"Computer Science and Nursery Rhymes" A Learning Path for the Middle School

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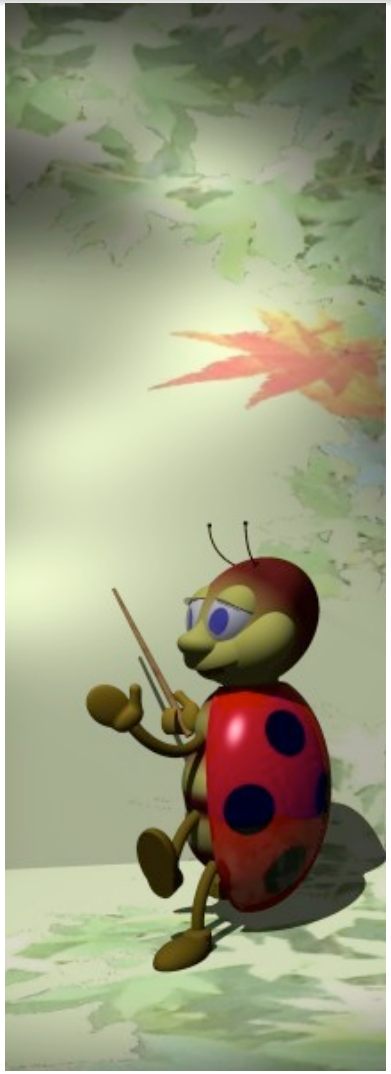
What this talk is about

An attempt to approach middle school informatics in the context of “mathematics and science” rather than as part of the “technology” subject (the latter being the ordinary choice)

- Extra-curricular activities
- Nursery rhymes as a vehicle to introduce CS ideas and way of thinking
- A bit of exposure to programming

Outline



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Motivations

Informatics as . . .

instrument	**pervasive technology**	**discipline**
focus on product	general patterns	focus on process
operating skills	analogical approach	methodology
imitation	cognitive invariants	critical thinking
can do	can generalize	can create
short-term	mid-term	long-term
training	enabling	educating

Motivations

Middle school Informatics is usually perceived as a tool

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Motivations

Or, at best, as a category of software artifacts

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Motivations

Is there room to link Informatics to Science?

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Scope

what our work is...	**what it is not...**
"Prototype" experience	Educational research
Context-sensitive (teacher of maths & science)	Multi-institutional study
Opportunity to explore CS ideas and way of thinking	Overview of specific CS topics
...and to get a feel of the *nature* of programming	...nor systematic approach to programming in Logo

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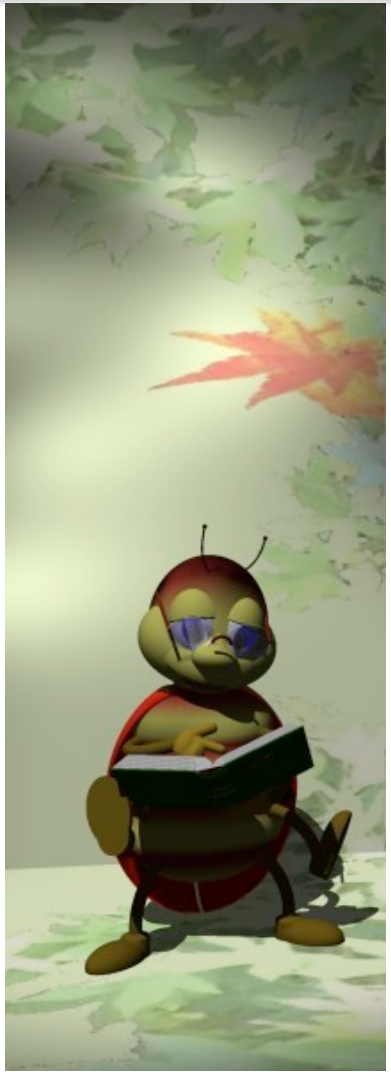
Scope

To be feasible, extra-curricular programs:

- Cannot be too ambitious in terms of time investment;
- Should integrate as far as possible with the syllabi of one or more school subjects.

Leitmotiv: "Nursery rhymes"

- Links with primary school / home experiences.
- The pupils themselves can collect the material.
- Observation, analysis, modeling, re-elaboration.
- Concrete and abstract models.
- Experiments with simple programs.



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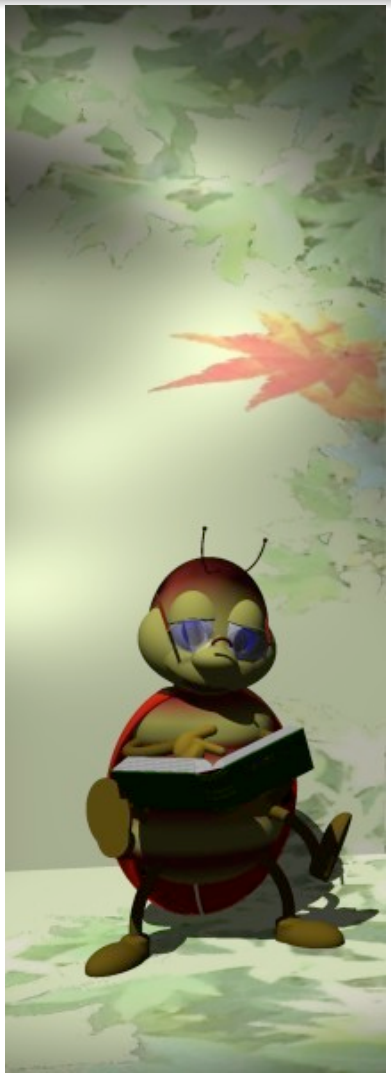

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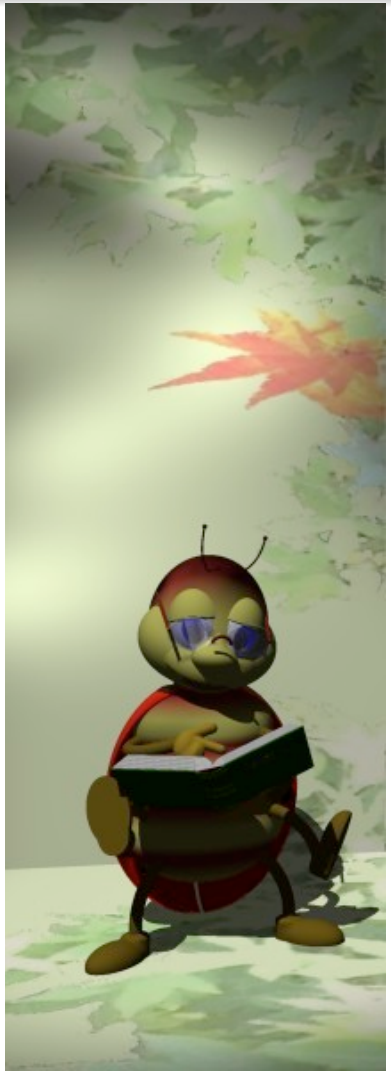

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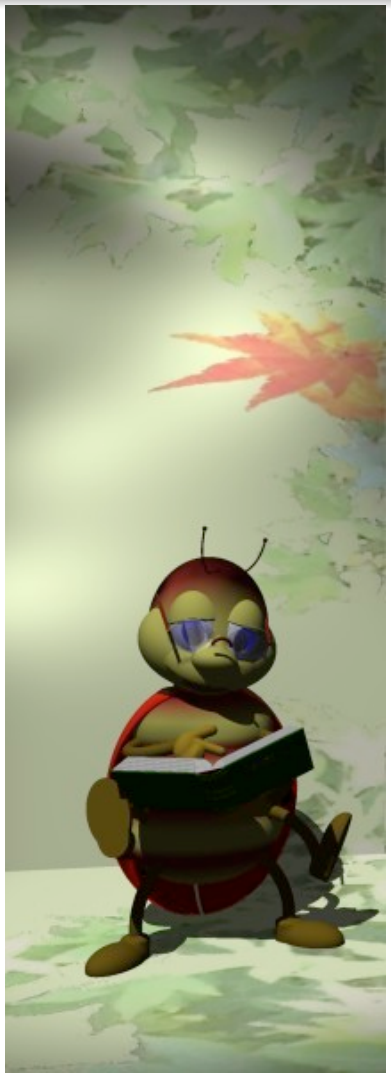

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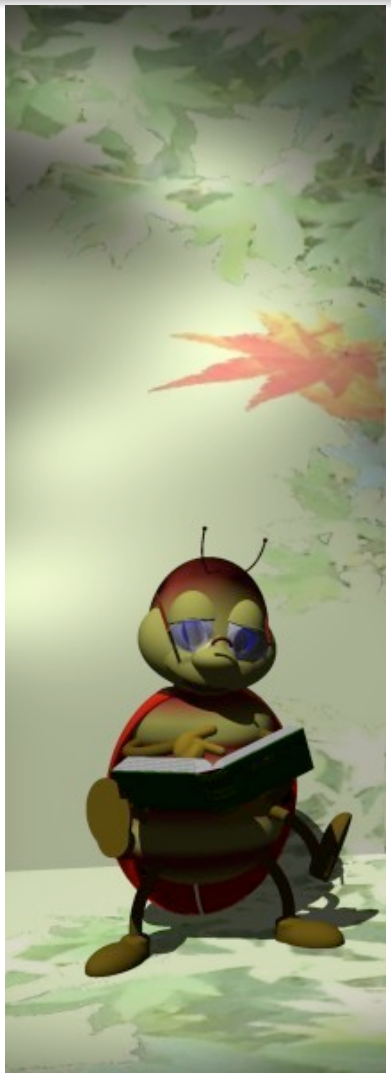

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- Based on the lower-secondary framework, *informatics* is not an autonomous subject.
- The schools can choose how to implement it as part of one or more other subjects.
- Ordinarily, *informatics* means ICT literacy and is one of the topics of a technology course.
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Interesting interdisciplinary section of the *maths* syllabus

"introduction to rational thinking":

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Reference models and related work

- CS Unplugged
  (Bell et al.)
- CS4FN
  (Curzon et al.)
- Pupil-friendly environments
  (e.g. *Storytelling Alice*, *Scratch* . . .)
- Miscellaneous work
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I. Taking a "computational perspective"

II. Understanding the nature of programming

III. Thinking about potentials and limits of computing

Extra-curricular units to be scheduled in three years.

Compatible with the middle-school context.

