



UNIVERSITÀ  
DI TORINO



DBMSS

Dipartimento di Biotecnologie  
Molecolari e Scienze per la Salute

# Integrated Digital Learning Environments: theoretical frameworks and applications

## Marina Marchisio

Università degli Studi di Torino

With the patronage of



THE LMS-MARM PROGRAM  
PRESENTS

# NAISSMA 2022

# 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

4

*A place where learning is fostered and supported.*

(Wilson, 1995)



# Learning Environment

5

What elements should be included?

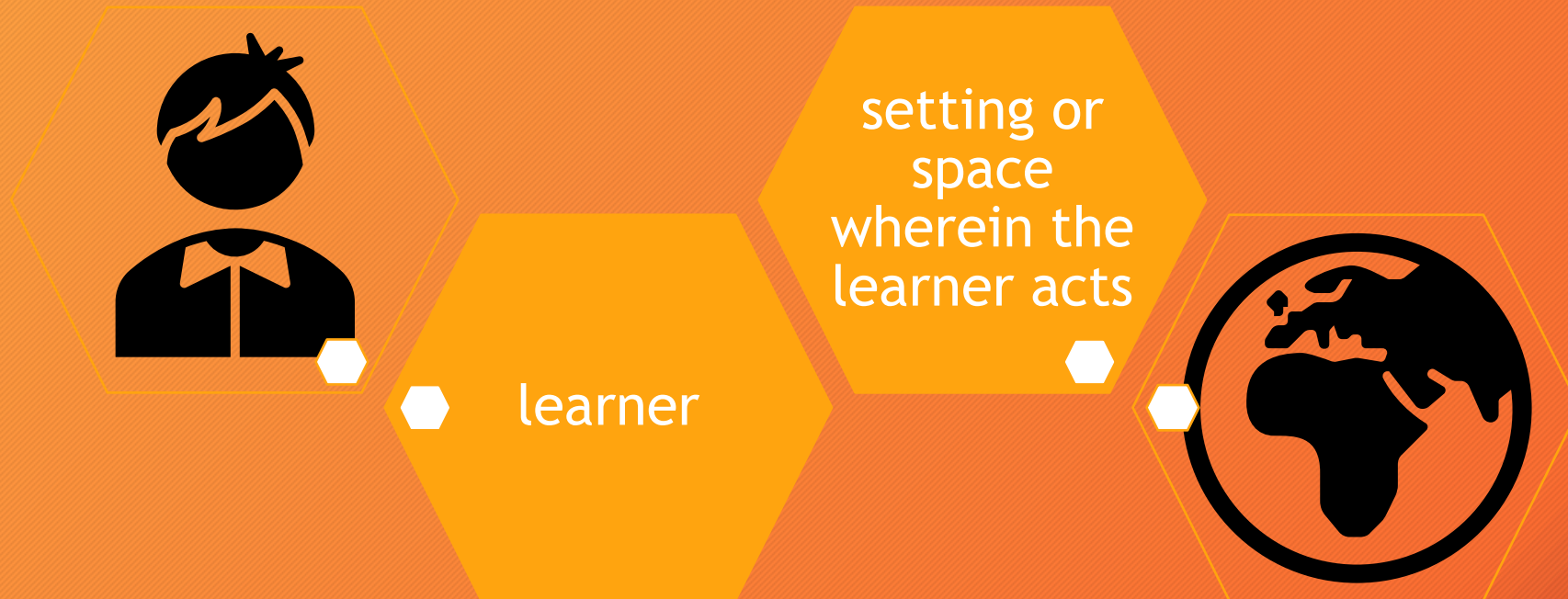




# Learning Environment

6

It includes at least two elements:



# Ecosystem

7



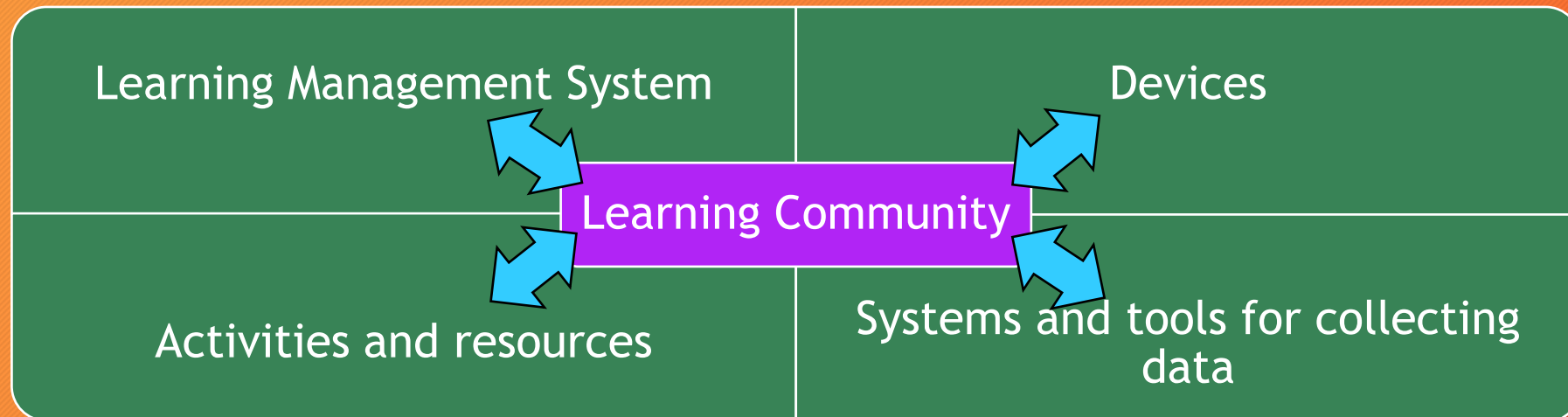
*A complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space.*

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**.*



(Barana & Marchisio, 2021)



# Components of a DLE

9



## 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:

Risposta corretta:  $3c^2$

Clicca su Verify per controllare la tua risposta e proseguire.

A diagram of an L-shaped polygon. The top horizontal side is labeled  $c$ . The left vertical side is labeled  $2c$ . The bottom horizontal side is labeled  $2c$ . The right vertical side is labeled  $c$ . The shape is composed of a square with side length  $c$  on top, and a rectangle with width  $c$  and height  $c$  attached to the right side of the square.

