The secondary-tertiary transition

Many students have problems in the mathematics tertiary transition.

It is considered “a major stumbling block in the teaching of mathematics” (De Guzmán et al., 1998).

So far the amount of research in this field is modest and limited to some specific topics (Selden A. & Selden J., 2001; Artigue, 2001).

Usual academic reactions

Adapting curricula to the actual students’ knowledge, in particular lowering the level of the mathematics taught.

The development of students as autonomous learners might be hindered (De Guzman et al. 1998).

Usual academic reactions

Reducing the examination standards while formally keeping the usual curricula.

“This situation had dramatic effects on their beliefs about mathematics and mathematical activity. This, in turn, did not help them [students] to cope with the complexity of advanced mathematical thinking” Artigue.
Usual academic reactions

Running bridging courses aimed at filling gaps in prerequisite knowledge

As research suggests, students' difficulties cannot be reduced to lack in content knowledge or to purely cognitive factors.

Adapting curricula to the actual students' knowledge, in particular lowering the level of the mathematics taught.

Reducing the examination standards while formally keeping the usual curricula.

Running bridging courses aimed at filling gaps in prerequisite knowledge.

These reactions appear to be inefficient and sometimes even counter-productive.

Our challenge

- developing a teaching design grounded in research findings,
- evaluating the results,
- sharing the main ideas with secondary teachers.

Trying to link research and practice, suggesting a new way to face with transition difficulties.

Conceptual framework

Clarification of the causes [of students’ difficulties] plays a fundamental role in the building of appropriate didactical actions (Gueudet, 2008)

Research highlights several different aspects:
- Necessity of developing new thinking modes (Lithner, 2000; Sierpinska, 2000)
- Difficulty for students to become autonomous learners (De Guzmán et al. 1998)
- Difficulties linked to metacognitive, affective and linguistic/semiotic factors
Our interpretation

We identified four main aspects linked to students’ difficulties in transition:
- prerequisite knowledge;
- passage from elementary to advanced mathematical thinking;
- metacognitive and linguistic abilities;
- attitude toward mathematics.

These factors are strictly interrelated. There is a need to go beyond the purely cognitive interpretation. Intervention focalised on a unique aspect are fated to be inefficient.

Experimental university preparatory course

An experimental mathematics course was designed and carried out in the frame of a Pisa University Project (PORTA a.y. 06/07).

The setting up strategy consisted in promoting teaching actions at the secondary level for working in advance on the causes underlying students’ difficulties in mathematics, in order to prevent/limit their occurrence.

Main ideas were based on previous experiences of the research team (development of bridging courses in mathematics for the whole Faculty of Science since 2003).

P.O.R.T.A. Course: the data

Two parallel teaching sequences were provided open to 35 voluntary students (grade 12-13) for each course.

Each course consisted of seven 3-hours long meetings (held once a week, in extra-school time).

P.O.R.T.A. Course: meetings

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Each meeting was structured into three phases:

1. Small group works on accomplishing given tasks
   - Make students challenge and question their knowledge through:
     - Open-ended problems (no-routine exercises)
     - Requests of commenting/producing definitions and argumentations
     - Requests of communicating ideas.

2. Collective discussion on the work carried out in phase 1
   - Students’ participation is crucial so it is important to:
     - Maintain a relaxed atmosphere and a non-judgmental, non-prescriptive style
     - Value all the contributions
     - Not ignore incorrect answers or inadequate ways of thinking
     - Foster sharing and discussion

3. Final synthesis
   - Tutor sums up the discussion synthesizes and makes clear the main aspects emerged.
   - Also issues concerning transversal competencies were highlighted.
P.O.R.T.A. Course: the methodology

Each meeting was structured in three phases:

1. small group works on accomplishing given tasks
2. collective discussion on the work carried out in phase 1
3. final synthesis

Obviously the choice of the tasks has a crucial importance: the actual outcome of the first phase sustains and structures the enactment of the subsequent phases.

P.O.R.T.A. Course: an example of activity

Read the list of mathematical terms below. Do you know the meaning of some of these terms? Try to explain the meaning of the terms you know.

1) natural numbers
2) integer numbers
3) rational numbers
4) irrational numbers
5) real numbers

Reasons of the choice

The first activity of the first meeting: it had a great relevance to introduce the students to the course methodology.

Some concepts involved (e.g. natural numbers) are very familiar to all secondary students.

The request is purposefully vague.

Comments about the outcomes

This task works very well:

- all the students (also the weakest) felt that they could say something and participated in the classroom discussion.
- some surprising (also for high-achiever students) aspects always emerged (e.g. the difficulty to avoid circularity in the mathematics definition process).
- It emerges that single answer is less important than the consistency of the whole set of answers.
Evaluation of the PORTA course

Based on:
- direct observations
- answers to two purposefully designed questionnaires (administered at the end of the course and four months later)

At the end of the course...

I will remember the need to explore the reasons of any odd thing in my next studies

...four months later (answering about differences between regular and Porta lessons)

[PORTA course and classroom lessons] are different because in PORTA we worked in groups, we faced real justification of the concepts taught and above all because there was always a debate and a continuous exchange of ideas

[In the PORTA course] we explained what we knew and we learned from the other students

[In the PORTA course] concepts were not explained, rather I tried to understand them by myself

Evaluation of the PORTA course

Activities carried out by the students, evolution of their interventions over time and answers to the questionnaires support our belief that, during the course, the path toward the development of students’ autonomy have been undertaken.

It should be interesting to monitor the effectiveness of the intervention after long time.
Dissemination

PORTA course was an attempt (at the tertiary level) to face with the challenge of linking theory and practice.

Results was good and students involved in the Project appreciated the methodology experimented.

Need to go beyond the experimental phase.

Dissemination

Need to go beyond the experimental phase.

We disseminated the results and materials amongst secondary teachers and…

…some of these teachers began to experiment the methodology in their regular lessons for the entire classroom…

Dissemination

Nevertheless it is clear that absence of any formal assessment was an important condition for students to feel free of participating in collective discussions…

I was not anxious of understanding in view of the test.

I felt free because there was not a real teacher to assess pupils.

I was not anxious of understanding in view of the test.

Dissemination

Nevertheless it is clear that absence of the any formal assessment was an important condition for students to feel free of participating in collective discussions…

…both teacher’s feelings and students’ reactions were positive!
Conclusion

We are conscious that:
- our course is only an experimentation (based on at least 5 years of work)
- it is not simple to replicate the methodology in classroom
But we are convinced that:
- this way might be fruitful (acting directly in secondary school)

going toward the fundamental direction marked by Wood (2001, p.98):

"it is time to stop reacting and being more proactive in the transition to mathematics curriculum at tertiary level"

1 – Numerical sets

“Definition” of the numerical sets

“Justification” of rules and conventions

Closedness of numerical sets with respect to the usual operations