

# The “Resource” approach to (mathematics) education

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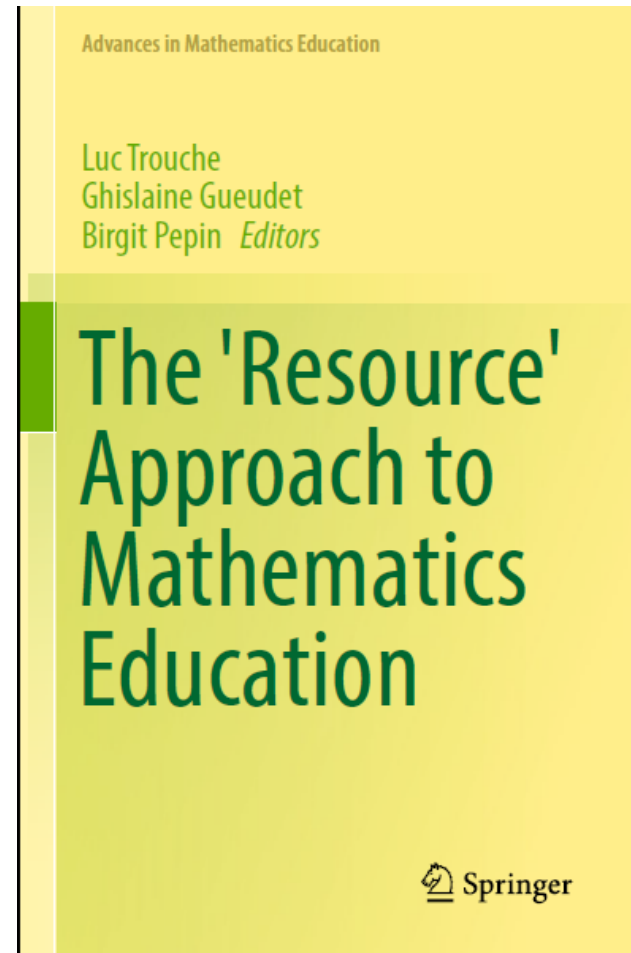
# Outline

- 1) Introducing the « Resource » approach
- 2) The documentary approach to didactics:  
elementary concepts and principles, first  
examples
- 3) Teachers' resource systems
- 4) Collective documentation work
- 5) Conclusion/perspectives

# 1. The « Resource » approach

Focusing on the interactions between teachers (or teacher educators, or students) and **resources**, and on the consequences of these interactions.

In a context of deep evolution of the available resources  
Mathematics and other disciplines



# 1. The « Resource » approach

Different existing research domains concerned:

- Domain1. Educational technologies and their use by teachers in class (Guin et al. 2005, Ruthven 2009);
- Domain 2. Curriculum materials (in particular textbooks), their features, design and use by teachers (e.g. Remillard 2005);
- Domain 3. Teachers' professional development and teachers' collective work (Adler 2000)

# 1.The « Resource » approach

An ongoing re-conceptualization, the emergence of a new research field.

Definition of resource by Adler (2000):

“It is possible to think about resource as the verb re-source, to source again or differently”

(Context: teacher education in post-apartheid South Africa. Lack of material; many different languages...)

A focus on resources-in-use

*Material, socio-cultural, human resources*

# 1. The « Resource » approach

Recent evolutions of these domains (context and perspectives):

## ***Educational technologies and digital curriculum resources***

“it is the attention to sequencing—of grade-, or age-level learning topics, or of content associated with a particular course of study (e.g., algebra)—so as to cover (all or part of) a curriculum specification, which differentiates Digital Curriculum Resources from other types of digital instructional tools or educational software programs” (Pepin et al. 2017)

## ***Curriculum ergonomics***

Interactions between curriculum design and curriculum use (Choppin et al. 2018)

## 2. The documental approach, theory

### Origins

Activity theory (Vygotsky, 1978): a subject is engaged in a goal-directed activity; resources mediate this activity.

