

# **STUDENT MODELLING AND KNOWLEDGE ACQUISITION PROCESS IN COMPLEX NATURE DOMAINS**

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# Background

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PhD in Computer Science

Federal University of Paraná (UFPR), Curitiba

Artificial Intelligence applied in Education

Main research interests:

- Intelligent tutoring systems.
- (Multiple) external representations.
- Knowledge and student modelling.

→ Teaching of Computer Programming.



# Problem Background

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- *Teach yourself programming in ten years* [Norvig, 2001].
- **Deliberate practice** is a key factor in expertise development for a wide variety of areas.
- Suggestions:
  - Perform tasks which are just **above the current ability level** of the learner.
  - Informational feedback.
  - Opportunity for **repetition** (task revisiting).
  - Opportunity for **error recovery** scenarios.
- **Ordering the statements** (exercises) to be presented to learners is a **crucial pedagogical aspect** in the expertise development.

# Problem Background

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- Problem of providing mechanisms in a ITS to **backward** or **forward problem statements** according to the learner's performance in the resolution.
- For that, the tutoring system need a precise model that dynamically adjusts the **learner profile** in accordance with the **domain knowledge**.
  - It is also necessary to **classify each statement** according to the demanded fraction of domain knowledge.
- Problem to provide a **epistemology** that describes:
  - Progress of the **learner's capacities**; and
  - **Statements** to be offered for the learner.

# Conceptual Framework

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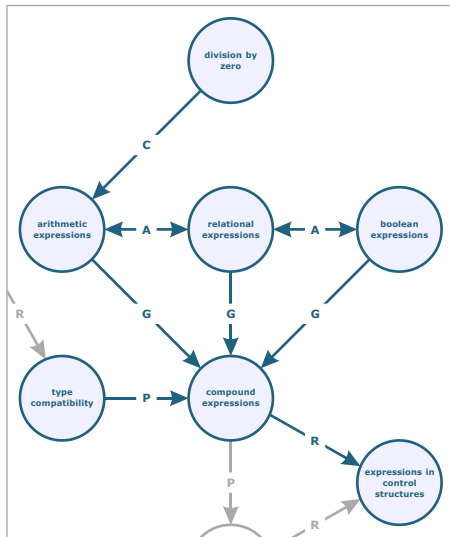
## Learner modelling and statement sequencing for learning sessions [Maschio and Direne, 2015]

- We revisited the **genetic graph** or **overlay model** [Goldstein, 1979].
- The approach consists in representing the **learner knowledge** as a subset of the **domain knowledge**.
- By **overlaying** both sets, a tutoring system can **infer** (or replan) pedagogical objectives.
- This assumes that domain and learner models are using comparable representations.
- The genetic graph is a **evolutionary** and **epistemological** model.

# Conceptual Framework

## Genetic Graphs

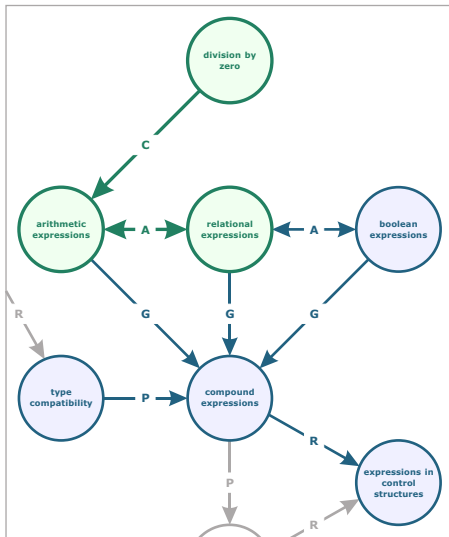
- Skills
  - vertices
- Evolutionary relationships
  - edges
  - generalization / specialization
  - analogy
  - simplification / refinement
  - deviation / correction
  - prerequisite / post-requisite



