda 1

Una sola delle seguenti affermazioni è vera. Quale?

- Aggiungendo uno stesso numero ai due termini
- Sottraendo uno stesso numero ai due termini
- Moltiplicando o dividendo per due numeri diversi
- Moltiplicando o dividendo per uno stesso numero

Risposta corretta:

Moltiplicando o dividendo per uno stesso numero

Associa ad ogni frazione quella ad essa equivalente

1.  $\frac{33}{429}$    2.  $\frac{1}{2}$    3.  $\frac{9}{4}$    4.  $\frac{15}{72}$

1.  $\frac{66}{132}$

2.  $\frac{1}{13}$

3.  $\frac{21}{21}$

Automatic and interactive feedback

# Theoretical frameworks to build DLEs

# Different terms, different concepts

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Emergency  
education

Distance  
education

Online/digital  
education

# 4 “A” in education

## Human Rights Obligations in Education

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✓ Acceptability

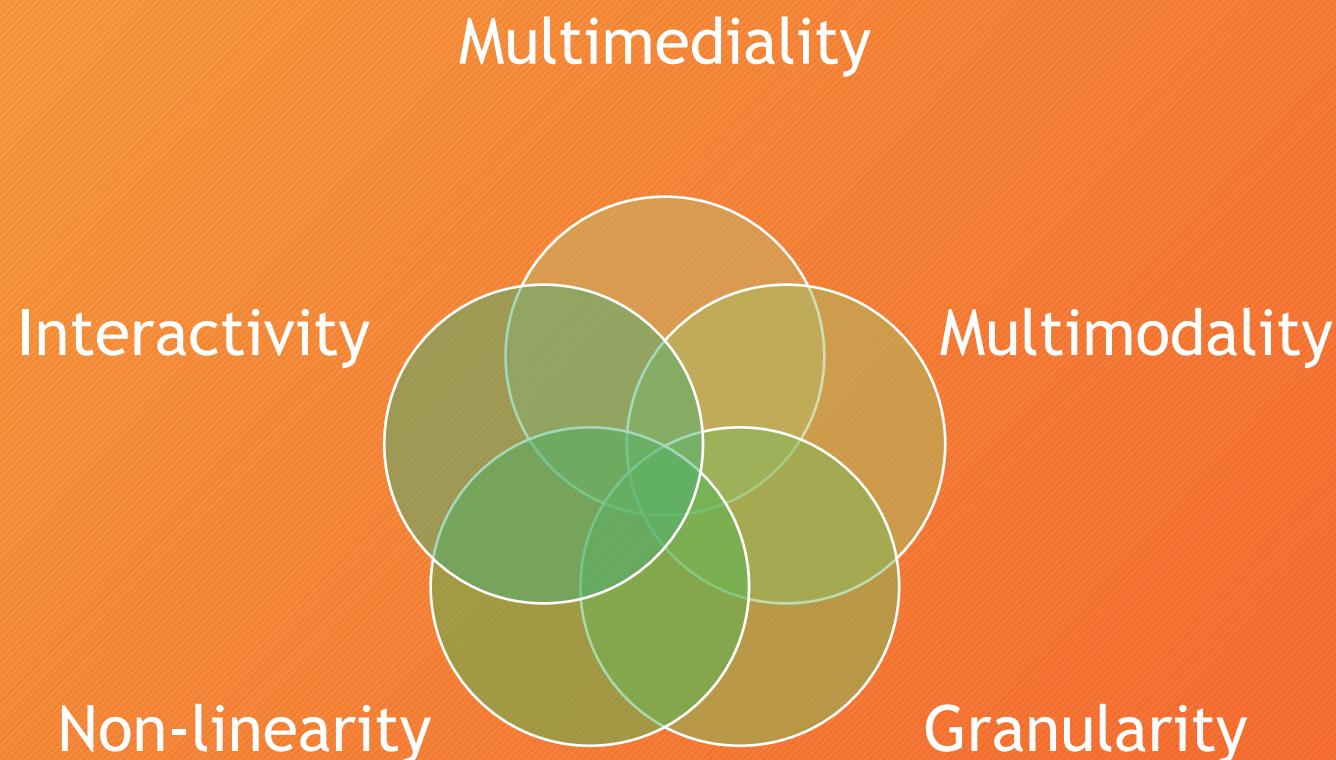
 Accessibility



Adaptability

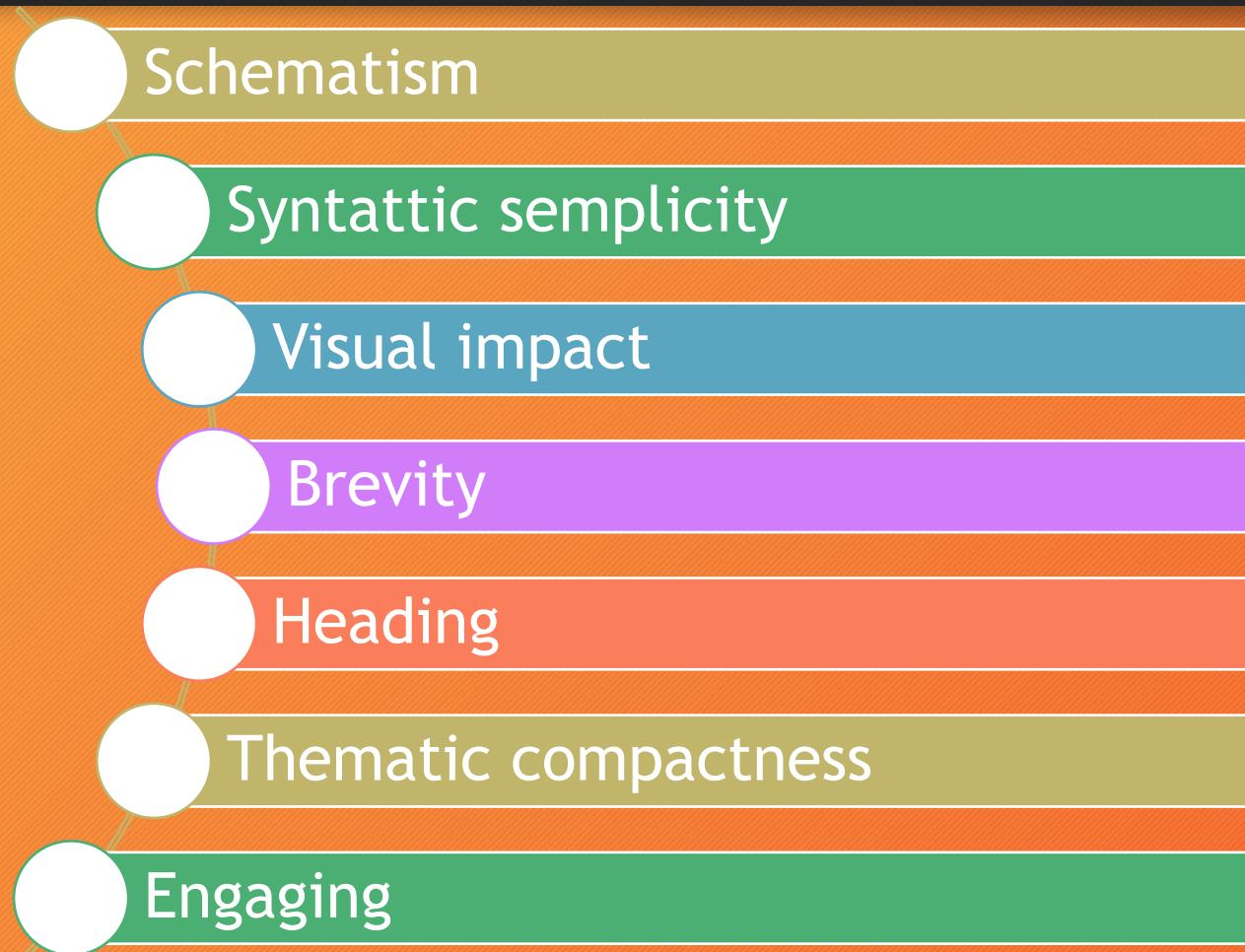


Availability



# Characteristics of online resources

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*Learning is a lifelong active process of knowledge building mediated by experiences and relations with the environment and the community*

(von Glaserfeld, 1989)



Technology can support the creation of constructivist digital environments through

- computer mediated communication
- computer supported collaborative work
- case based learning environments
- computer supported cognitive tools

(Jonassen, et al., 1995)



# Example: the Digital Math Training Project

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Challenging real-world math problem

Forum to discuss about how to solve  
the problem

Submission of students' solutions

Self-assessment questionnaire

Interactive solution

## Nono problema

Accesso consentito dal 5 marzo 2017



Il Prodotto Interno Lordo Italiano



Discussioni sul problema "Il Prodotto Interno Lordo Italiano"

Utilizza questo forum per confrontarti con i compagni sulla  
soluzione sul problema "Il Prodotto Interno Lordo Italiano"