Instrumental genesis (Rabardel, 1995; Guin et al. 2005)

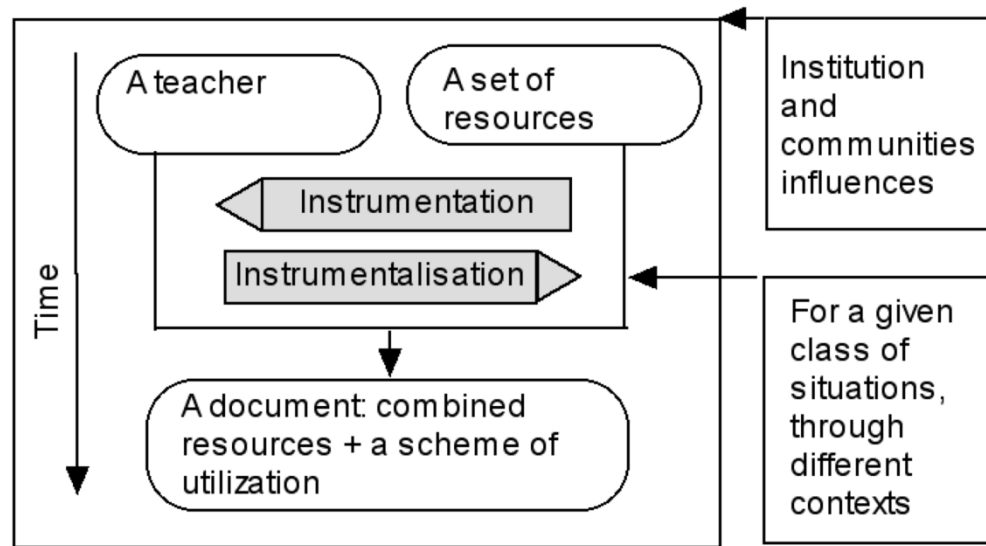
### Principles and elementary concepts of the documental approach to didactics (DAD)

Teachers interact with resources to design their own teaching.

Searching for resources, selecting them, modifying, using them in class: ***teachers' documentation work*** (Gueudet & Trouche 2009)

Along their interactions with resources, the teachers develop ***documents***: associating resources and a ***scheme of use*** of these resources (Vergnaud 1998): stable organisation of the activity.

## 2. DAD, theory



The development of a document is a ***documentational genesis***, associating two processes:

- ***Instrumentation***, the features of the resources shape the schemes developed
- ***Instrumentalization***, the already existing schemes intervene in the appropriation of the resources by the teacher.

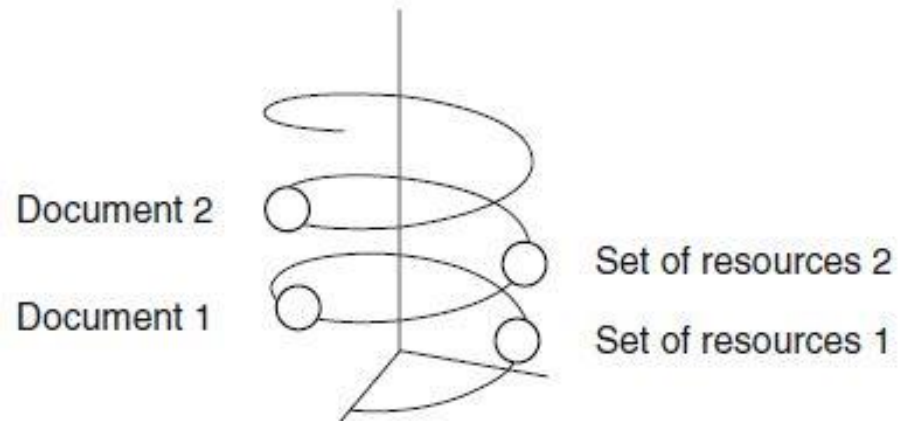


## 2. DAD, theory

From a set of resources (*mother resources*, Hammoud 2012), a teacher develops a document.

This document is composed by selected, modified resources, and a scheme of use of these resources.

The « resource » part of the document (*daughter resources*) can contribute to the developement of a new document (for example the following year), can be shared with colleagues etc.