# Conceptual Framework

## Genetic Graphs

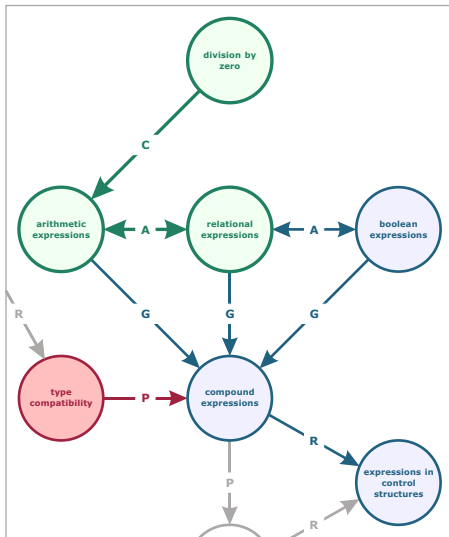
- Learning Modelling
  - Overlay of the domain knowledge.
- Tutoring
  - Suggest the tutoring topic.
  - Supplies multiple explanations.
- Learning Process
  - Learning measures (graph-based, like distance, path).
  - Learners simulation.



# Conceptual Framework

## Genetic Graphs

- Learning Modelling
  - Overlay of the domain knowledge.
- Tutoring
  - Suggest the tutoring topic.
  - Supplies multiple explanations.
- Learning Process
  - Learning measures (graph-based like distance, path).
  - Learners simulation.



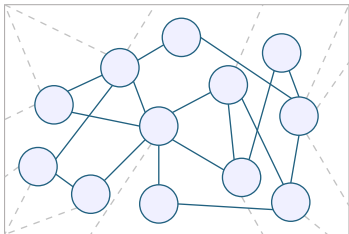


# Conceptual Framework

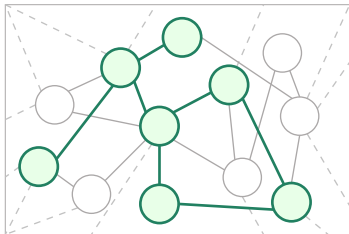
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## Overlay Model

The learner is modeled as a subset of the domain knowledge model.



**Domain Model**



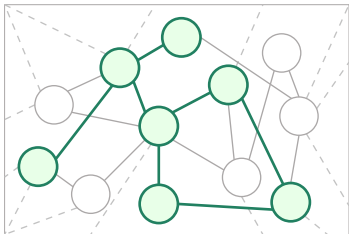
**Learner Model (Overlay)**

# Conceptual Framework

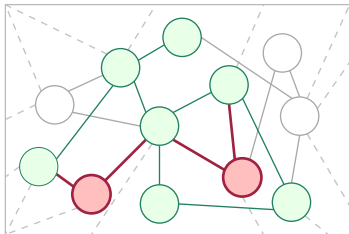
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## Overlay Model

A search algorithm finds and returns a list of **priority skills** to be learned, based on a set of criteria.



Learner Model (Overlay)



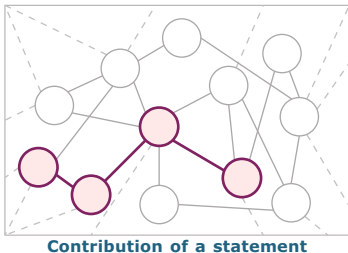
Priority skills to be explored

# Conceptual Framework

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## Overlay Model

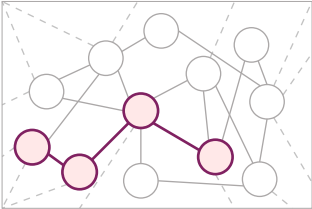
**Elicitation** and **catalogation** of **problem statements** which are described as subgraphs of the Domain Model, also as a **overlay**.



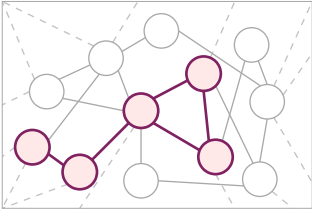
Here, we **extended** the original idea of [Goldstein, 1978].