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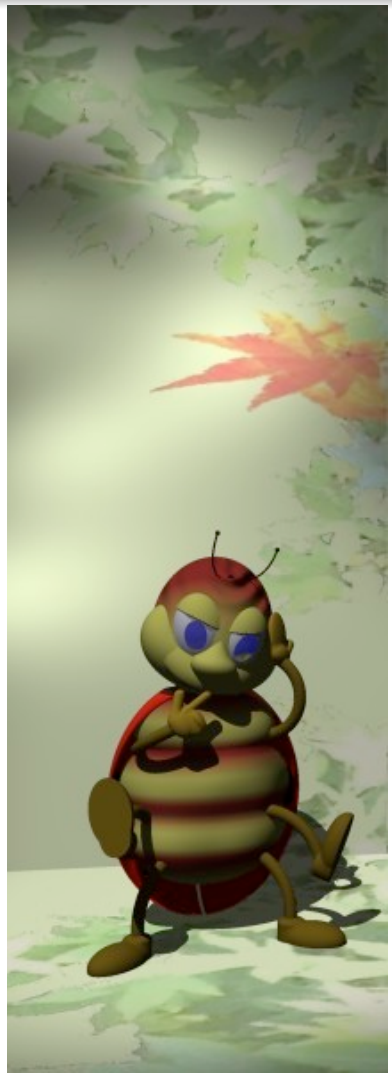
First year: Computational perspective (20 hours)

- The pupils collect examples of nursery rhymes;
- Analysis of nursery rhymes (repeats, fixed/varying parts);
- Discussion + classification based on structural properties;
- Playful elaboration of the underlying "mechanisms"...
  - *concrete* models (e.g. cardboard machine),
  - experiments with the *ladybug* application;
- The pupils create their own nursery rhymes;
- *Ladybug*'s rules: conjectures, verification.

Second year: A bit of programming (20 hours)

- Basic constructs of *Logo*;
- Programs examples;
- Experimentation in the laboratory;
- Development of programs to automate the production of simple nursery rhymes;

Logo: good tradeoffs
between expressiveness and ease of use,
between functional and imperative features.



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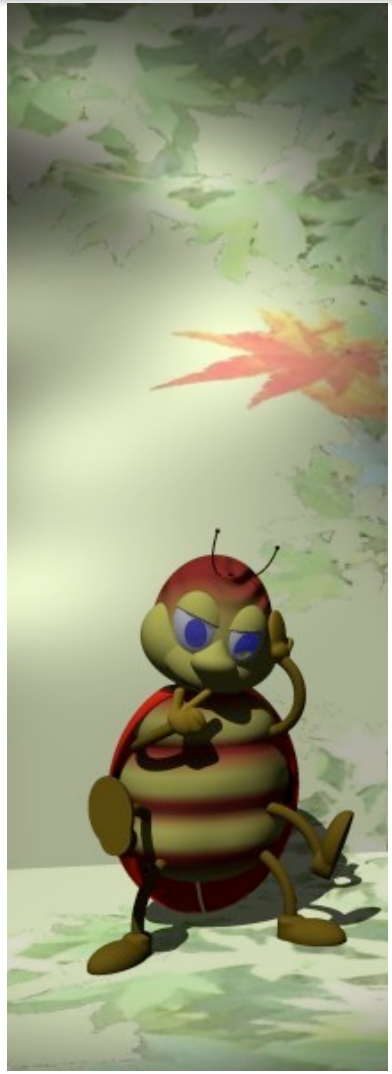

Third year: Towards critical thinking (10 hours)

- Further lab work with Logo;
- Re-thinking about *Ladybug*'s behavior in the light of the programming experience;
- Re-thinking about *Ladybug*'s potentials vs. limits: what's going on "backstage"?
- "Concept transfer" to related IT tools (e.g. text-processing applications).

A few steps along the track. . .

"There was a little green house"

There was a little green house,
And in the little green house

There was a little brown house,
And in the little brown house

There was a little . . . house,
And in the little . . . house

. . .

There was a little heart.

Analysis and discussion: Abstract model(s)

"There was a little green house"

There was a little	green	*house,*
And in the little	green	*house*
There was a little	brown	*house,*
And in the little	brown	*house*
There was a little		*house,*
And in the little		*house*
...	...	
There was a little	*heart.*	

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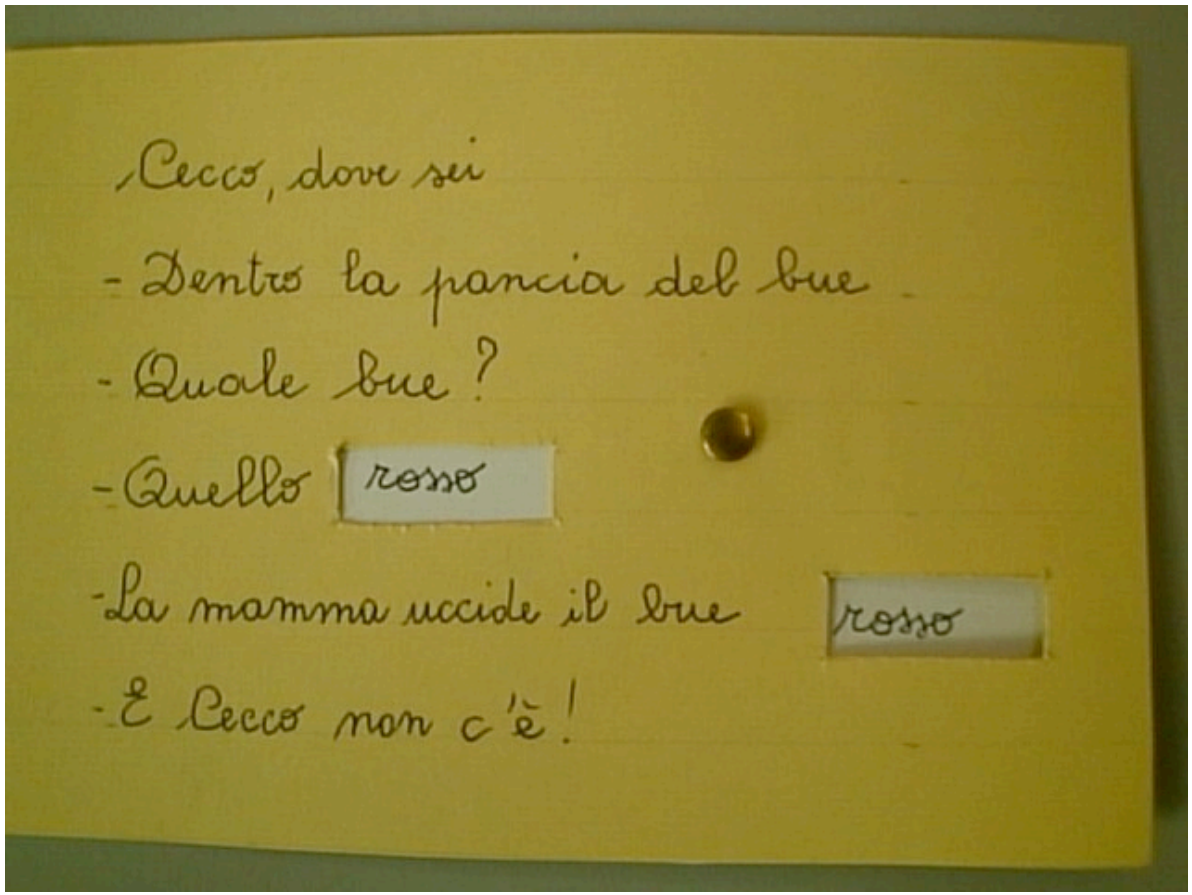
And in the little	blue	*house*
...	...	
There was a little	*heart.*	

Analysis and discussion: Abstract model(s)

"There was a little green house"

There was a little	green	*house,*
And in the little	green	*house*
There was a little	brown	*house,*
And in the little	brown	*house*
There was a little	pink	*house,*
And in the little	pink	*house*
...	...	
There was a little	*heart.*	

"Cardboard machine": Concrete model



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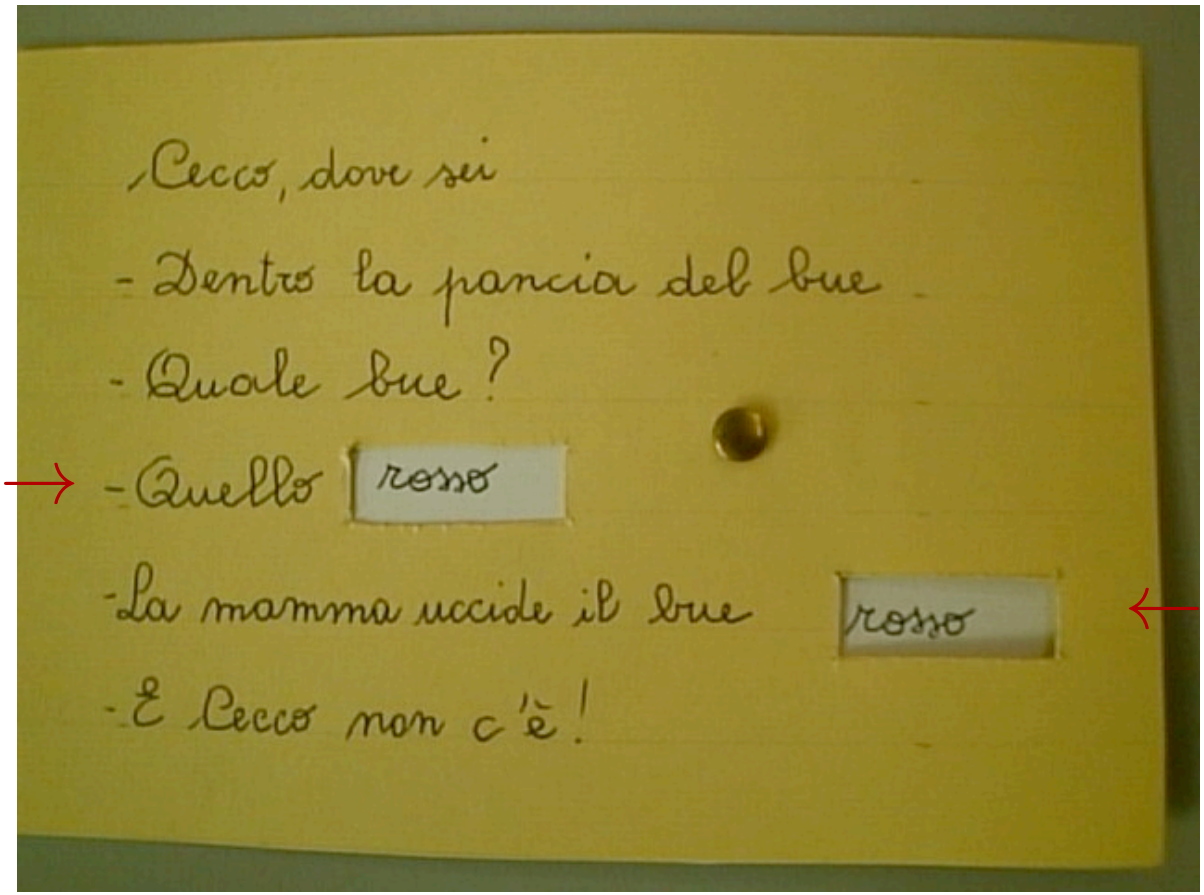