## Interrelationships (methodologies, interactions...)

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

# Components of a DLE

10

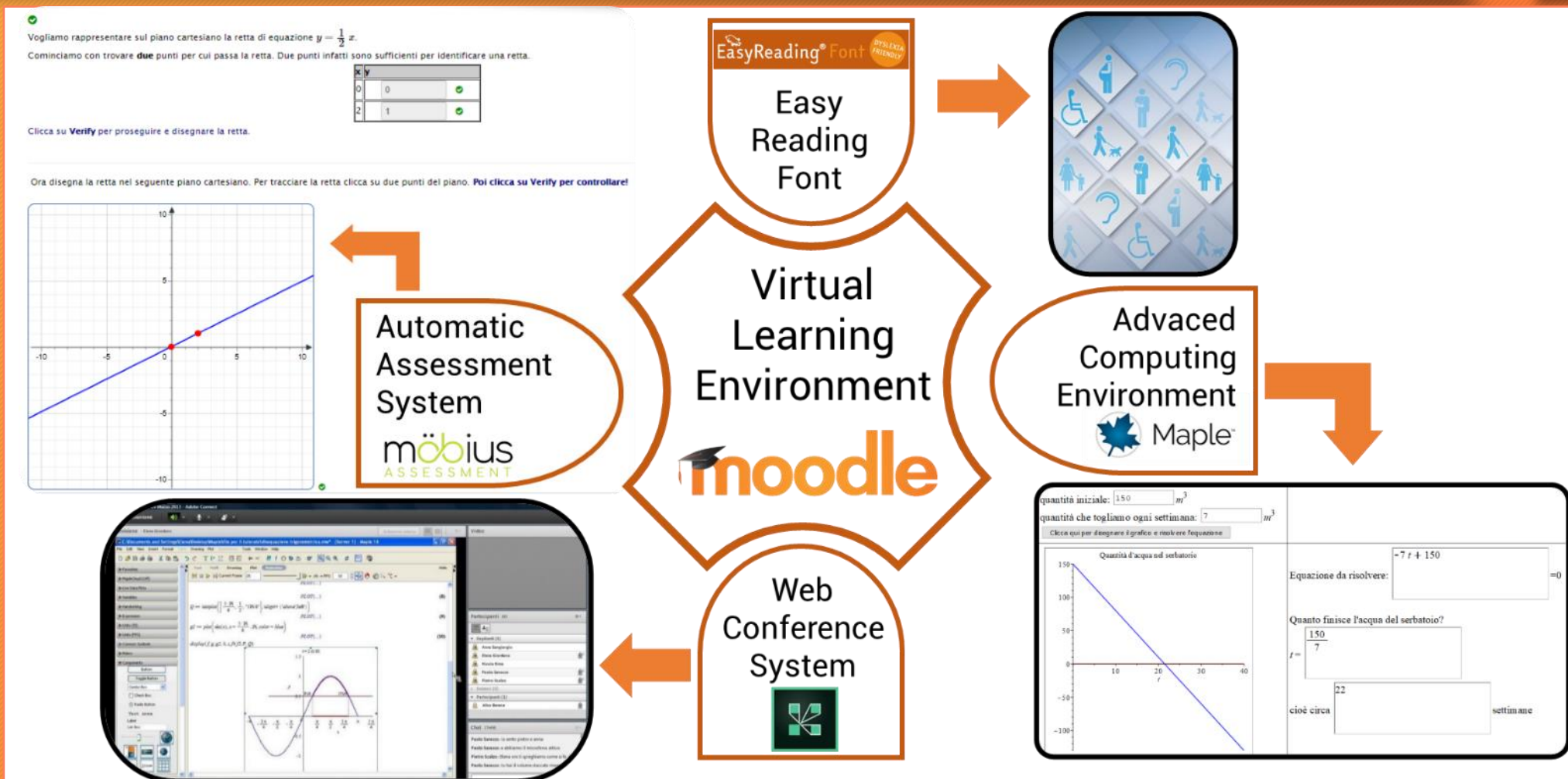




# Integrated Digital Learning Environment

# Technological components of a DLE for Mathematics

12





# Virtual Learning Environment

13



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

14

The screenshot displays a web conference interface. At the top, there's a header with the name 'Riunione' and a 'Condividi' button. Below this, a window titled 'MapleCloud (Off)' is open, showing a math application. The application's main text reads: 'Inserisci il numero di persone nel pubblico e nella giuria e muovi gli slider per vedere come varia il risultato!'. It features two input fields: 'Pubblico in studio: 100 persone' and 'Giuria di esperti: 90 persone'. Below these are two sliders for 'Percentuale di voti del pubblico del primo concorrente' (set at 35%) and 'Percentuale di voti della giuria del secondo concorrente' (set at 65%). The results are shown as: 'Voti totali primo concorrente: 49' (35%) and 'Voti totali secondo concorrente: 91' (65%). A pie chart below the results is divided into two segments: a yellow segment labeled 'Concorrente 1' and a blue segment labeled 'Concorrente 2'. To the right of the application window, there's a 'Video' section with a 'Condivisione schermo' button and a 'Schermo intero' button. Below that is a 'Partecipanti (2)' list showing 'Relatori attivi' (0), 'Ospitanti (1)' (Cecilia), and 'Partecipanti (1)' (Francesco). At the bottom right, there's a 'Chat (Tutti)' window with messages from Rosalba, Alice, Marinella, and Sara.

Condividi - Cecilia Fissore

Video

Condivisione schermo  
Per una condivisione dello schermo più efficace, passate alla modalità Schermo intero

Partecipanti (2)

Relatori attivi

Ospitanti (1)  
Cecilia

Relatori (0)

Partecipanti (1)  
Francesco

Chat (Tutti)

Rosalba : grazie

Alice : a voi, buon proseguimento!

Marinella : ciao

Sara : ciao!

Tutti



# Advanced Computing Environment (ACE)

15

System which allows to embed in a single worksheet:

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

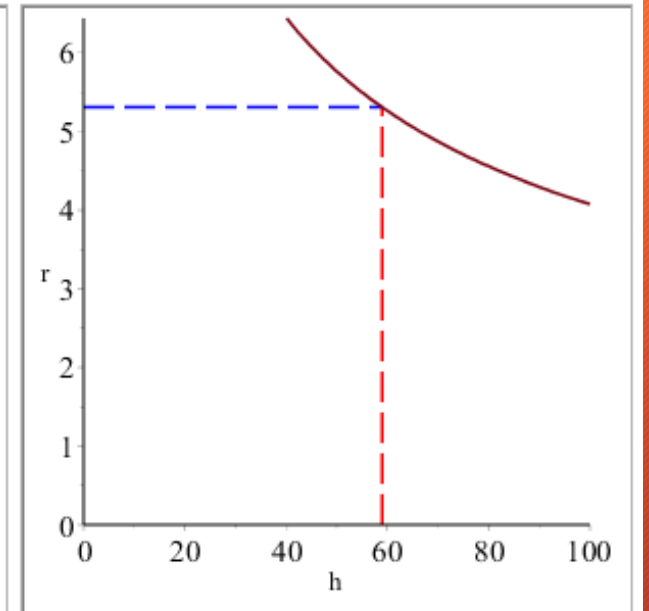
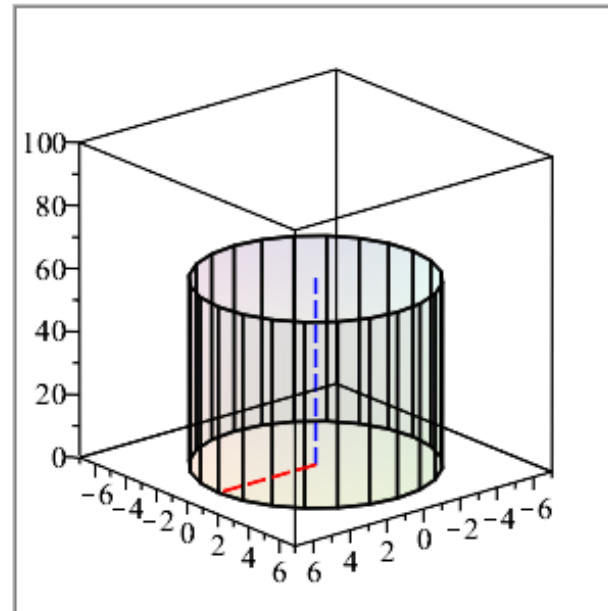


FLEXIBLE TOOL FOR STEM

Observe how the form of the cylinder of given volume changes depending on its height.

$h =$

$$r = \sqrt{\left(\frac{5225}{\pi 59}\right)}$$



# Advanced Computing Environment (ACE)

16

## ACTIVE USE of the ACE

- Students actively use the ACE to solve problems

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

## INTERACTIVE USE of the ACE

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


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



# Automatic Assessment System

17

**Question 3: Score 1/1**  
Question type: Mathematical Formula


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

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	Correct response
Trova lo zero della funzione	Trova lo zero della funzione
$f(x) = \frac{\ln(x-1)}{x}$ X = <input type="text" value="0"/> (0%)	$f(x) = \frac{\ln(x-1)}{x}$ X = <input type="text" value="2"/>  Incorrect

Total grade: 0.0x1/1 = 0%  
Comment:

---

**Question 5: Score 1/1**  
Question type: Maple-Graded  Correct

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:


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

k=

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

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

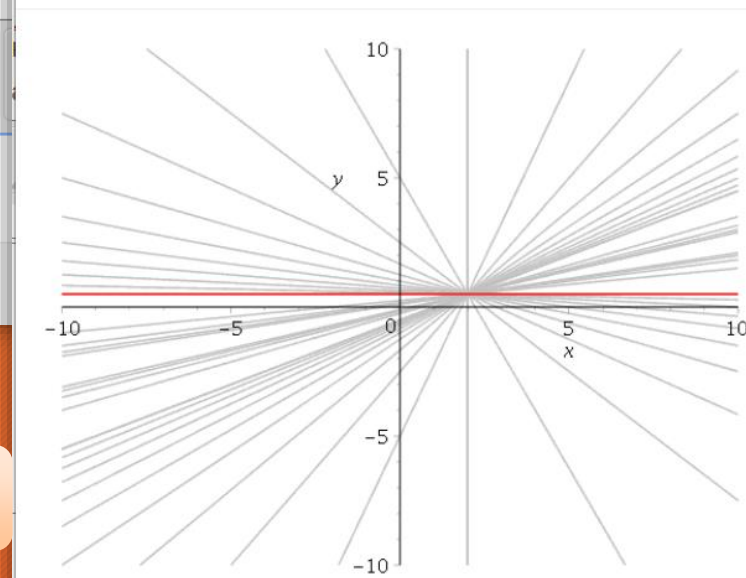
$y = \frac{1}{2}$

Grade

Refresh

Close

Preview



Close

Adaptivity


Immediate feedback

Algorithm based questions

Open Math answers

# 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:**  $b/a)^n$   
Use the symbol / to write a fraction. E.g.: a/b

---

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

**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

19

- ✓ 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	<input type="text" value="156"/> ✓
2	<input type="text" value="152"/> ✓
3	<input type="text" value="148"/> ✓
4	<input type="text" value="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.