## **2. DAD: the reflexive investigation method**

Following teachers' documentation work, principles:

- Long-term: several years, if possible
- An active participation of the teacher his/herself
- Different kinds of data collected: interviews, observation of preparation work, observation of lessons in class, collection of the resources used and produced

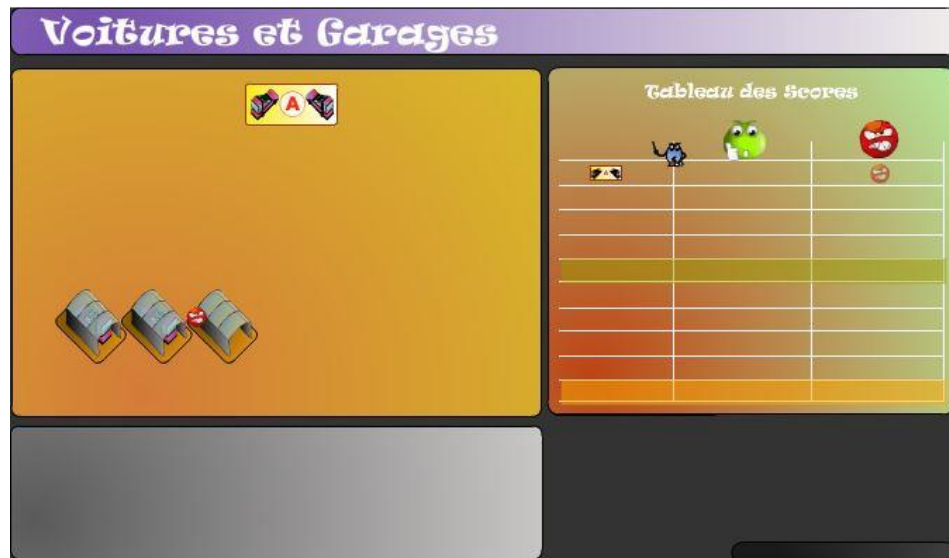
For the identification of schemes:

- Identify regularities in the teachers' activity for a given aim
- Identify convictions of the teachers (expressed in the interviews)
- Confronting the declarations of the teacher and his/her actual practice in class and resources produced.

## 2. Example 1, mathematics at Preschool

# Project MARENE (2012-2016, Resources for mathematics at Preschool)

Cars and garages, a software for learning quantity and number at Preschool (medium class, 4-5 years old)  
(Apprentice mode)



Cars and garages, expert mode

The garages disappear, the student must place the correct number of cars in the grey band.

Cars and garages material,  
Matchboxes



## 2. Example 1, mathematics at Preschool

(Besnier, 2016)

Mia, an experienced Preschool teacher (10 years), followed during three years. Change of school for year 3.

Year 1, five sessions with 6 students.

S1: Initial diagnostic, computer (mouse) and numbers

S2: Discovery of the software

S3, S5: Practice by pairs

S5: Synthesis





# Focus on session 5, year 1

**Resources:** The black board, and magnetized stickers reproducing elements of the software; the discussions, strategies with the software presented by the students

**Aim:** design and set up a synthesis

**Scheme of use of the resources:** the students are gathered in front of the board with the teacher. A student shows his procedure, the others discuss, Mia manages the debate.

Mia's usual scheme for syntheses, **instrumentalization process**. Appropriation of the software: no use of the material; design of a new material (stickers).

For Mia in mathematics, importance of verbalisation, importance of confronting strategies. The synthesis comes at the end, in the last session.



# Year 2

Year 2, 6 sessions with groups of 6/7 students

S1: Initial diagnostic, computer (mouse) and numbers

S2: Discovery of the situation with the material

S3: Discovery of the software

S4 : Practice with the software and the material

S5: Synthesis

S6 : Practice with the software and the material



# Focus on session 5, year 2

**Resources:** Same as year 1 + observation of the students in year 1 + a grey band reproducing the grey zone of the software

**Aim:** design and set up a synthesis

**Scheme of use of the resources:**

Same as year 1+ each student goes to the board, the number of garages is changed each time.

Mia observed in year 1 that some students think it is always the same number: **instrumentation process**

A new practice session after the synthesis.





## Example 2: Chemistry, grade 10



(Jameau, 2017, REVEA project)

Lara, teaching physics and chemistry at upper secondary school for 5 years, followed during two years.

Designing and implementing a practical work in chemistry about Copper at grade 10. Data collected each year:

- General interview on resources
- Video of preparation
- Practical work sessions videotaped
- Interview after the lesson
- Collection of the resources used and produced

Focus on year 2.

# A practical work about Copper, grade 10

## Puzzle:

A magician makes a coin disappear, and then is able to make reappear the copper forming it. Can you discover his secret?