red →

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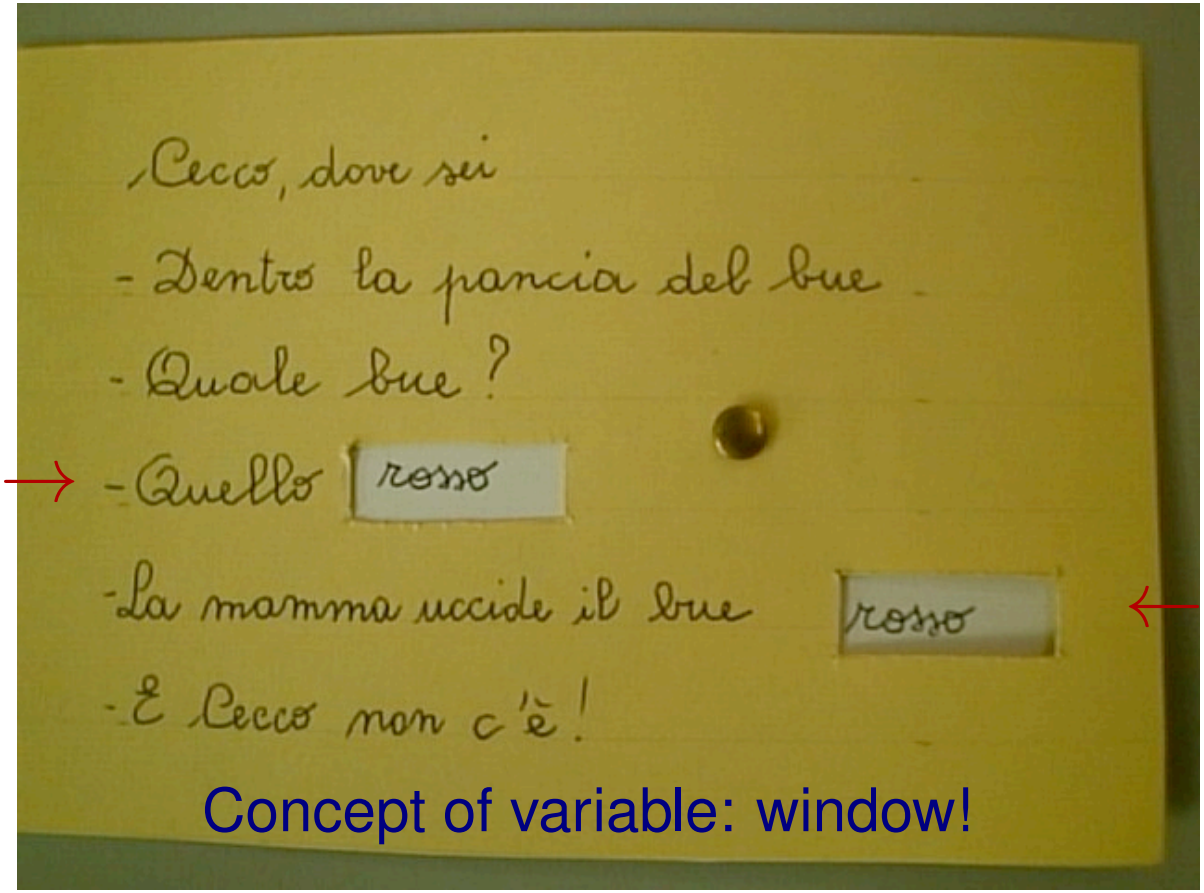

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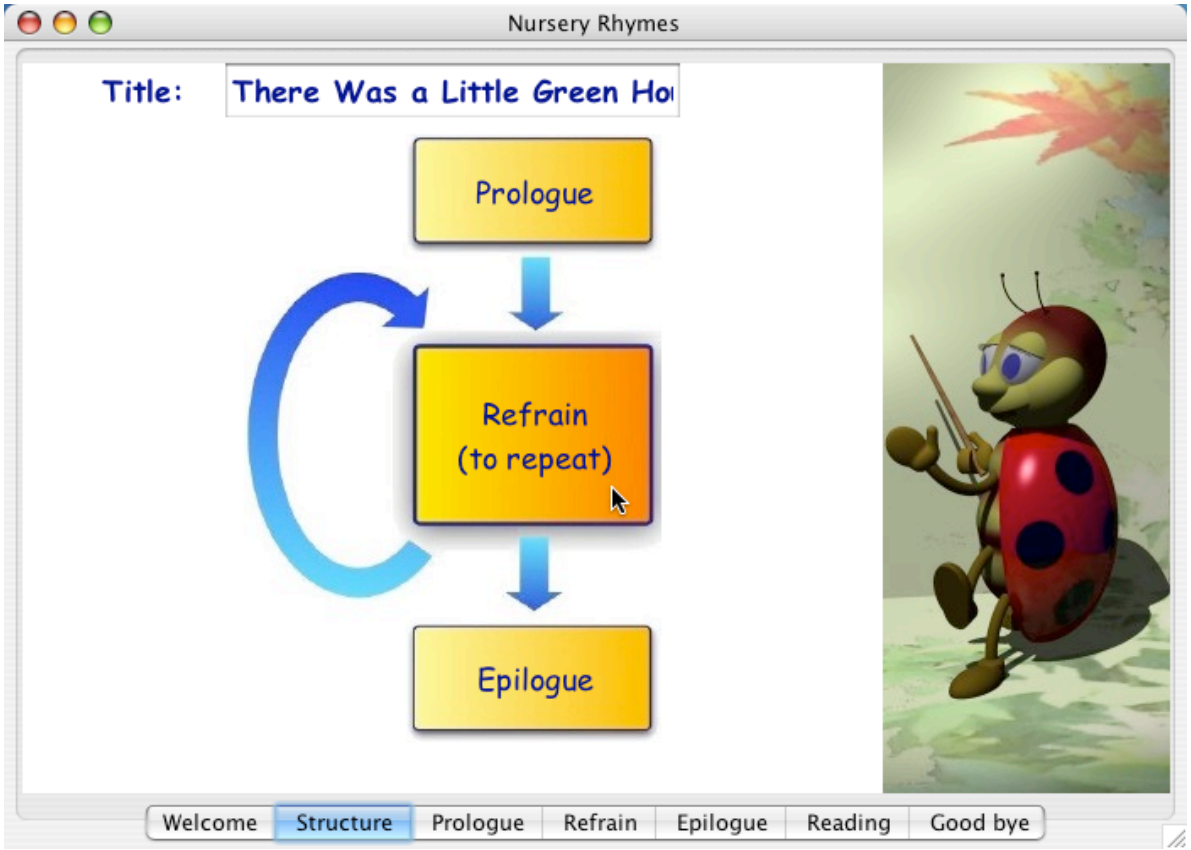
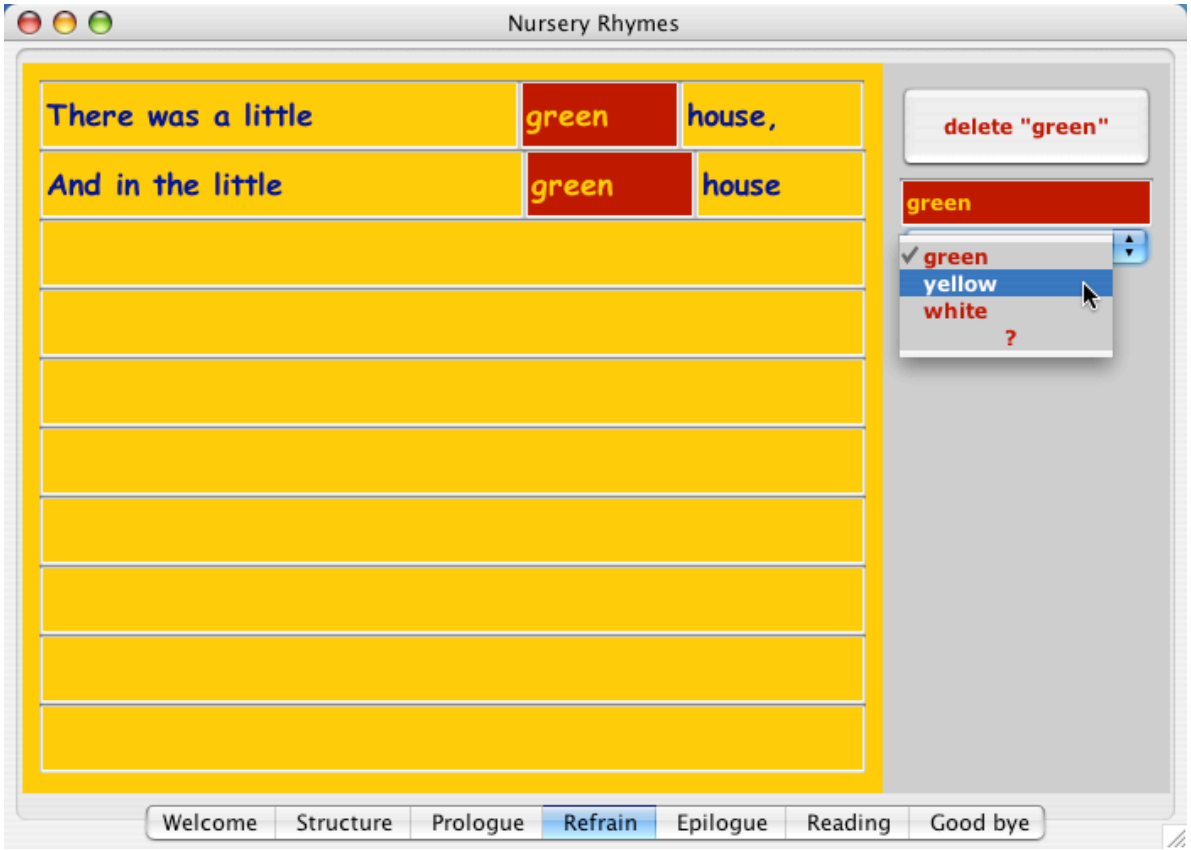
Experimentation: *Ladybug*'s model (structure)



Experimentation: *Ladybug*'s model (variables)



Experimentation: *Ladybug*'s model (outcome)

Structure, relations, rules. . . : *Ladybug*'s model

- Simple iterative structure (*prologue – refrain – epilogue*) + a few variables;
- Partial support for suffixes, articles, other particles;
- Limited support to check rhyming words.
- Syntax vs. semantics;
- How would you "fool" the *ladybug*?

Logo program: Algorithmic model

Under the teacher's guide...

```
to  refrain :color
    print (sentence [There was a little] :color [house,])
    print (sentence [And in the little]  :color [house] )
end

to  epilogue
    print [There was a little heart.]
end

to  there_was_a_little_green_house :colors
    foreach :colors "refrain
    epilogue
end
```

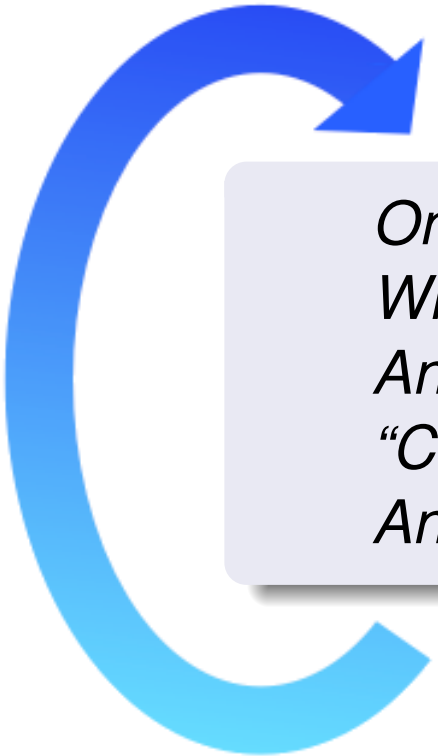
Further discussion: Beyond iteration

"Once upon a time there was a king"

Once upon a time there was a king
Who sat on his throne
And said to the fool,
"Can you tell me a tale?"
And his witty jester did begin:

Once upon a time there was a king . . .