$n(t) =$   ✓

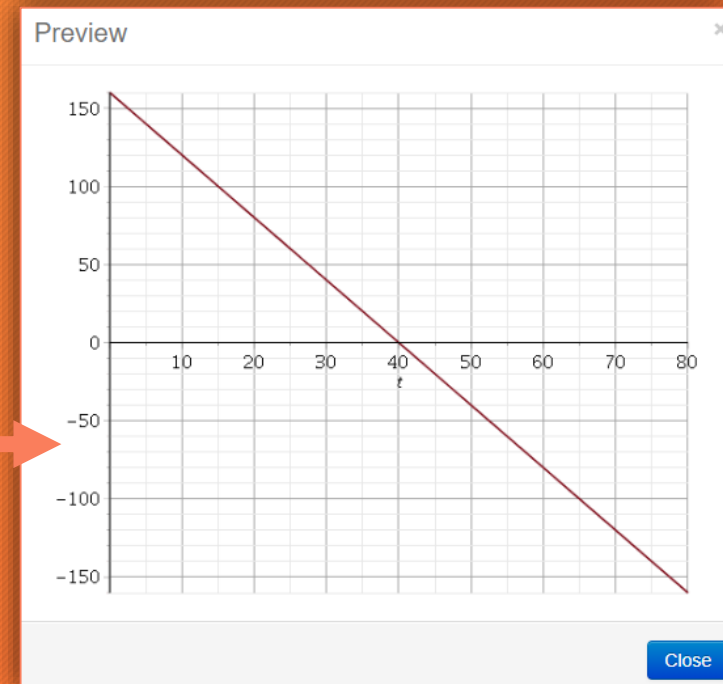
Correct response:  $160-4*t$

After how many weeks will the tank be empty?

✓

Multiple representations

Real-world problems



# Integrated virtual learning environment

20

Modular structure

The screenshot shows a learning path for 'Module 1' with the following items and their completion status (checkboxes):

- Module 1: In this module you can review the main concepts about fractions and operations with fractions (checked)
- 1.1 Fractions (checked)
  - EXPLORE equivalent fractions (checked)
  - TEST: verify to have learnt the main concepts about fractions (checked)
- 1.2 Operations with fractions (checked)
  - COMPARE fractions and decimal numbers generated by fractions (unchecked)
  - TEST: some operations with fractions (checked)
  - TEST: verify to have learnt the main concepts on operations with fractions (checked)
- Solve the problem! (unchecked)
- FINAL TEST ON FRACTIONS (checked)

Review of the theory

Explorative interactive activities

Automatic assessment

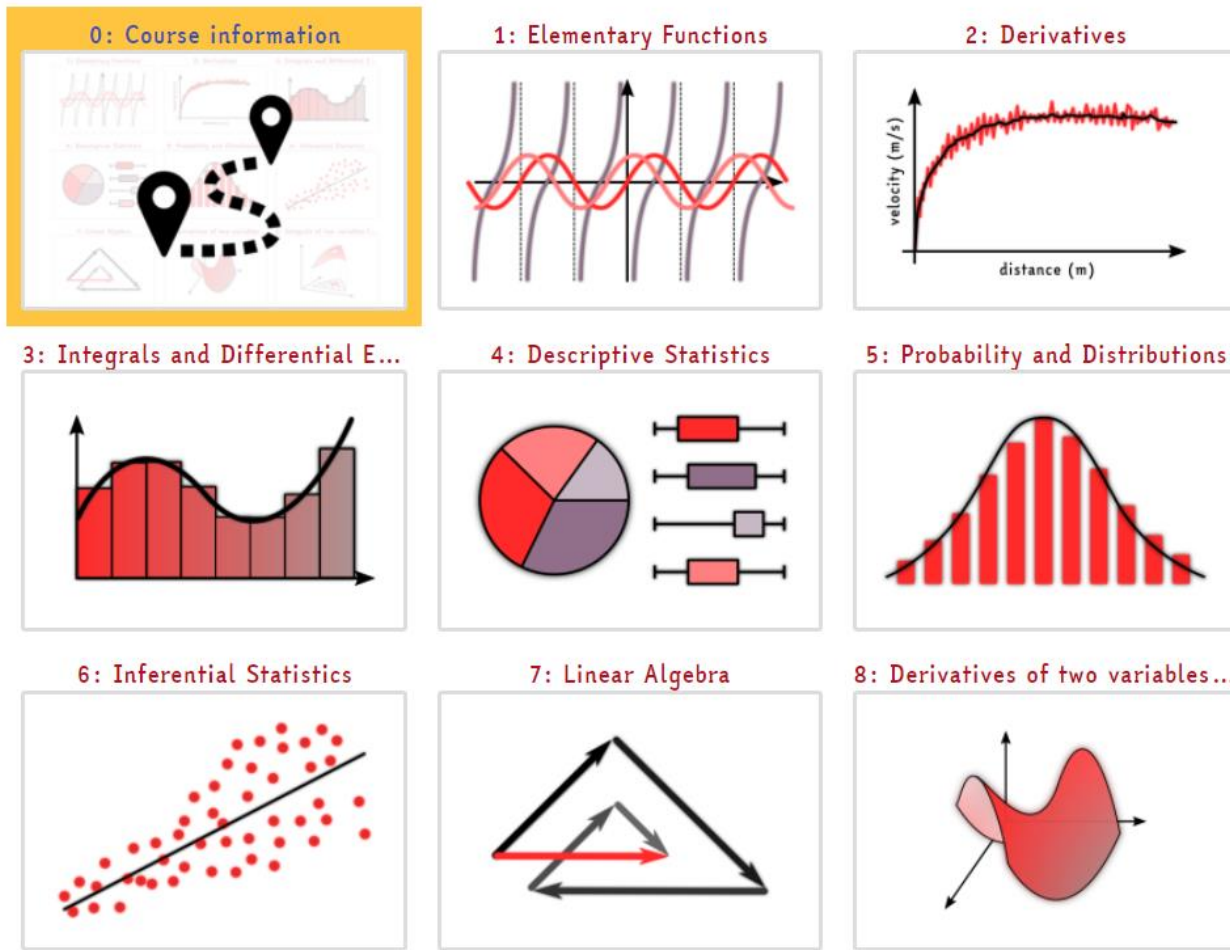
Final tests

Problem Solving



# Integrated virtual learning environment

21



## ACTIVITIES

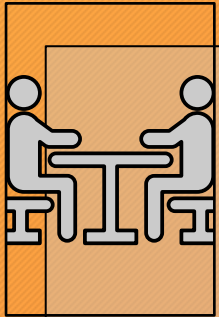
- Interactive files
- Quiz
- Forum
- Glossary
- Submission of assignments
- Online meeting
- ...

## RESOURCES

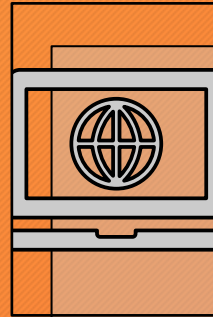
- Static pages
- Pdf files
- Videos
- Podcast
- Url
- ...