## Resources used (1):

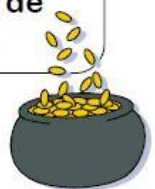
- A lesson plan found on the Internet, following an advice from a colleague
- The lesson plan from the previous year
- Yearly «progression » written with the colleagues teaching in grade 10

## The Magic Copper (LE CUIVRE MAGIQUE)

*A Las Vegas, on peut assister à un tour de magie surprenant :  
l'illusionniste fait « disparaître » une pièce de 1 penny  
et « réapparaître » le cuivre dont elle est constituée.*



A l'aide de la banque de données,  
montrez qu'il n'y a rien de « magique »  
dans ce tour et réalisez la suite de  
manipulations nécessaires.



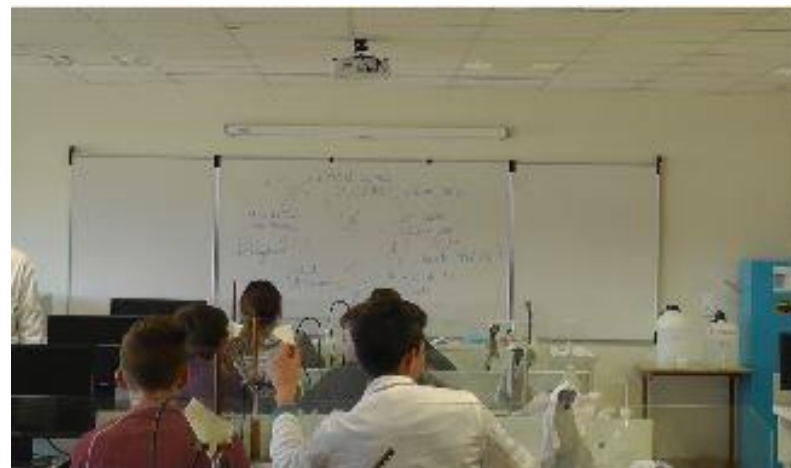
## A practical work about Copper, grade 10

Because of difficulties of the students observed the year before:

- modification of the question (Year 1 “he makes the coin reappear”), to avoid suggesting that the coin will reappear
- information added.

Availability of the products checked with the technician at the science laboratory of the school.

Written report as homework.



# A practical work about Copper, grade 10

## TP1 : Magic copper !!!!!

### Resources used (2):

- Laboratory technician
- Laboratory material
- Remarks of the students of previous year

Objectifs :	<ul style="list-style-type: none"> <li>• Savoir .....</li> <li>• Mettre en œuvre un protocole expérimental pour répondre à un problème</li> <li>• Rédiger un compte rendu</li> <li>• Manipuler en respectant les règles de sécurité</li> </ul>
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A Las Vegas, le célèbre illusionniste Timothy Best fait "disparaître" une pièce de un penny et fait "réapparaître" le cuivre dont elle est formée. On vous propose de découvrir son secret.

Au début de son tour, Timothy plonge la pièce dans une solution d'acide nitrique. Cette opération est délicate car il se forme un gaz roux, le dioxyde d'azote qui est toxique. Cette opération sera donc réalisée par le professeur sous la hotte.

Vous disposez de la solution obtenue réalisée au préalable. **Attention, cette solution est toujours acide.**

### Comment allez vous faire réapparaître le cuivre issu de la pièce ?

- Montrez qu'il n'y a rien de « magique » dans ce tour : Élaborez votre protocole et faites-le vérifier.
- Réalisez les manipulations nécessaires après accord du professeur.
- Rédiger un compte rendu comportant :
  - le schéma des expériences réalisées
  - les résultats obtenus
  - une **conclusion**

### Banque de données

- On note Cu l'atome de cuivre et  $\text{Cu}^{2+}$  l'ion cuivre (II) (voir chapitre 4)
- Le métal cuivre est un solide rouge-orangé constitué d'atomes de cuivre.
- L'oxyde de cuivre (II) réagit avec une solution d'acide chlorhydrique pour former une solution bleue contenant des ions cuivre (II).
- Les ions cuivre (II) réagissent en solution aqueuse avec le métal fer pour donner du métal cuivre. (\*)
- L'un des produits de la réaction entre le cuivre et l'acide nitrique est le monoxyde d'azote qui est un gaz incolore mais celui-ci se transforme immédiatement, sous l'action de l'air, en dioxyde d'azote, gaz roux très toxique.
- Les ions cuivre (II) sont de couleur bleue en solution aqueuse.
- Par chauffage, l'hydroxyde de cuivre (II) donne de l'oxyde de cuivre (II) qui est un solide noir.
- Les ions cuivre (II) réagissent avec les ions hydroxyde contenus dans la soude pour donner un précipité bleu d'hydroxyde de cuivre (II).