# Conceptual Framework

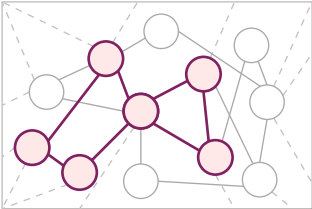
## Overlay Model



Statement 1

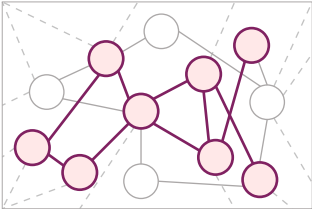


Statement 2



Statement 3

(...)

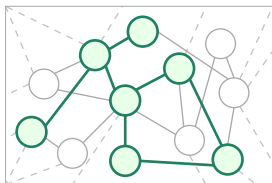


Statement N

# Conceptual Framework

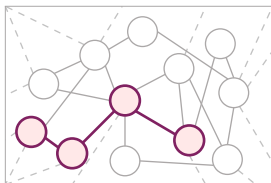
## Overlay Model

Updating the Learner Model after a problem statement resolution.



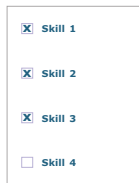
**Learner Model**

+



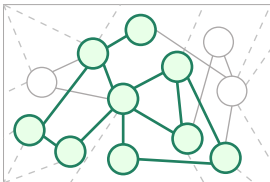
**Statement 1**

+



**Evaluation**

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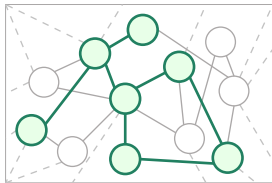
**Updated Learner Model**

# Conceptual Framework

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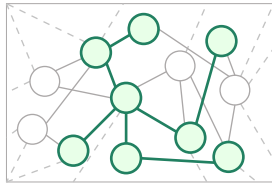
## Overlay Model

Overlaying the Learner Model of a group (classroom) and have a mirror of the emphasis with which the skills were taught.



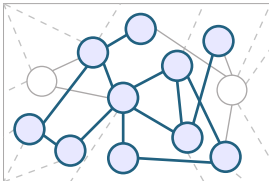
Learner 1

+ (...)



Learner N

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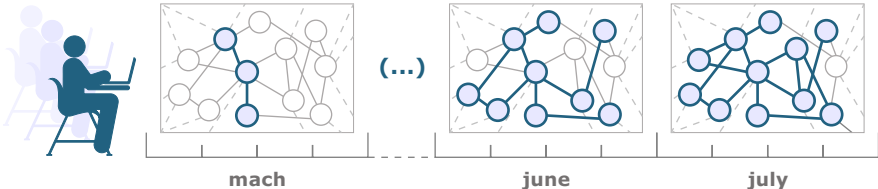
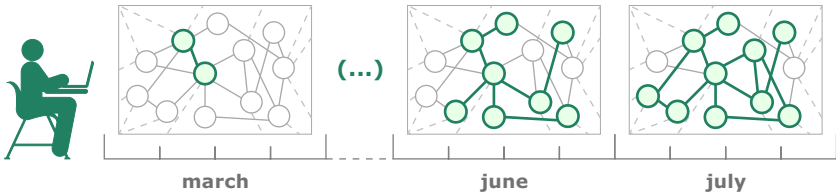
Classroom Model

# Conceptual Framework

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## Overlay Model

Providing details of the temporal dimension (history) of the progress of a learner (or a classroom).



# Prototyped Tools

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The conceptual framework is supported by three implemented tools.

1. **Domain model description**

By constructing the genetic graph with the skills.

- Validation of the graph structure by running reachability of any feature.

2. **Problem statements elicitation**

That are described as subgraphs of the domain model.

- Requisition of problem statements.

3. **Problem statements ordering**

Intelligent and adaptive, considering the learner dynamic modelling.

- Update of the Learner Model.



# Conclusion

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## Open Questions

- Parameters adjustment.
- (Re)solutions assessment for update the Learner Model.
- Deeper evaluation of the framework.
- Reduce the distance between research and application.  
(my problem vs. community problem)

## Future Directions

- Hybrid modelling with bayesian networks [Vier et al., 2015].
- Open Student Modelling.
- Open Social Student Modelling [Brusilovsky et al., 2016].
- Competitive and collaborative approaches.
- Gamification.