# Teaching and learning modalities in a DLE

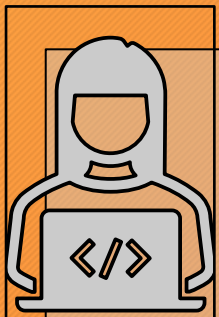
22



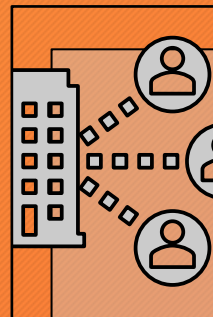
Face-to-face



Online



Blended



Hybrid



# Time of the activities in a DLE

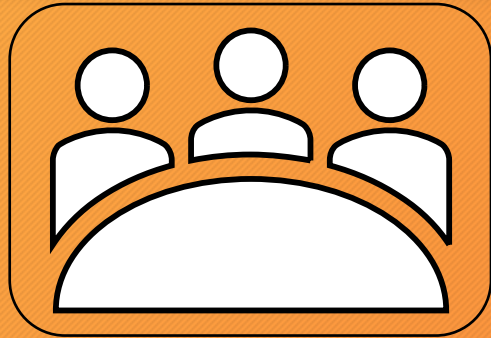
23

Synchronous

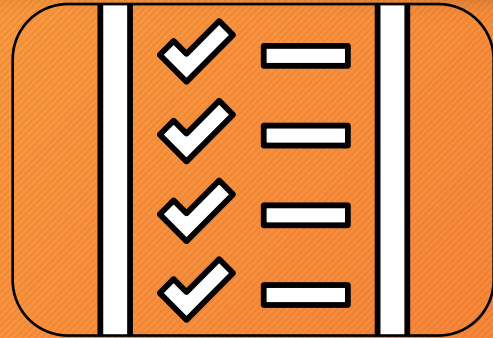
Asynchronous

# Asynchronous activities

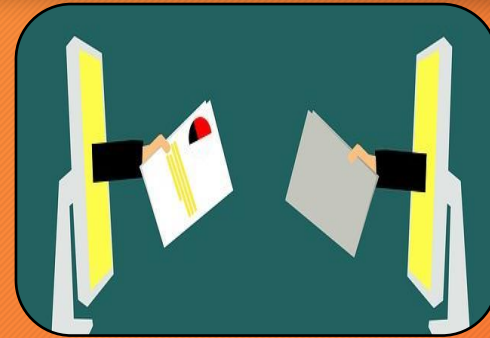
24



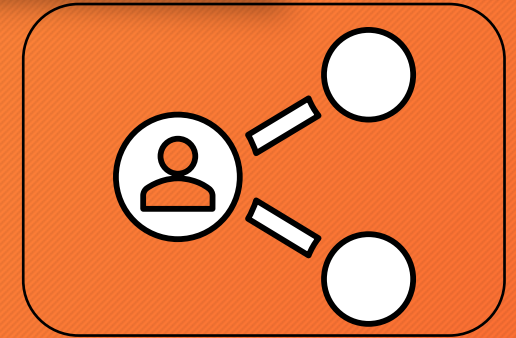
Discussions



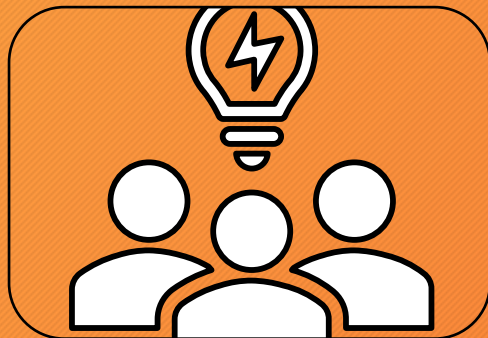
Automatic assessed tests



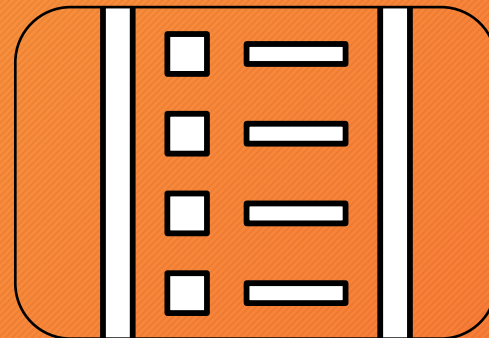
Submission of assignments



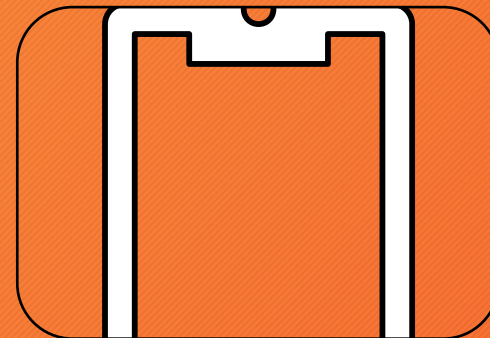
Shared materials



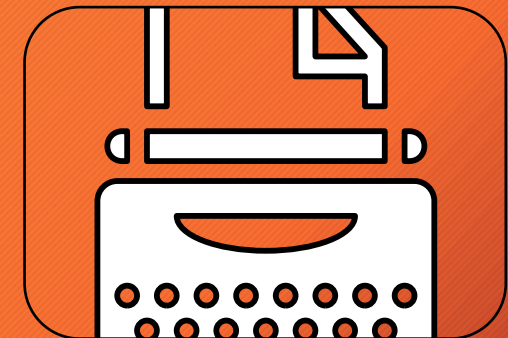
Workshops



Questionnaires



Surveys



Logbook

# Functions of a DLE

25

**Creating and managing courses and activities**

**Delivering and displaying activities and resources**

**Collecting qualitative and quantitative data**

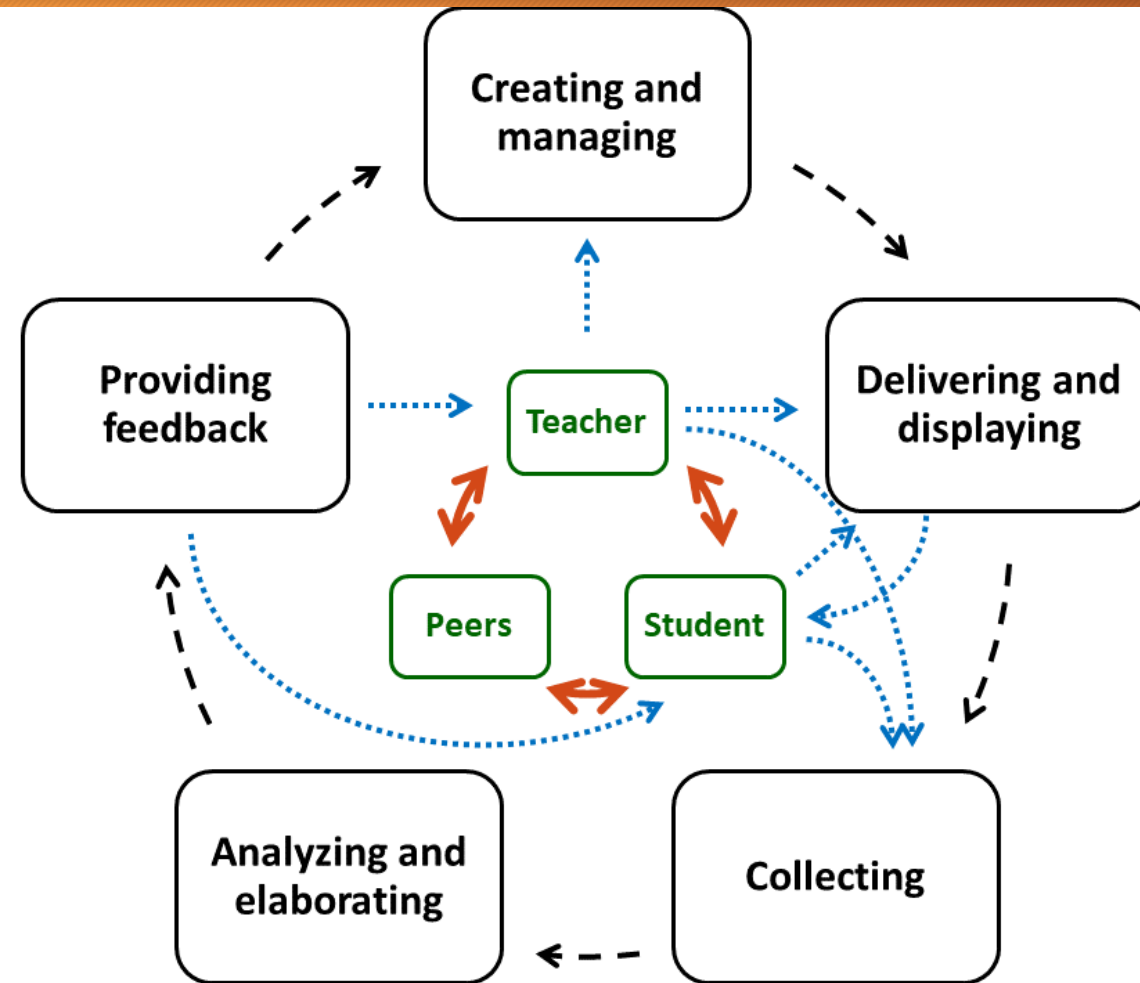
**Analyzing and elaborating data and answers**