Remarque :

(\*) En milieu fortement acide, le fer est attaqué par l'acide et ne réagit pas avec les ions cuivre (II).

## Example 2: Chemistry, grade 10

Lara developed a document from these resources, for the aim:  
« Designing and setting up a practical work about Copper for grade 10 »

*Intervention of an existing scheme of use:* a practical work is organized following inquiry-based learning principles

- Starting with a puzzle to stimulate students' interest
- The students have to read the information provided, and plan an experiment

*This existing scheme influenced the choice of the mother resource, and the design: Instrumentalization*

## Example 2: Chemistry, grade 10

« Designing and setting up a practical work about Copper for grade 10 »

*Development of new elements of scheme, in particular after the observation of students (instrumentation)*

- The sheet presenting the practical work must be on a single page
- The formulation of the question should not suggest that the coin will reappear
- The report can be written as homework to save time, and follow the common progression

### 3. Teachers' resource system

- Along his/her work, a teacher develops a *structured resource system*.
- This system is structured according to « classes of situations » : situations with a similar aim of the activity
- Some resources intervene in several classes of situations: pivotal resources

*A study of the resource system, what for?*

- The appropriation of a new resource by the teacher means its integration in the teacher's resource system.
- Observing the evolutions of the resource system permits to understand essential aspects of teachers' professional development.