Consegna il problema "Il Prodotto Interno Lordo Italiano"



Autovalutati! - Il Prodotto Interno Lordo Italiano



Il Prodotto Interno Lordo Italiano - Soluzione proposta



Accesso consentito dal 15 marzo 2017



Il PIL Italiano - migliore soluzione consegnata



# Example: the Digital Math Training Project

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Case-based learning environment

Computer supported collaborative work  
Computer mediated communication

Case-based learning environment

Computer supported cognitive tools

Computer supported cognitive tools

## Nono problema

Accesso consentito dal 5 marzo 2017



Il Prodotto Interno Lordo Italiano



Discussioni sul problema "Il Prodotto Interno Lordo Italiano"



Utilizza questo forum per confrontarti con i compagni sulla soluzione sul problema "Il Prodotto Interno Lordo Italiano"



Consegna il problema "Il Prodotto Interno Lordo Italiano"



Autovalutati! - Il Prodotto Interno Lordo Italiano



Il Prodotto Interno Lordo Italiano - Soluzione proposta



Accesso consentito dal 15 marzo 2017



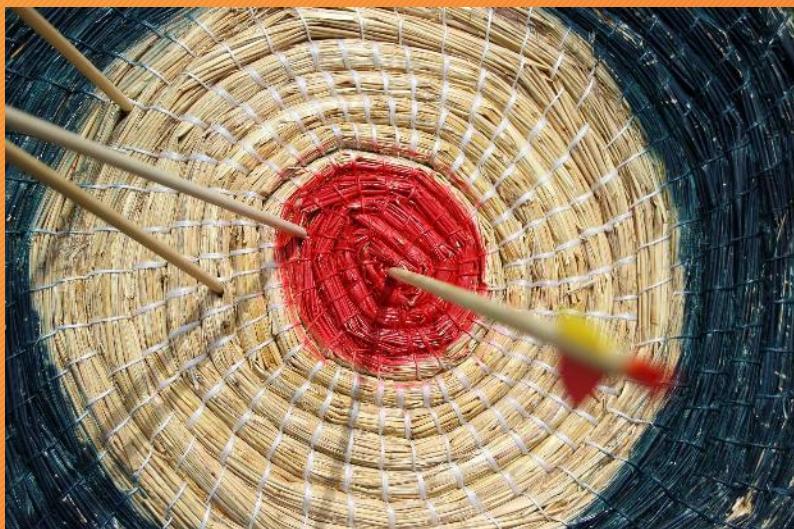
Il PIL Italiano - migliore soluzione consegnata



# Constructivist DLEs

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7 goals for building learning environments  
(Honebein, 1996)



- to provide experience with the **knowledge construction process**
- to provide experience in and appreciation of **multiple perspectives**
- to embed learning in **realistic and relevant contexts**
- to encourage **ownership and voice** in the learning process
- to embed learning in **social experience**
- to encourage the use of **multiple modes of representation**
- to encourage **self-awareness** in the knowledge construction process

# Constructivist DLEs

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to provide experience with the  
**knowledge construction** process