**Providing feedback to students and teachers**



# Modelling interactions in a DLE

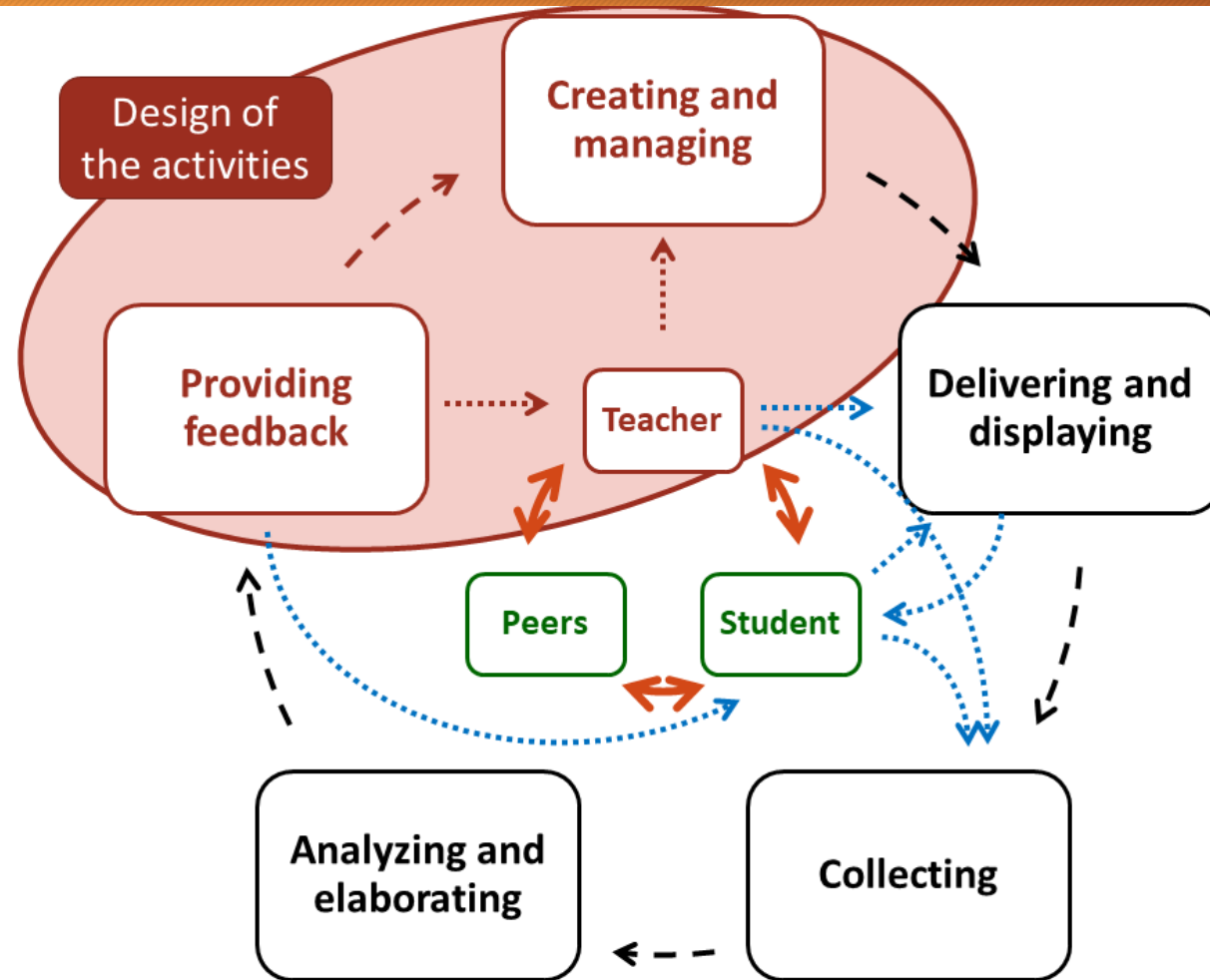
26



(Barana & Marchisio, 2021)

# Modelling interactions in a DLE

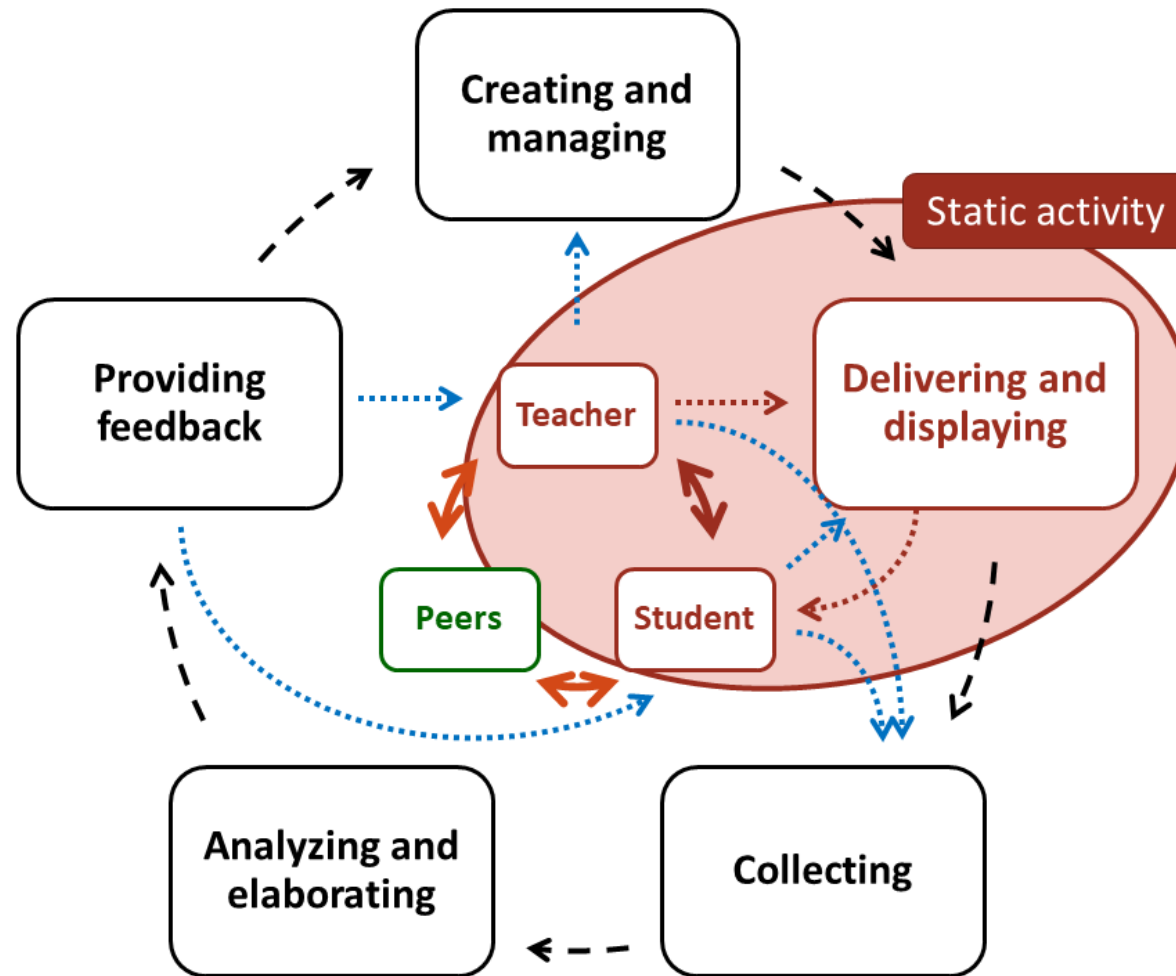
27



(Barana & Marchisio, 2022)