Further discussion: Iteration...



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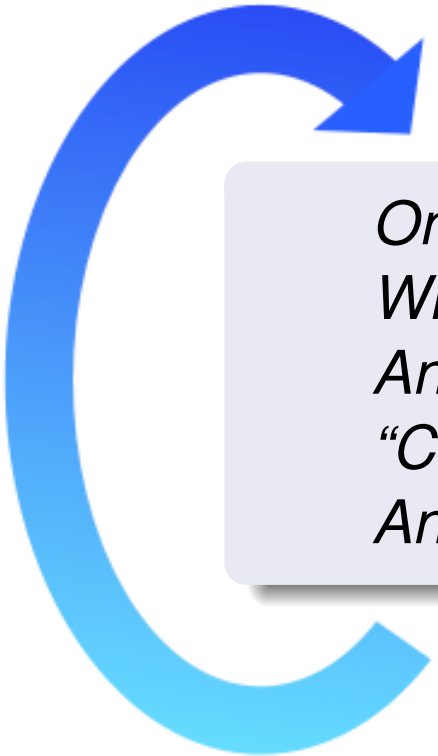

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Syntax: bare repetition

Further discussion: . . . or recursion?

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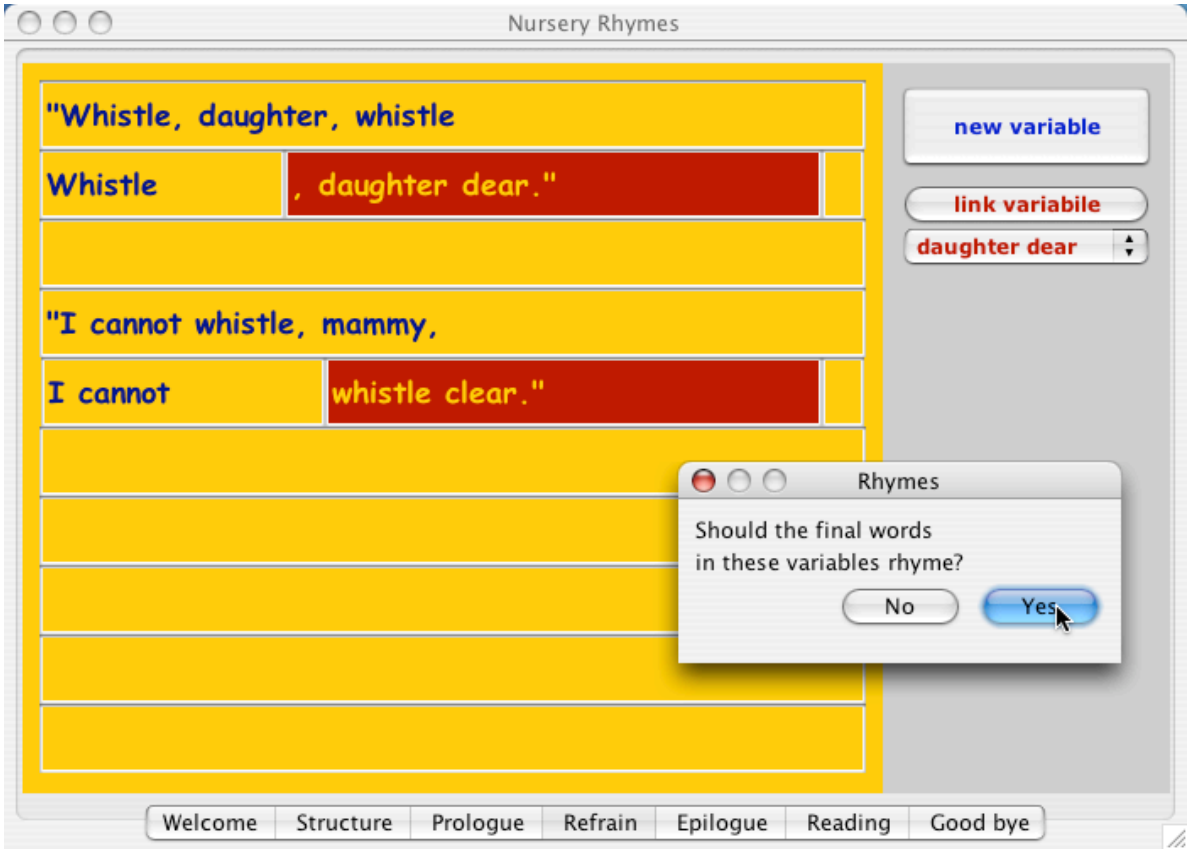
Semantics: more interesting
(see also Dougherty, 2008)

Further discussion: Rules of rhyme checking



To sum up...

The ideas should be understood in their broader sense, after seeing (and mapping between) a variety of instantiations:

- Analysis and discussion: Abstract/conceptual models;
- Cardboard implementation: Concrete/physical models;
- Experiments with *ladybug*: Interactive/relational models;
- Program design and development: Algorithmic models;
- Further discussion: Transfer of models to related domains (critical thinking).

Multidisciplinary links

Strong links with Maths & Science.

- Links with Mathematics:
  - concepts of variable and function;
  - use of formal languages;
  - accuracy.
- Links with Science:
  - observation, identification of patterns, classification;
  - modeling;
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- Implementation:
  - Prominent role of the teacher of Maths & Science;
  - Cooperative design and discussion of path, objectives and units (frequent meetings);
  - One class of 17–22 students (follows previous experience on first year material).
- Feedback:
  - Test and questionnaires administered to students;
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  - Open-answer questionnaire on the perception of computing and on the ability to draw connections.
- 2nd year:
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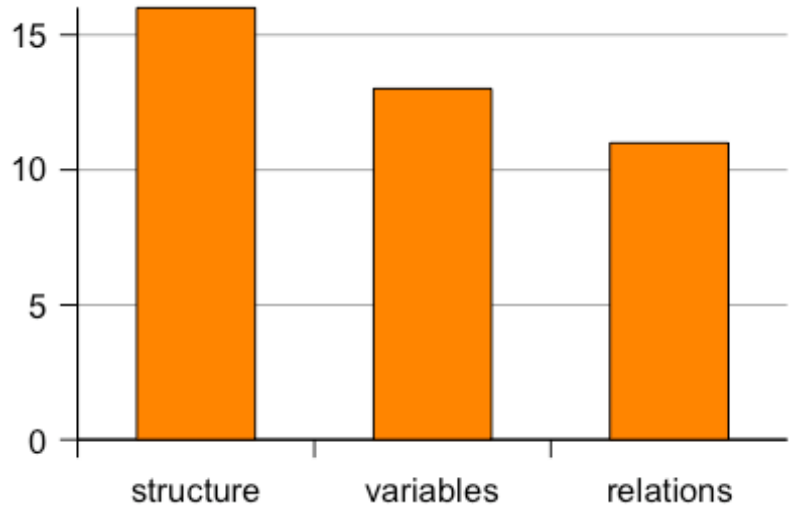


Analysis of nursery rhymes (1st year)

Fila la lana
Fila la lana
e con lei
Fila le stagioni
Arriva la primavera
E il cuore spera
Arriva l'estate
E porta giornate assolate
Arriva l'autunno
E il cuore si fa taciturno
Arriva l'inverno
E il freddo sembra eterno.
Il tempo passerà
E il tuo cuore crescerà.

Il gelato
Ho mangiato un bel gelato
Colorato e profumato.
Marrone
è il color del cioccolato
Bianco
È il color della panna
Giallo
È il color della crema
Verde
È il color del pistacchio.
In un lampo l'ho inghiottito
E la pancia lo ha digerito.

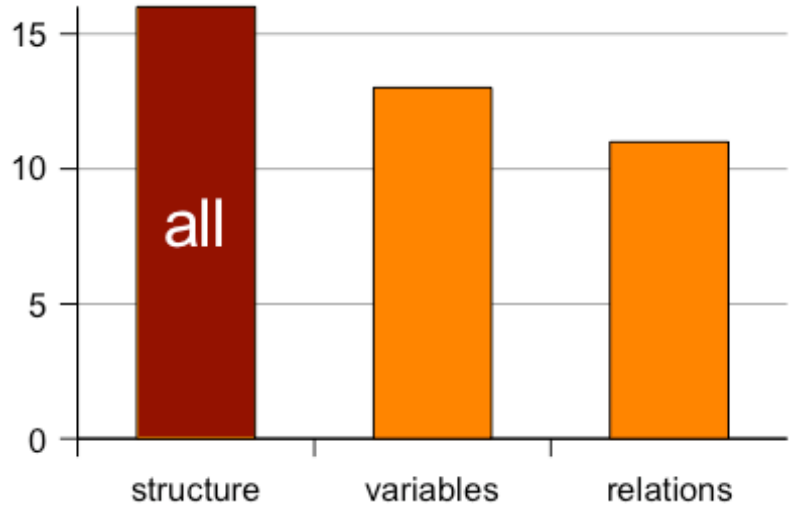
Le oche
Un'oca, un'ochina e
un'ochetta andavano a bere
alla fonte del Re
Due oche andavano a ber
Un'oca, un'ochina e
un'ochetta andavano a bere
alla fonte del Re
Tre oche andavano a ber
Un'oca, un'ochina e
un'ochetta andavano a bere
alla fonte del Re
Quattro oche andavano a
ber
Un'oca, un'ochina e
un'ochetta andavano a bere
alla fonte del Re
Cinque oche andavano a ber
.....

Nelle filastrocche ripetitive:

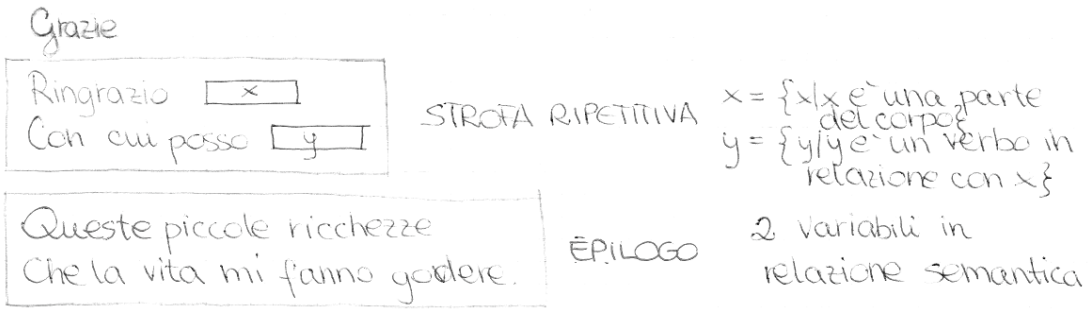
P.FISSA VARIABILE

2) individua quando è possibile: *prologo* , *strofa ripetitiva* ed *epilogo.*
3) nella strofa ripetitiva individua la parte fissa
4) nella strofa ripetitiva individua le variabili e definisci l'insieme in cui variano.