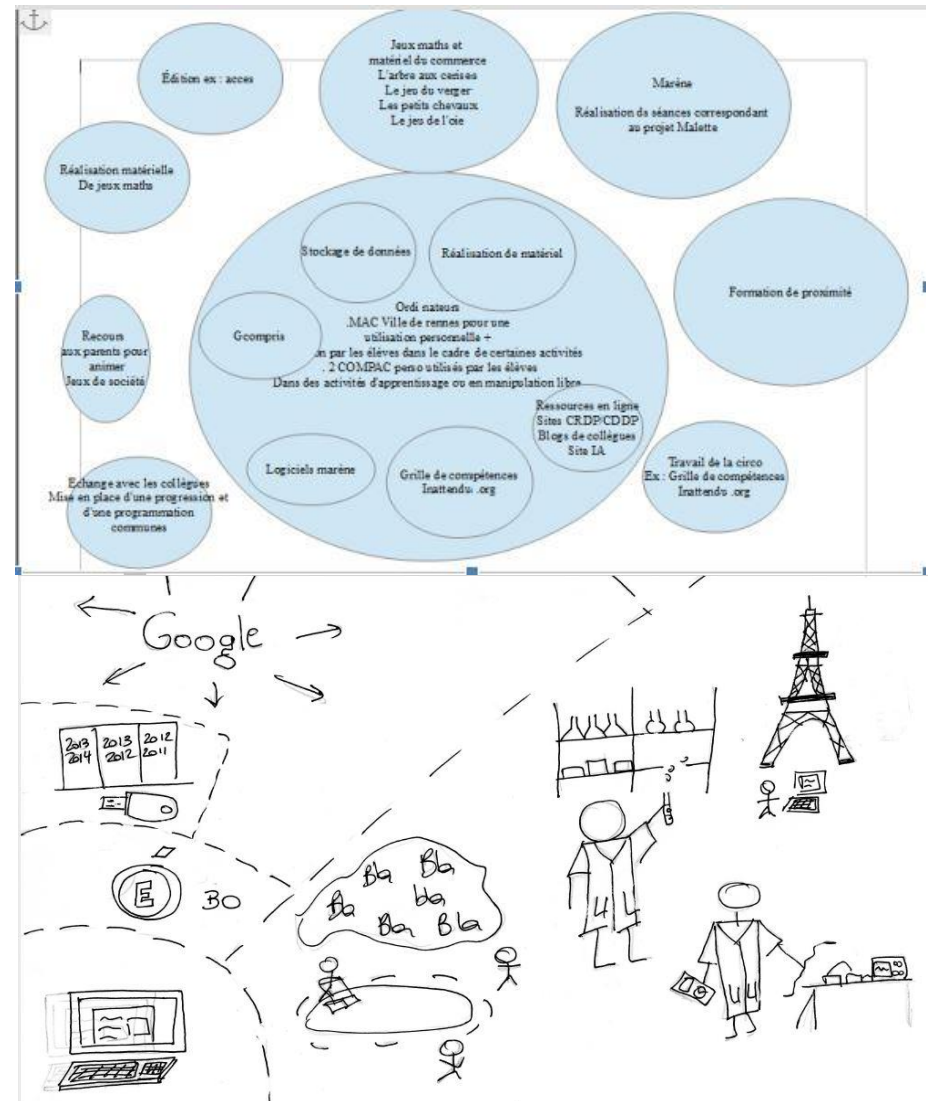


### 3. Teachers' resource system, a specific method

Schematic  
Representation of the  
Resource System  
(SRRS)

During an interview;  
completed during the  
follow-up.

Can also be proposed  
by the researcher, and  
modified by the  
teacher.





### 3. The example of Mia's resource system

- A general resource system for her teaching for medium class at Preschool
- *A subsystem, for the teaching of mathematics for medium class (in red, classes of situations specific for mathematics)* (Besnier, 2016)

Design and implement a learning progression

Design and implement moments of introduction, of practice

Communicate with the colleagues and the families

Design and implement moments of mobilization of knowledge

Professional development

Follow the students

### **3. Mia's resource system: pivotal resources, evolutions**

- *Games* for the learning of numbers.  
Commercial games, and games designed in class with the students. The families can borrow the games during the week-end (pivotal resource)
- *Integration of new situations*, for the teaching of number, for supporting the transition between small section and medium section
- *Integration of the textbook ACCESS* (Year 3).  
The textbook replaces « programming tables », after a discussion with a colleague and the decision to choose a common « progression ».

### 3. Mia's resource system: pivotal resources, evolutions

Year 3, IWB in the  
classroom

Use of counting  
nursery rhymes,  
illustrated on the  
IWB

Design of « IWB  
booklets » for the  
students and their  
families (pivotal  
resource)



## **4. Teachers' collective documentation work**

- Groups of teachers have a common documentation work
- Communities of practice (CoPs, Wenger 1998) of teachers have a shared repertoire – a shared resource system.
- The schemes of use are not completely shared, even in CoPs.

## 4. Example of the Sesamath association in France

An association of Mathematics secondary school teachers, designing free teaching resources : “Mathematics for all”.



- Online exercises,
- e-textbooks and textbooks on paper,
- A website for teachers (Sesaprof)
- A complete virtual learning environment (LaboMEP)

# 4. Example of the Sesamath association in France

The Sesamath resources are very popular :

1.3 million visits on the websites each month

900 000 (over 5 millions) students inscribed on LaboMEP, 14000 (over 58 000) teachers inscribed on Sesaprof

Vous êtes connecté en tant que professeur - Cliquez ici pour passer en mode élève (qui ne comprend pas de corrections)




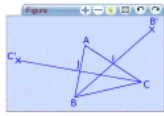
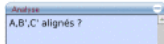

Sommaire N.R. N1 N2 N3 N4 D1 D2 G1 G2 G3 G4 G5 M1 M2 Méth. Corr. Propriétés Lexique Formulaire

## Activités de découverte

### Activité 1 : Somme des angles d'un triangle (découverte)


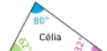

- Trace deux triangles quelconques de formes différentes et mesure leurs angles à l'aide d'un rapporteur.
- Trace un triangle particulier (isocèle, rectangle ou équilatéral) puis mesure ses angles à l'aide d'un rapporteur.
- Pour chaque triangle tracé, additionne les mesures des trois angles. Que remarques-tu ?
- Essaie de tracer un triangle dont la somme des angles est égale à  $220^\circ$ . Que remarques-tu ?