# Modelling interactions in a DLE

28

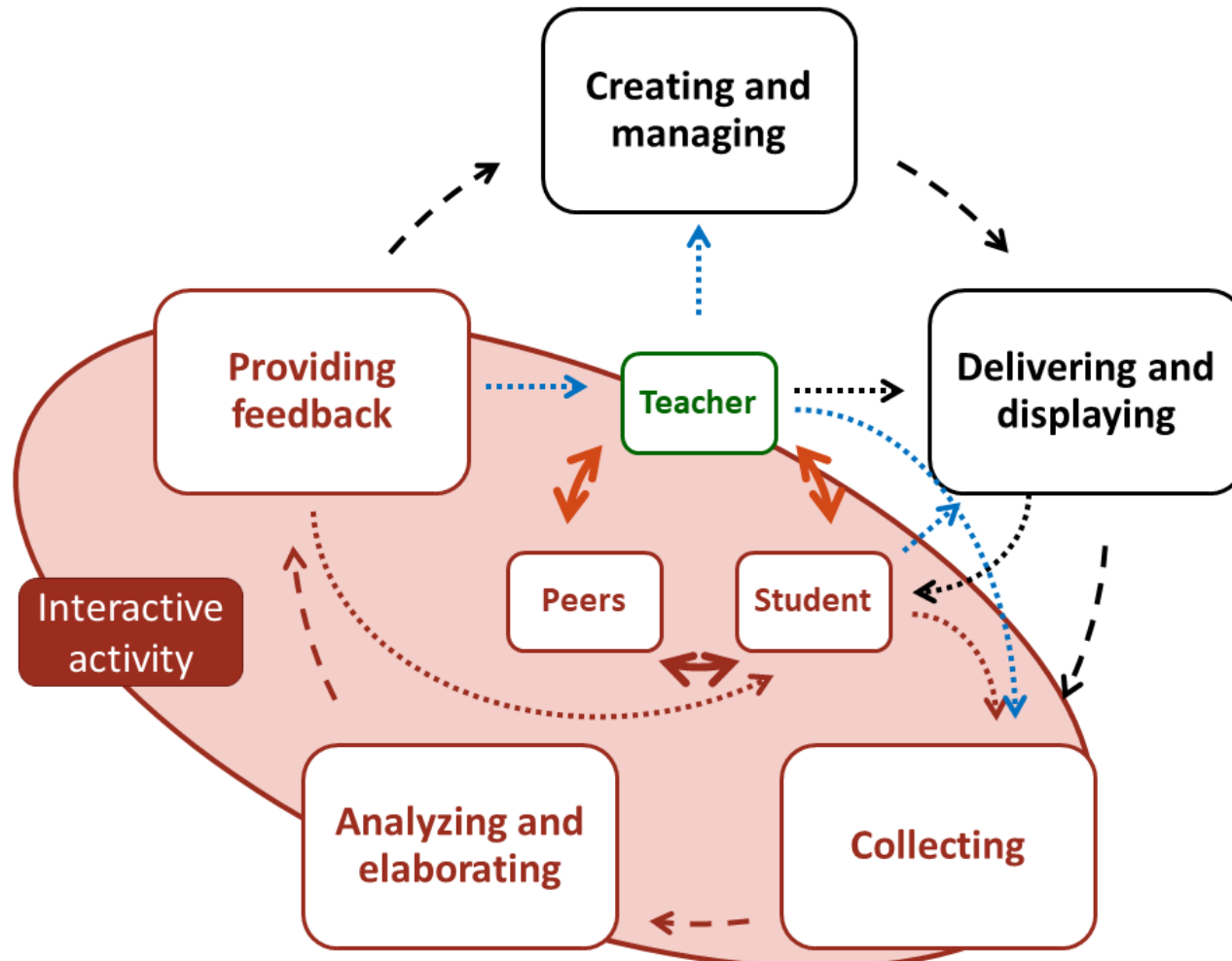


(Barana & Marchisio, 2022)



# Modelling interactions in a DLE

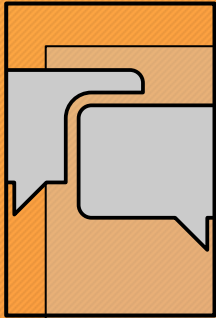
29



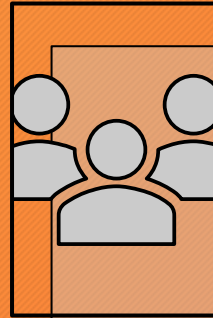
(Barana & Marchisio, 2022)

# Outcomes of an integrated DLE

30



To Create an  
Interactive Learning  
Environment



To Support  
Collaborative  
Learning



To Promote  
Formative  
Assessment

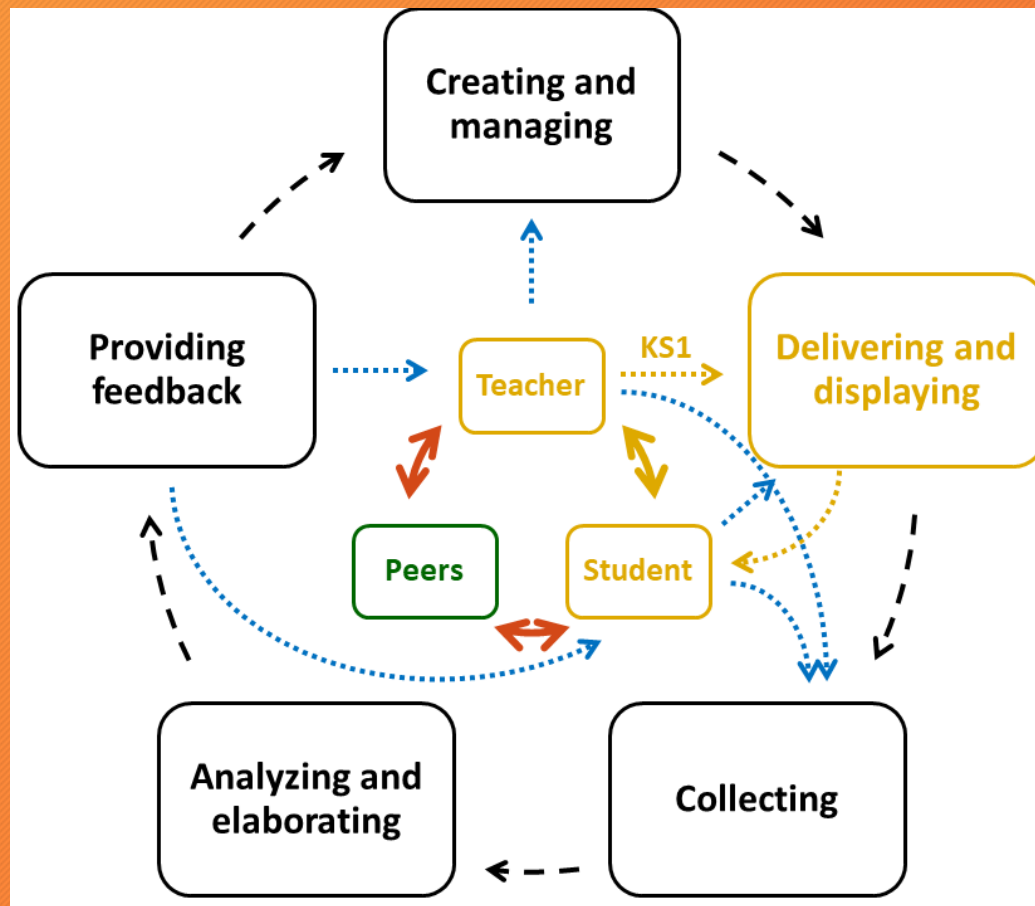
# Example

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

(Barana & Marchisio, 2022)