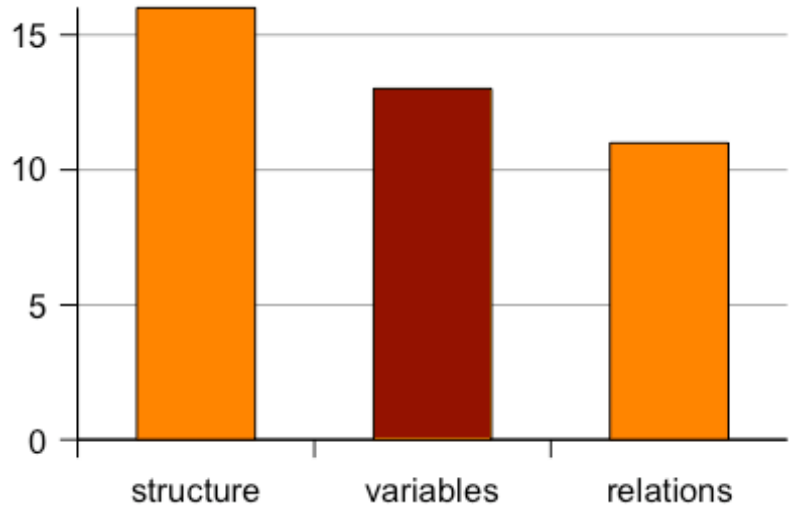
general structure
invariant vs. variant



Analysis of nursery rhymes (1st year)



variables
domain of values



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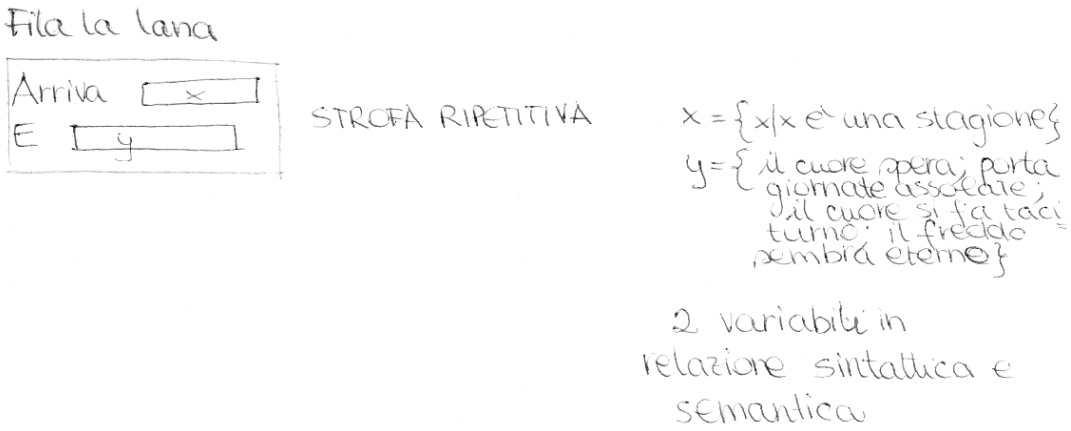
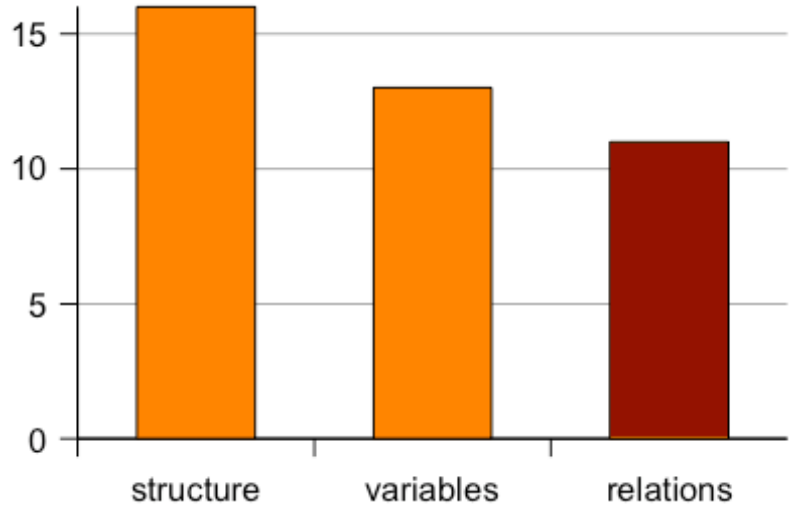
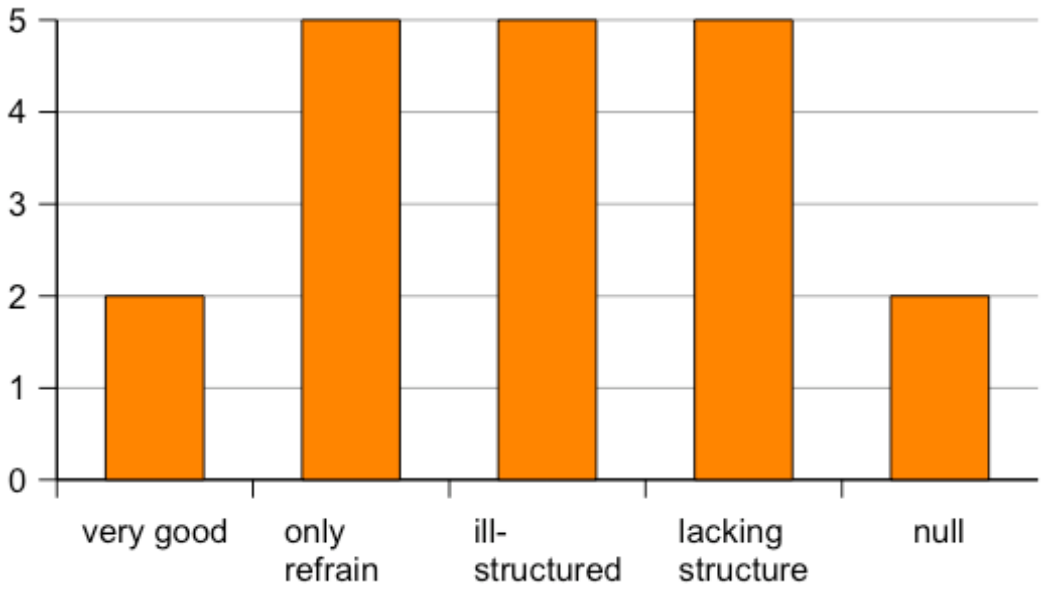


vars relationships
syntactic vs. semantic

vars relations:
rhyme and meaning



Programming in Logo (2nd year)



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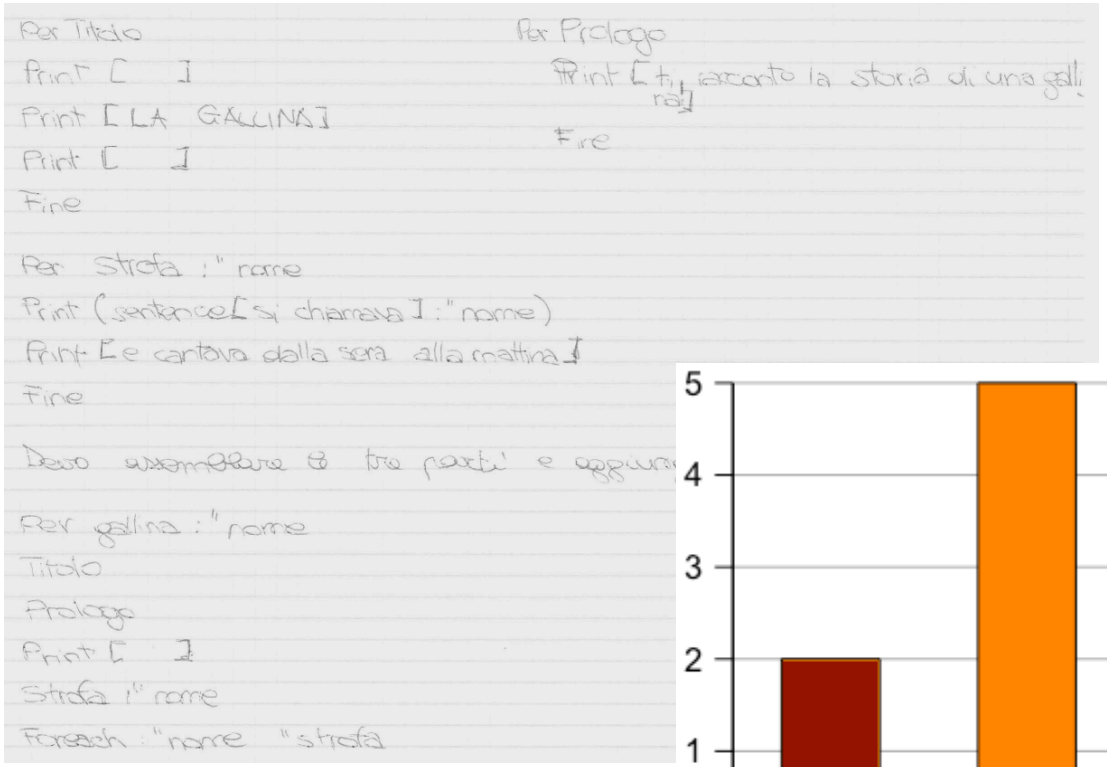
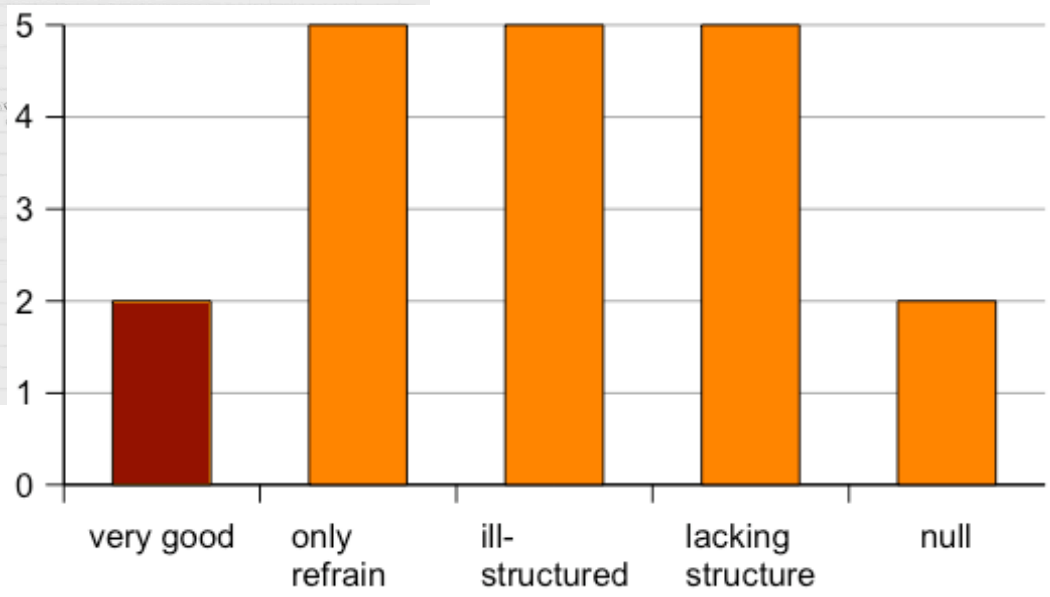
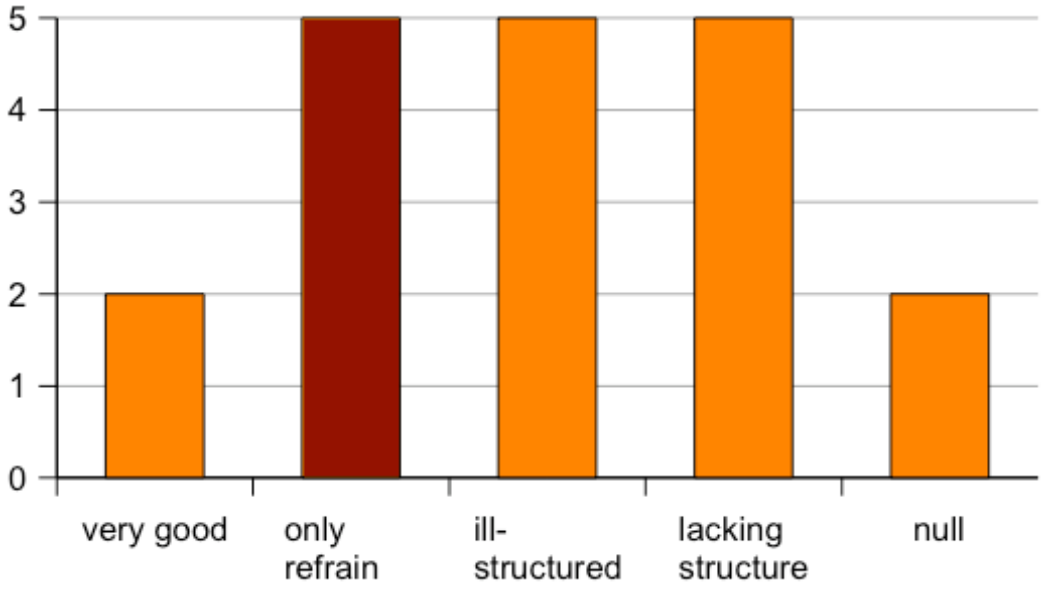