### Activité 2 : Somme des angles d'un triangle (démonstration)

- Avec TracenPoche, place trois points A, B et C. En utilisant le bouton , construis le triangle ABC. À l'aide du bouton , place les points I et J, milieux respectifs de [AC] et [AB]. En utilisant le bouton , construis le point C', symétrique de C par rapport à J et enfin le point B', symétrique de B par rapport à I.
- Dans la fenêtre Analyse, recopie :  
  
Appuie sur la touche F9. Quelle est la réponse ? Nous allons démontrer cette réponse.
- En utilisant une propriété sur la symétrie centrale, démontre que les droites (AB') et (AC') sont parallèles à la droite (BC). Dédus-en que les points C', A et B' sont alignés. Trace alors la droite (B'C').
- On va maintenant s'intéresser aux angles. Dans la fenêtre Analyse, recopie :  
  
Appuie sur la touche F9 puis déplace les points A, B et C. Que remarques-tu ?

Nous allons démontrer ce que TracenPoche affirme.

- En utilisant la symétrie de centre J, démontre que  $\widehat{ABC} = \widehat{BAC'}$  puis en utilisant la symétrie de centre I, démontre que  $\widehat{ACB} = \widehat{CAB'}$ .
- Dédus-en que  $\widehat{BAC} + \widehat{ABC} + \widehat{ACB} = 180^\circ$ .
- Application : Marco, Célia et Romain ont tracé chacun un triangle et ont mesuré leurs angles. Sans utiliser de rapporteur, indique si certains se sont trompés :



Marco Célia Romain

## Activités de découverte


### Activité 3 : Hasardons-nous à construire un triangle

tracé

Compléments

Cliquez sur l'icône correspondante pour accéder aux compléments indiqués ci-dessous.

Correction

Acti:  déplacer le point C ou C'. Lorsque le triangle est formé, la somme des trois angles apparaît.

Acti

imètre

50°.

C. Quelles mesures sont communes aux triangles RO1 et RO2 ? Contient y en ait-il ?

3. Trois mesures permettent-elles toujours de construire un triangle unique ? Justifie.

450 000  
textbooks edited

## 4. Example of the Sesamath association in France

Investigating the design of the grade 10 e-textbook (Gueudet, Pepin, Sabra & Trouche 2016).

Distant collaboration of a group of 14 teachers, between 2009 and 2013.

Using: the official curriculum; the usual courses of the different members, a distant platform.

The resources used and produced were collected, the distant discussions were followed.

- Initial intention: choose a list of keywords (called “atoms”), corresponding to elementary skills (for example: “Represent graphically the square function” ). Characterise with these keywords pieces of course; interactive exercises, problems etc.
- For the teachers using the e-textbook, this should permit to build many different coherent paths – the pieces of course, and the exercises, are seen as bricks that the teacher will arrange to build his/her course.

## 4. Example of the Sesamath association in France

**Bernard:** I think that the course belongs to a precise chapter with three different sections. On the other hand, for the exercises we have to mix up everything.

**Michael:** But we need to choose exercises according to the progression. We can perhaps try to make something clear and simple for the teacher, concerning the course, the introductory activities and the basic exercises.

**Sandy:** We need to have a **kernel** in each chapter, with the techniques of this precise chapter. In this kernel, we can not mix up things.

Finally: choice of a kernel in each chapter, with the introductory activities, the course, the basic exercises, corresponding to the same techniques. The more complex exercises can correspond to different keywords, they can be associated to different chapters.



## **4. Example of the Sesamath association in France**

### **A documental genesis in the community of authors**

Aim: design the organisation of a given chapter in a e-textbook

Resources used: the authors' own courses, the official curriculum, a list of « atoms »

A conviction expressed by Sandy: « the coherence is given by the techniques », then shared by the community.

Resources designed: « kernels », with introductory activities, the course, basic exercises, around a given technique.

## 5. Conclusions and future directions

*Using DAD for different subjects, in different countries*

DAD has been used so far in mathematics, physics, chemistry, biology, English education; and in many countries.

The comparative studies evidence specific features for each domain and/or country, in terms of resources used but also in terms of schemes of use (shared convictions).

*Using DAD to design and analyse professional development programs*

Professional development programs with different aims (e.g. using digital resources to support the development of students' autonomy), proposing collective documentary work.

## **5. Conclusions and future directions**

Investigating language issues to deepen our understanding of the concepts

Investigating the structure of teachers' documents systems, following long-term evolutions (20 years...)

Following different modes of teachers' collective work with resources

Investigating the use of resources by students, and the links between teachers' resources and students' resources

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Thank you!

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