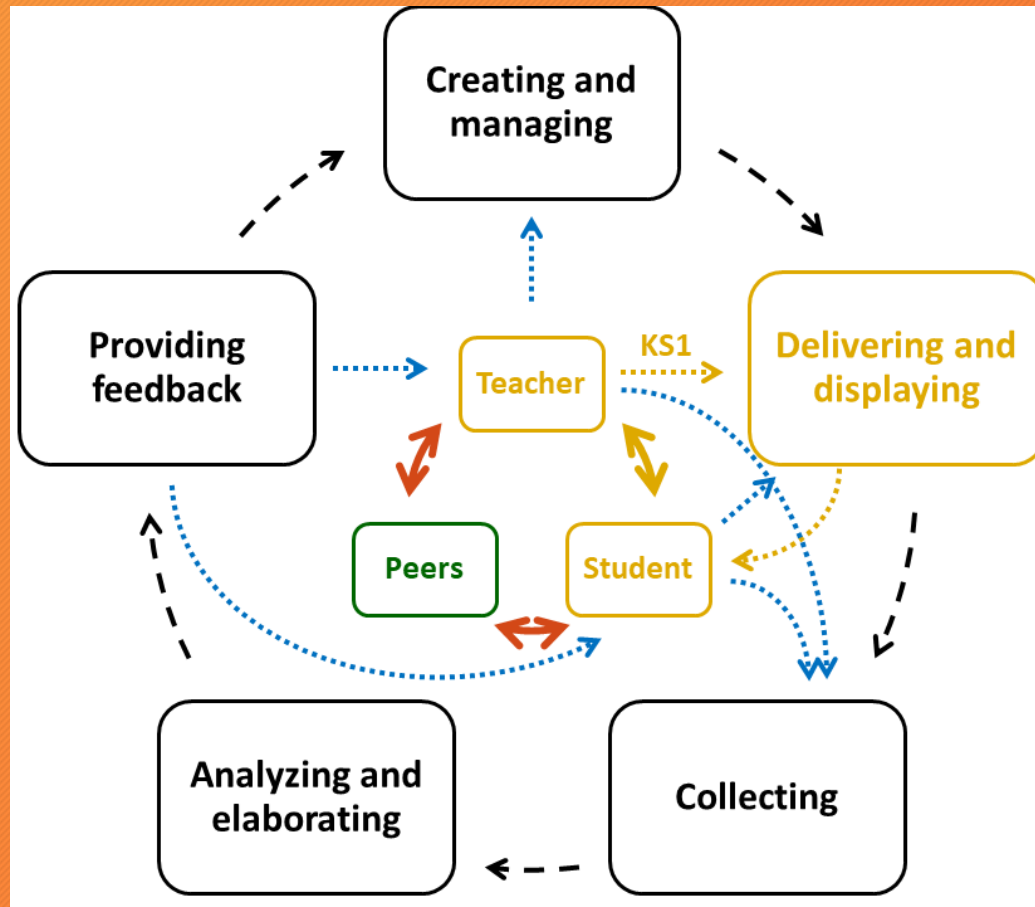
# Example

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

(Barana & Marchisio, 2022)

# Example

33



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

But we have  $a$ .

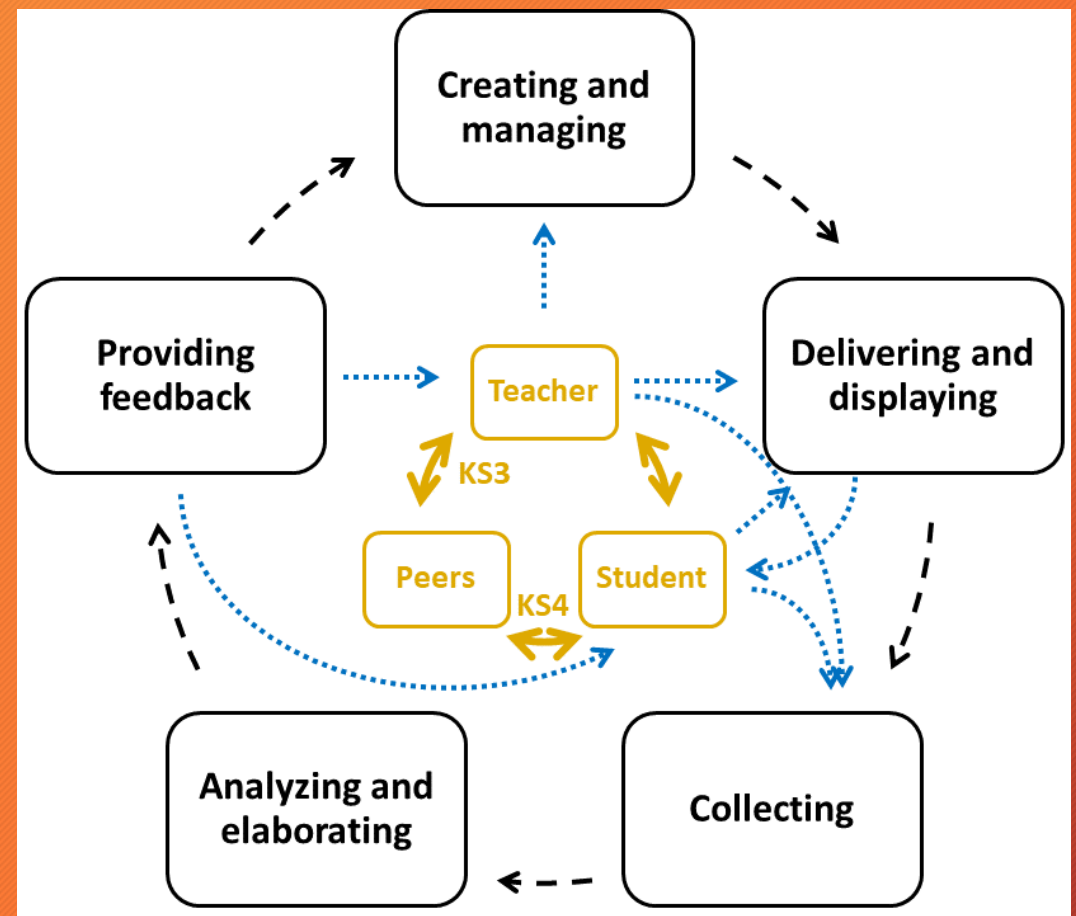
But  $a$  is not a number!

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?



(Barana & Marchisio, 2022)

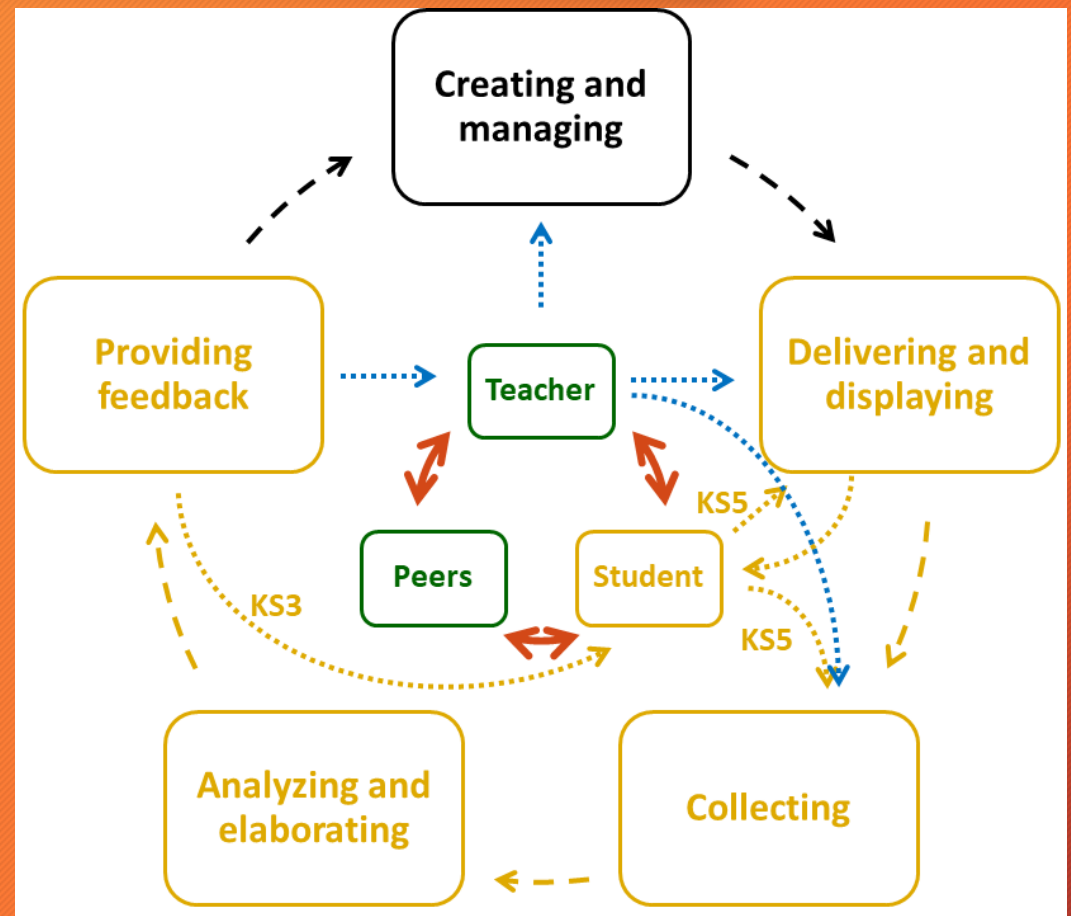
# Example

34



✓

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



(Barana & Marchisio, 2022)