Programming in Logo (2nd year)

```
per LA GALLINA: "nome
print [Ti racconto la storia di una gallina]
print (sentence [si chiamava]: "nome)
print [e cantava dalla sera alla mattina]
```

procedural structure



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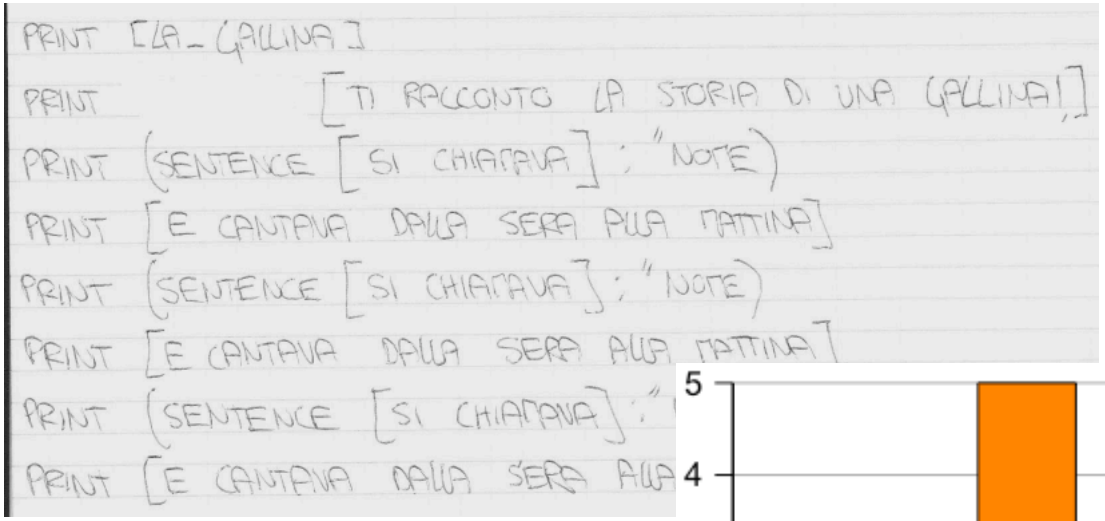

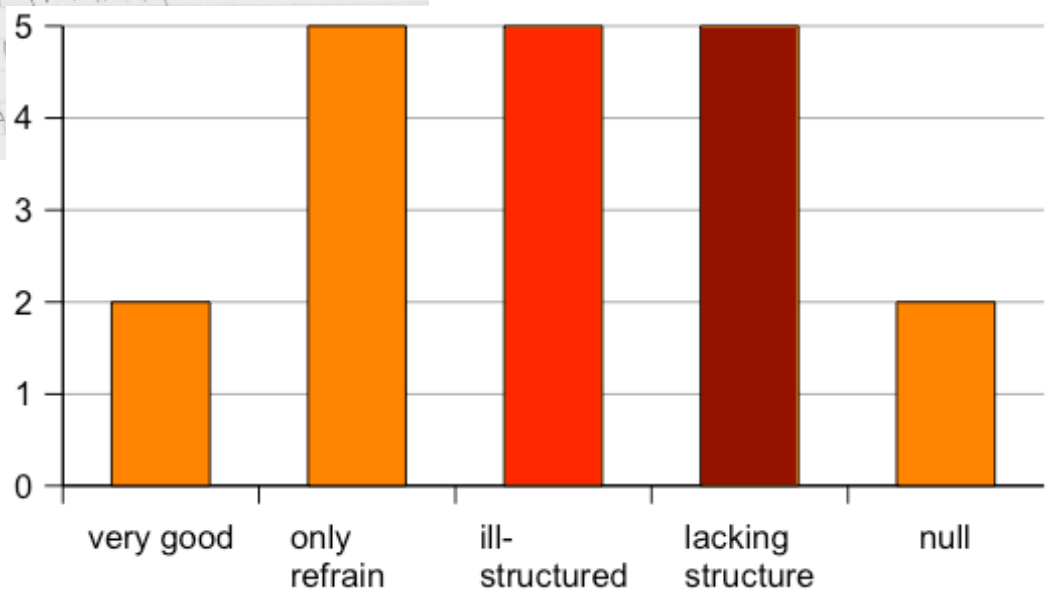

About the perception of Logo...

Did you prefer to use Logo or the Ladybug application?

students	2nd year	3rd year
7	Logo	Logo
2	Logo	both
6	Logo	Ladybug
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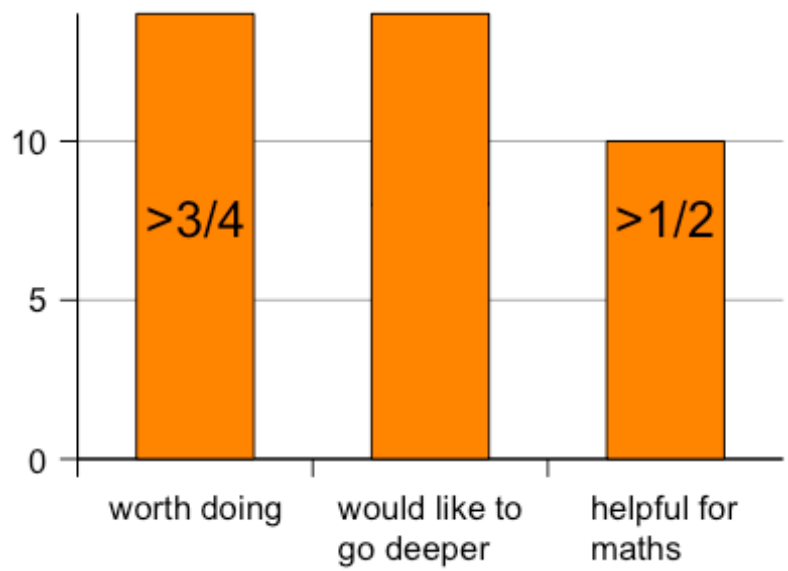
Perception of overall experience (3rd year)

Open-answer questions:

- Did you find the activity useful?
- Would you like to have done something more?
- Do you think that [...] it was helpful to better understand mathematics?



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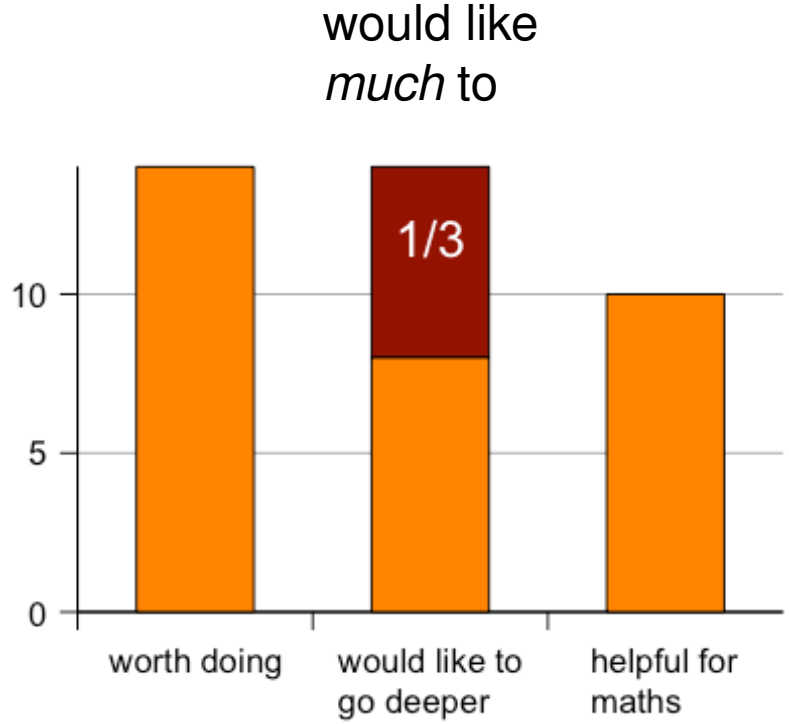

Miscellaneous annotations from the questionnaires

- Quite surprising that "computational" models can be applied to explain "everyday" phenomena.
- Some pupils found it difficult to program, whereas others felt positively challenged: *"I feel smarter when I'm able to achieve the result."*
- Some pupils pointed up the analogy between rhyme- and spell-checking with text editors.
- Several students raised the topic of *machine intelligence*.