to provide experience in and  
appreciation of **multiple perspectives**

to embed learning in **realistic and  
relevant contexts**

to encourage **ownership and voice** in  
the learning process

to embed learning in **social  
experience**

to encourage the use of **multiple  
modes of representation**

to encourage **self-awareness** in the  
knowledge construction process

Problem Solving  
Interactive activities

Explorations  
Interactive feedback

Real-world problems

Interactive activities  
Automatic assessment

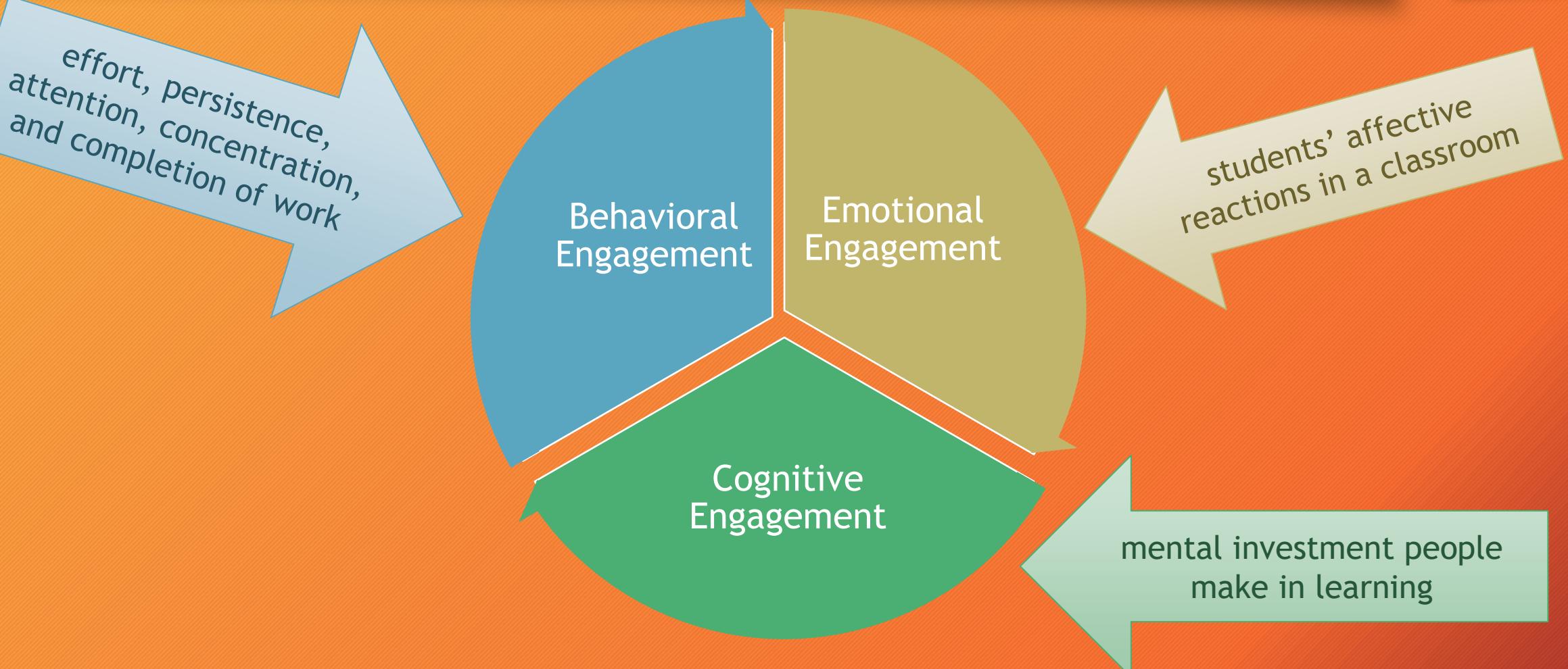
Classroom activities  
Forum discussions

Explorations  
Algorithmic questions

Immediate feedback  
Self-assessment

# Engagement

49



# Engagement

50



Interactive technologies | Low socio-economic status

# Approaches to foster equity in Mathematics

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- teaching mathematics through more **open-ended, collaborative, problem-solving** approaches, with students in mixed-ability groups (Boaler, 2008)
- classrooms need to be places where students have the **opportunities to change their current situation**, that is, covering their next step in their learning path (Heritage and Wylie, 2018)
- **metacognitive reflection** helps develop a strong sense of personal agency and identity as competent and confident doers of mathematics (Heritage and Wylie, 2018)
- **peer collaboration** and working in small groups during Mathematics classes were effective for addressing and overcoming language difficulties (Elbers and de Haan, 2005)
- Using **computers** (Nortvedt & Buchholtz, 2018)

# Approaches to foster equity in Mathematics

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1. employing collaborative, discursive, **problem-solving**, and problem-posing pedagogies, which promote the engagement of learners with Mathematics;
2. recognizing and drawing upon learners' **real-life experiences** to emphasize the cultural relevance of Mathematics;
3. promoting mathematical **inquiries** that enable learners to develop greater understanding of their social, cultural, political, and economic situations;
4. facilitating mathematical investigations that develop learners' **agency**, enabling them to take part in social action and realize their foregrounds; and
5. developing a **critical understanding** of the nature of Mathematics and its position and status within education and society to maintain equity in the classroom.

(Wright, 2016)

# ACTIVITY - PART 2

53

Start from the DLE you considered in the previous activity.

How could you change it in order to achieve Honebein's 7 goals for building learning environments?

You can add or change activities, elements, modalities, etc.

1. to provide experience with the knowledge construction process	
2. to provide experience in and appreciation of multiple perspectives	
3. to embed learning in realistic and relevant contexts	
4. to encourage ownership and voice in the learning process	
5. to embed learning in social experience	
6. to encourage the use of multiple modes of representation	
7. to encourage self-awareness in the knowledge construction process	

# *Thank you for the attention!*

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