# ACTIVITY - PART 1

35

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:

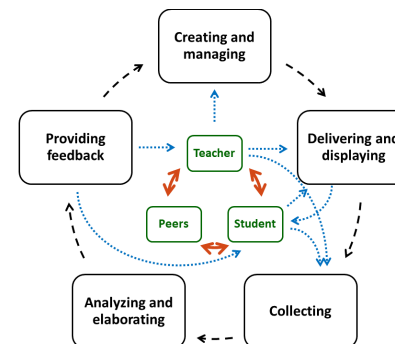
- ✓ Learning community: \_\_\_\_\_
- ✓ Technologies: \_\_\_\_\_
- ✓ Methodologies/interactions: \_\_\_\_\_

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

36

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

x	y	
0	0	✓
2	1	✓

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

Automatic formative assessment

# Advantages of using a DLE

37

For learners...



Learning  
community



Adaptive learning

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	$\frac{33}{420}$	2	$\frac{1}{2}$	3	$\frac{9}{4}$	4	
---	------------------	---	---------------	---	---------------	---	--

- $\frac{15}{72}$
- $\frac{66}{132}$
- $\frac{1}{13}$
- 21

Automatic and  
interactive feedback



# Theoretical frameworks to build DLEs

# Different terms, different concepts

39

Emergency  
education

Distance  
education

Online/digital  
education

# 4 “A” in education

## Human Rights Obligations in Education

40

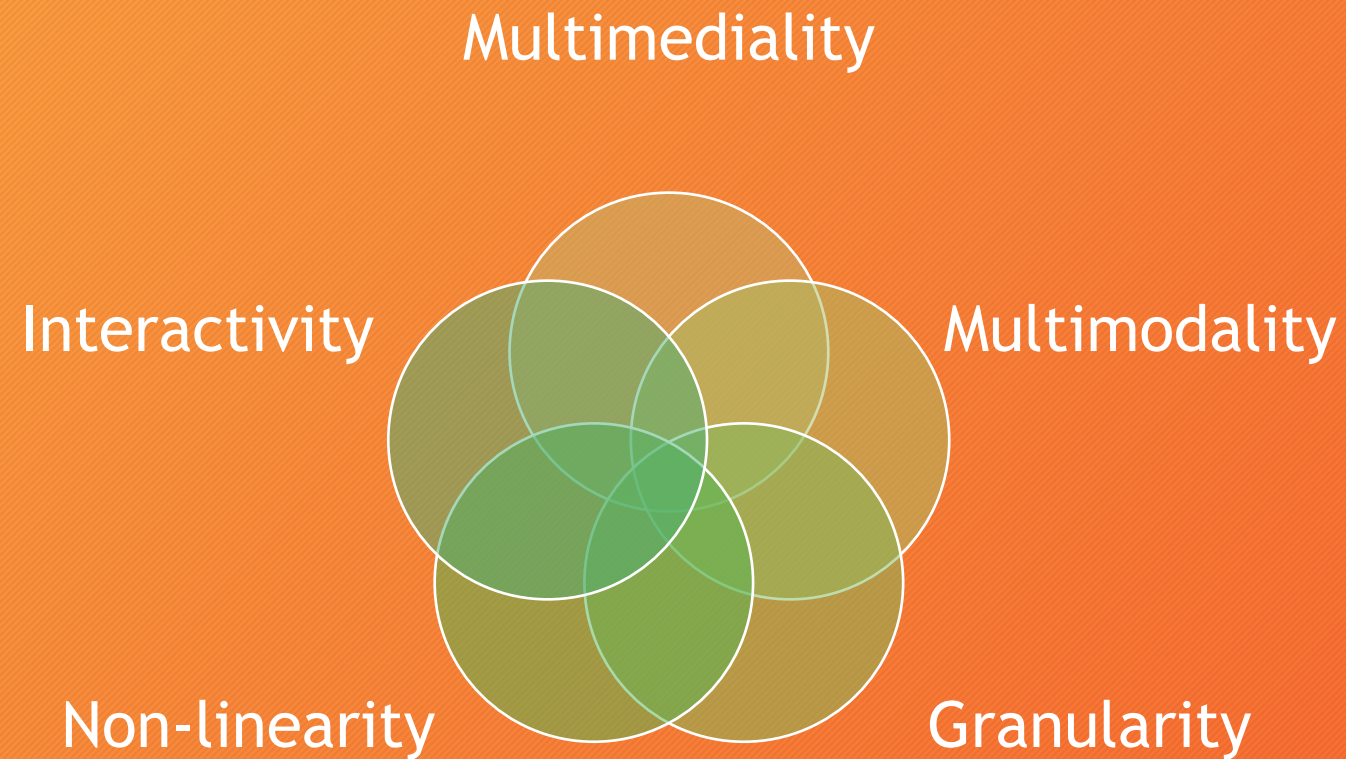
✓ Acceptability

 Accessibility

 Adaptability

 Availability





# Characteristics of online resources

42

- Schematism
- Syntactic simplicity
- Visual impact
- Brevity
- Heading
- Thematic compactness
- Engaging

# Constructivist DLEs

43

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

(von Glasersfeld, 1989)





# Constructivist DLEs

44

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

45

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

46

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

47

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

48

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

Problem Solving  
Interactive activities

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

Explorations  
Interactive feedback

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

Real-world problems

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

Interactive activities  
Automatic assessment

to embed learning in **social experience**

Classroom activities  
Forum discussions

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

Explorations  
Algorithmic questions

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

Immediate feedback  
Self-assessment

# Engagement

49





# Engagement

50



+

Interactive technologies	Low socio-economic status
--------------------------	---------------------------

# Approaches to foster equity in Mathematics

51

- 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

52

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

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!

54

Marina Marchisio - [marina.marchisio@unito.it](mailto:marina.marchisio@unito.it)

With the patronage of



# References (1/2)

55

- Barana, A., & Marchisio, M. (2021). Analyzing interactions in Automatic Formative Assessment activities for Mathematics in Digital Learning Environments. CSEDU 2021. Proceedings of the 13th International Conference on Computer Supported Education, 1, 497-504.
- Barana, A., Marchisio, M. (2022). A model for the analysis of the interactions in a Digital Learning Environment during mathematical activities. In Csapó, B., Uhomobhi, J. (eds), Computer Supported Education. CSEDU 2021 (pp. 429-448). Communications in Computer and Information Science, vol 1624. Springer, Cham.
- Boaler, J. (2008). Promoting 'relational equity' and high mathematics achievement through an innovative mixed-ability approach. British Educational Research Journal, 34(2), 167-194.
- Elbers, E., & de Haan, M. (2005). The construction of word meaning in a multicultural classroom. Mediation tools in peer collaboration during mathematics lessons. European Journal of Psychology of Education, 20(1), 45-59.
- Heritage, M., & Wylie, C. (2018). Reaping the benefits of assessment for learning: Achievement, identity, and equity. ZDM, 50(4), 729-741.



# References (2/2)

56

- Honebein, P. C., 1996. Seven Goals for the Design of Constructivist Learning Environments. In: Constructivist Learning Environments. Educational Technology Publications, New York, pp. 11-24.
- Jonassen, D., Davidson, M., Collins, M., Campbell, J., Haag, B. B., 1995. Constructivism and computer-mediated communication in distance education. American Journal of Distance Education 9(2), pp. 7-26.
- Nortvedt, G. A., & Buchholtz, N. (2018). Assessment in mathematics education: Responding to issues regarding methodology, policy, and equity. ZDM, 50(4), 555-570.
- von Glasersfeld, E., 1989. Constructivism in Education. In: Husen, T., Postlethwaite, T.N. (Eds.), The International Encyclopedia of Education. Pergamon Press, Oxford/New York, pp. 162-163.
- Wilson, B. G. (1995). Metaphors for instruction: Why we talk about learning environments. Educational Technology, 35(5), 25-30.
- Wright, P. (2016). Social justice in the mathematics classroom. London Review of Education, 14(2), 104-118.