Teachers' observations: Computation & programming

- Interestingly, the pupils proposed an "onion-skin" structure for Branduardi's popular song "Highdown Fair": specific language to describe recursive phenomena.
- Programming contributed to "de-mythicize" computers.
- Groupwork allowed to complete the programming tasks, but individual contributions were uneven.
- Compliance with (Logo) syntax requirements may be frustrating.

Teachers' observations: Competence transfer

- In order to communicate ideas, the students exploited a variety of verbal and graphical languages.
- By working with machines, the students could appreciate the reasons of formal accuracy (see also Ferrari, 2004).
- After a "concrete" experience with nursery rhymes, classifying living beings (natural sciences) or shapes (geometry) was easier than it used to be.
- Similarly, improved ability to recognize structures of narrative texts.

Teachers' observations: Weak students

- The grounding on simple, concrete examples seems to have improved the understanding of maths concepts.
- Weak students seem to have gained self-confidence, conceivably because the activities were not standard school tasks which are sources of anxiety to them.
- Interesting anecdote: After interviewing a weak student in mathematics, a psychologist was impressed by her *deep* understanding of the concept of *variable*.

Conclusions

- Nursery rhymes: overly juvenile?
  - At first: emotional engagement;
  - Later: attention on structures.
- Difficult to schedule time slots for extra-curricular activities.
- Limited (and not properly administrated) lab resources.
- Overall, positive experience:
  - seems to have been beneficial to students;
  - . . . but also to the teachers.
- Answers to open questions turned out to be scarcely informative. . .
- It would be interesting to replicate this experience to assess it from an educational research perspective.

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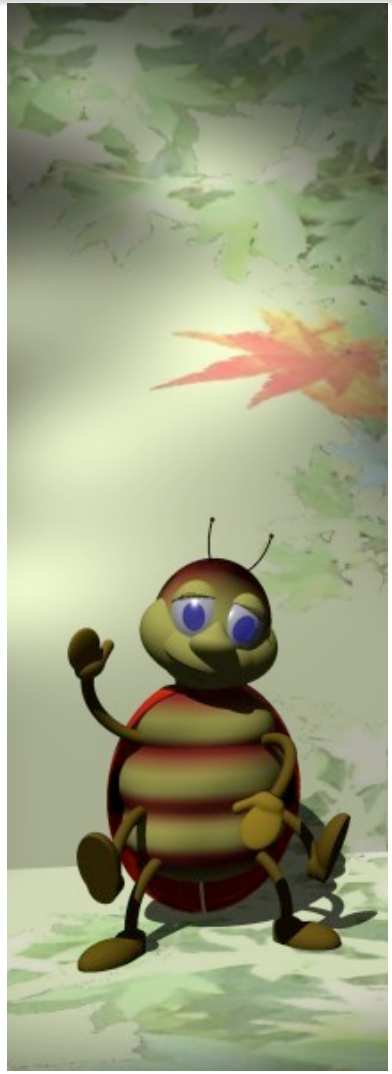

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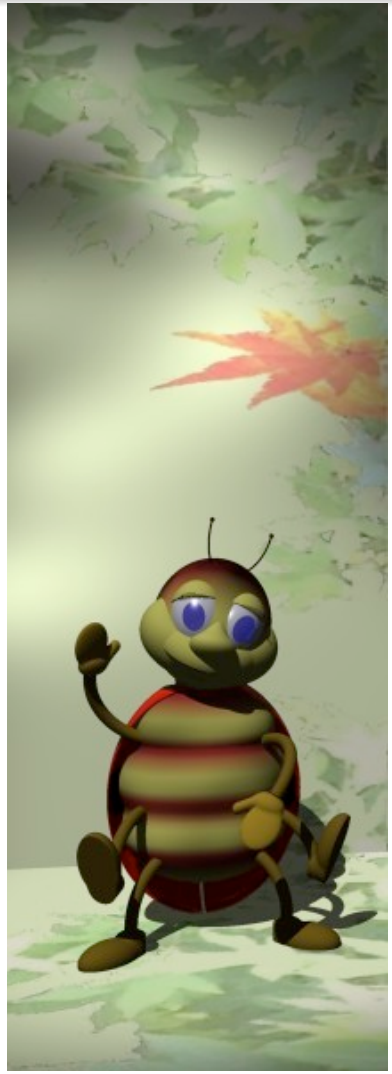

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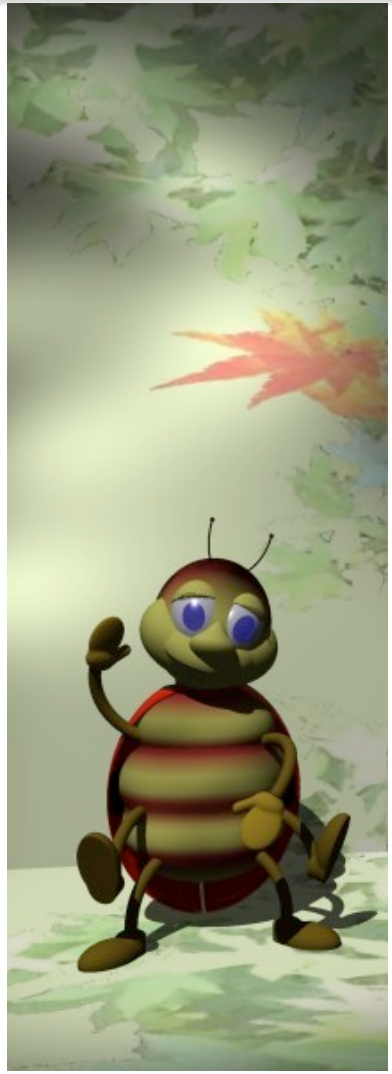

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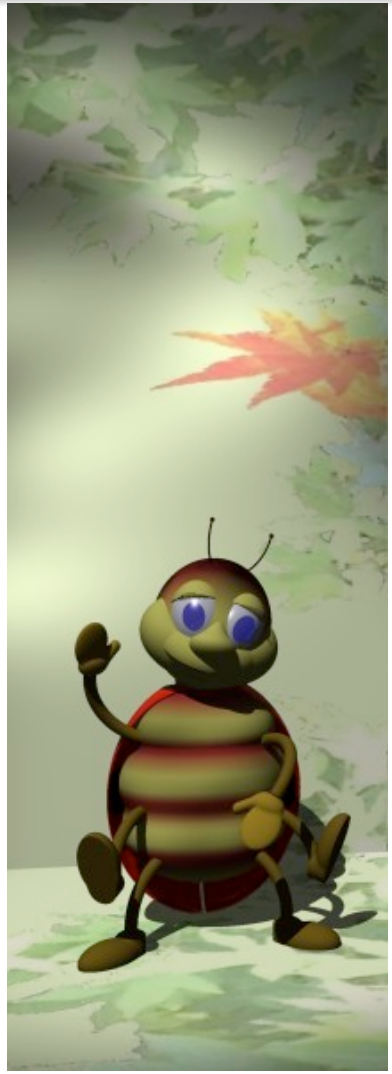

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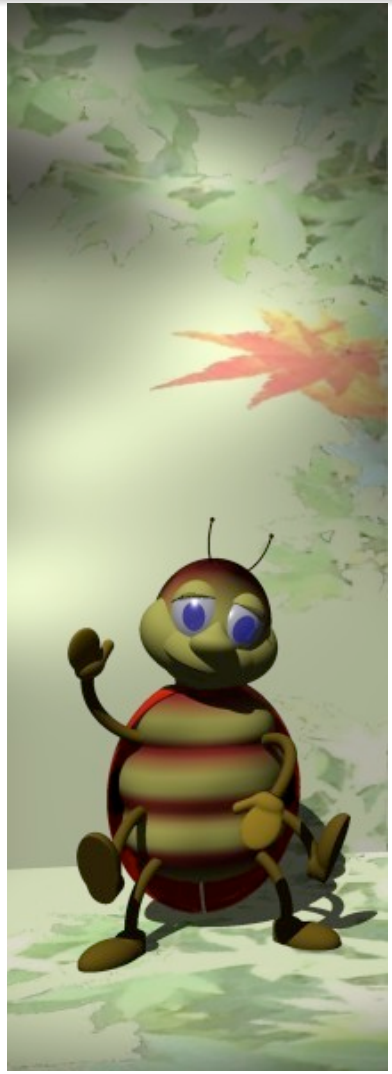

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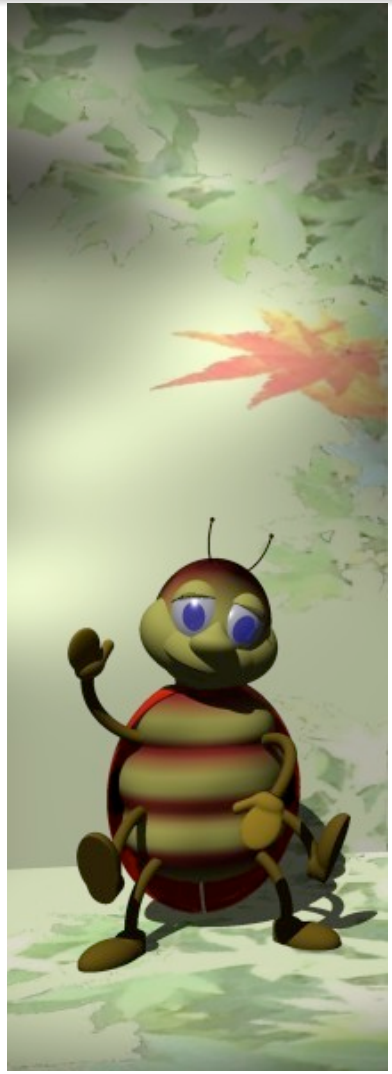

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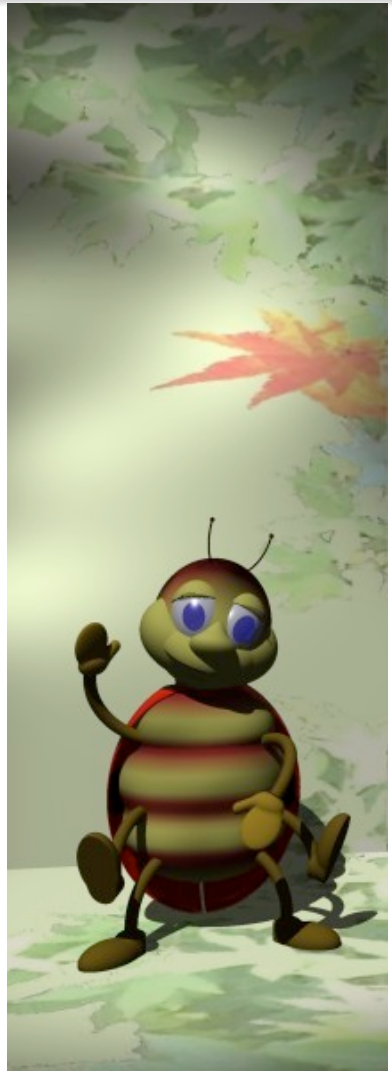

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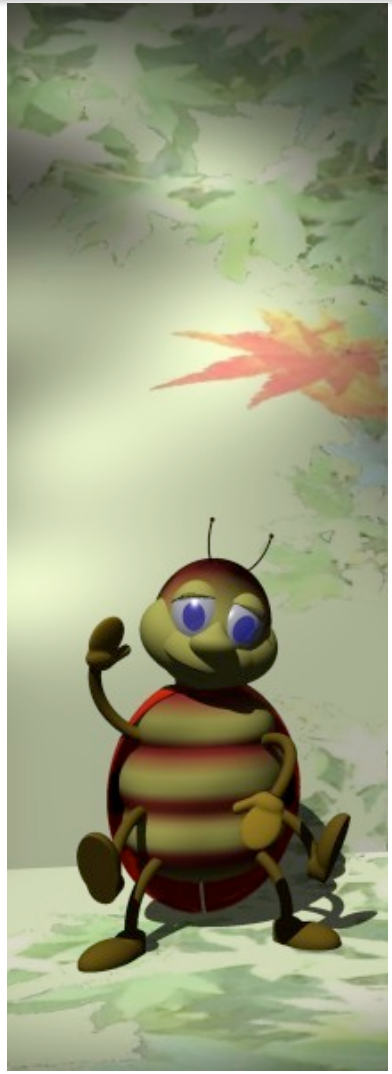

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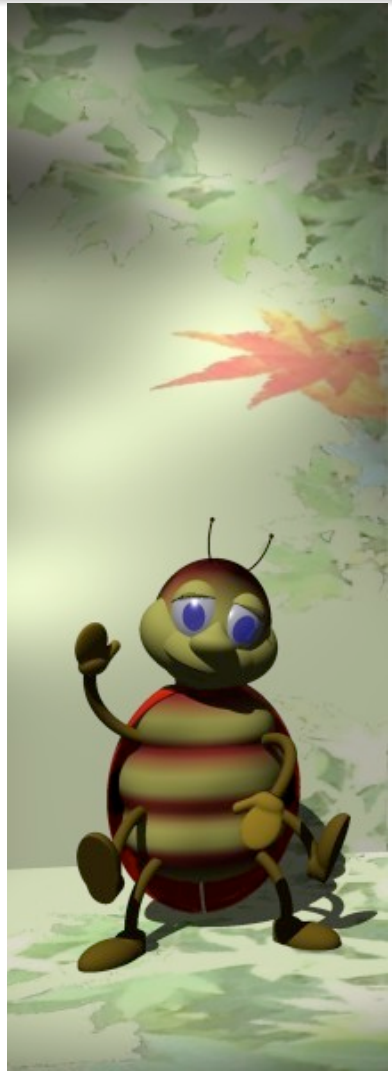

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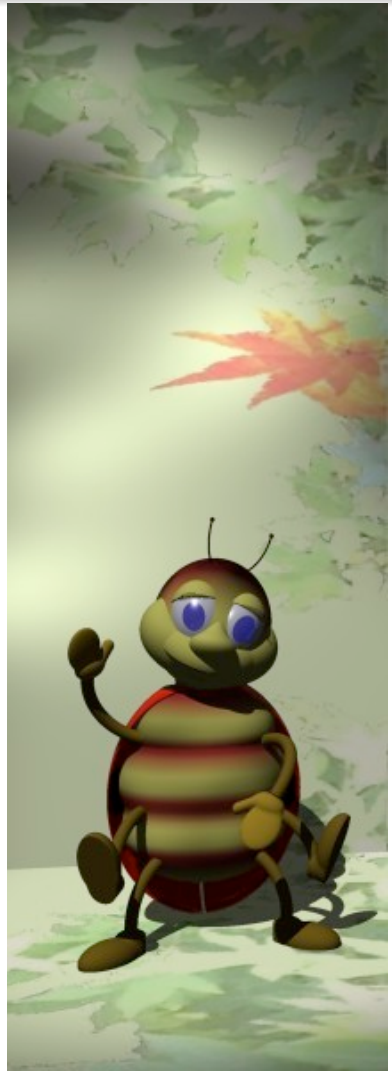

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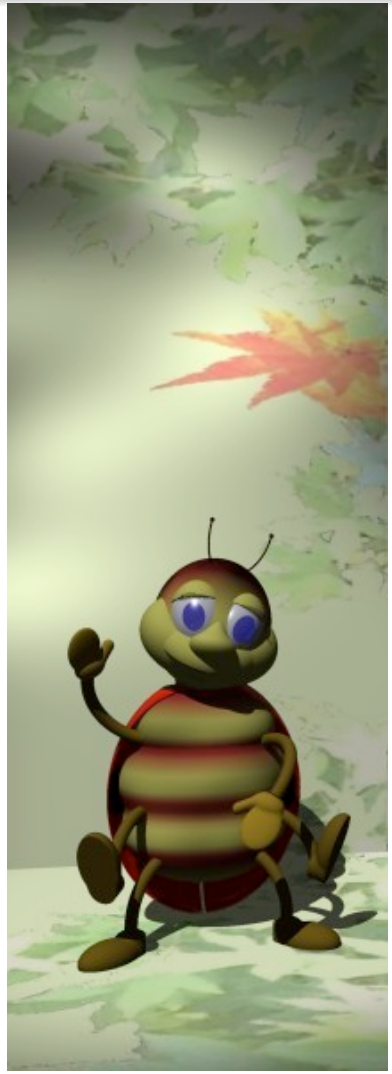

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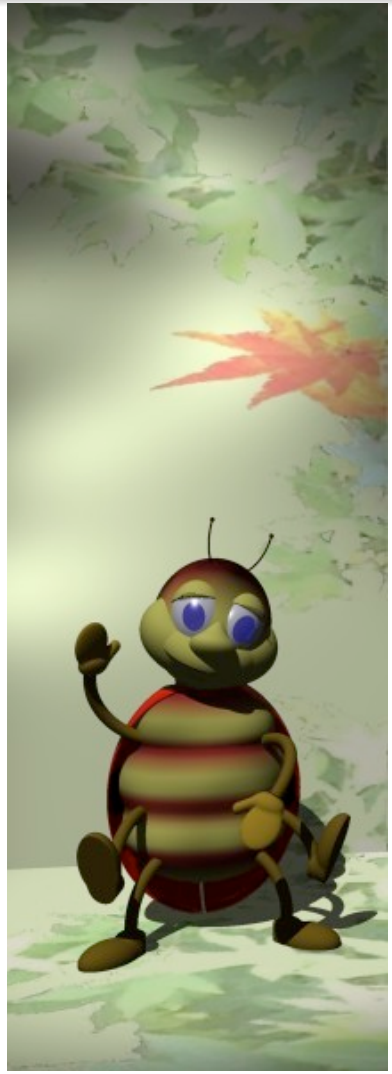

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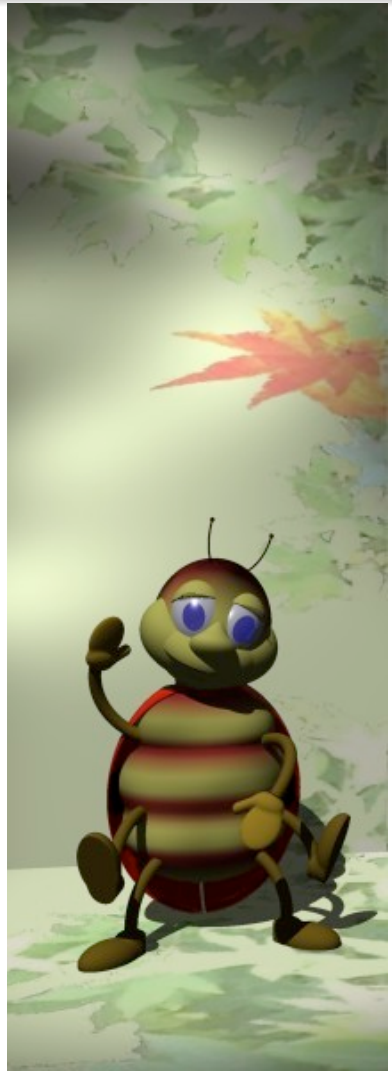

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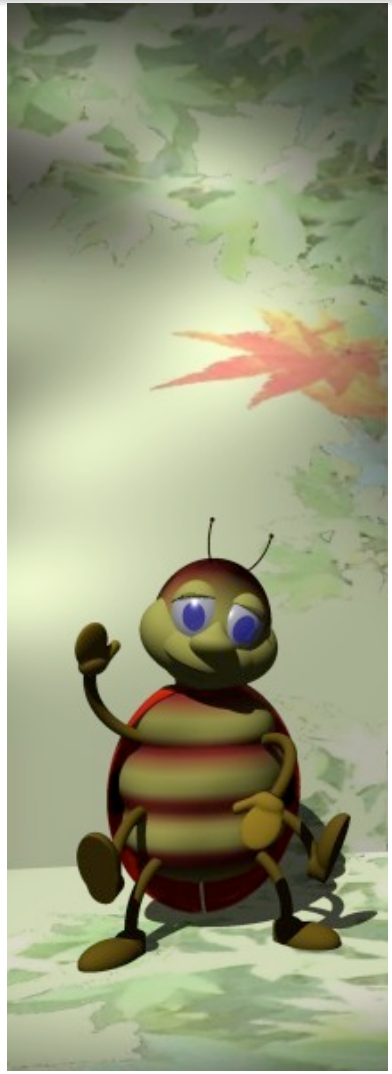

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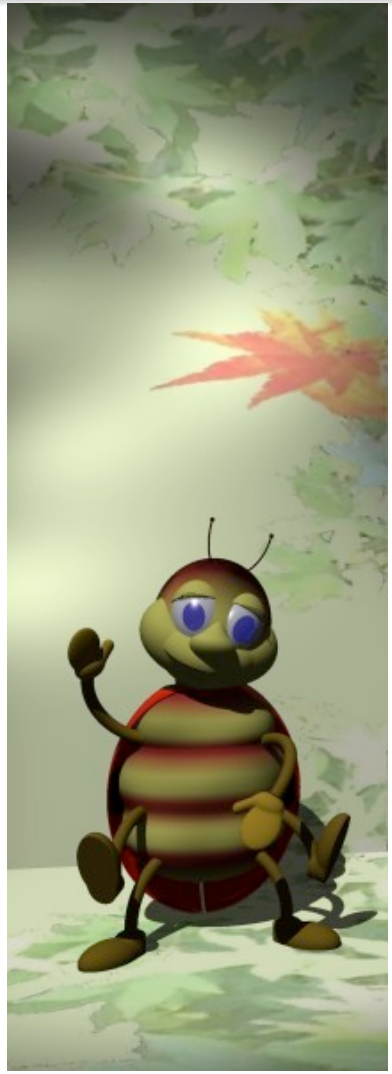

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