Construction Spaces
for the Design of Learning Tasks
in Virtual Worlds

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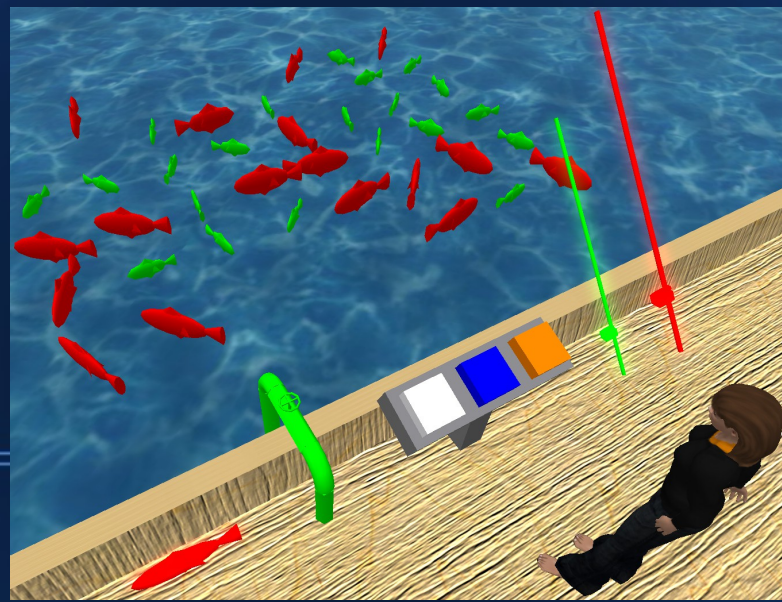ECGBL 2014

Agenda

- Problem Statement
- Study case
- Design approach
- Evaluation

Introduction

and Problem Statement

Virtual Worlds in Ecuation

- Multi-user virtual environments, e.g. *Second Life*

- Games,
  e.g. computer role-playing games

- Activities: Crafting, Conversations ...

Biology experiment
[*OpenSim*]

Literature game
[*Neverwinter Nights*]

Ferdinand von Walter
Ich habe mich in Ihnen betrogen, Lady.
Ich erwartete - ich wünschte, Sie
meiner Verachtung würdig zu finden.
Fest entschlossen, Sie zu beleidigen
und Ihren Hass zu verdienen, empfing
ich Sie - glücklich wir beide, wenn mein
Vorsatz gelungen wäre! Ich liebe,
Milady, liebe eine Bürgerliche - Luise
Millerin, eines Musikus Tochter. Können
Sie eine Hand ohne Herz erzwingen?
Können Sie einem Mädchen den Mann
entwenden?

1. Weil ich es muss. Meine Leidenschaft, Walter,
   weicht meiner Zärtlichkeit für Sie. Meine Ehre
   kann's nicht mehr. Unsre Verbindung ist das
   Gespräch des ganzen Landes. Alle Augen, alle
   Pfeile des Spotts, sind auf mich gespannt. Die
   Beschimpfung ist unauslöschlich, wenn ein
   Untertan des Fürsten mich ausschlägt. Wehren
   Sie sich, so gut Sie können. Ich lass alle Minen
   sprengen!
2. Walter, ich habe Kerker gesprengt - habe
   Todesurteile zerrissen und manche
   entsetzliche Ewigkeit auf Galeeren verkürzt.
   Und jetzt kommt der Mann, der allein mir das
   alles belohnen sollte. Der Mann, den mein
   unerschöpftes Schicksal vielleicht zum Ersatz
   meiner vorigen Leiden schuf. Der Mann, den ich
   mit brennender Sehnsucht im Traum schon
   umfasste... und sagt Nein??
3. Höre, Walter. Wenn eine Unglückliche -
   unwiderstehlich allmächtig an dich gezogen -
   sich an dich presst mit einem Busen voll
   glühender unerschöpflicher Liebe, Walter, und
   du jetzt noch kalte Worte sprichst... Wenn
   diese Unglückliche - niedergedrückt vom
   Gefühl ihrer Schande, des Lasters überdrüssig,
   heldenmäßig emporgehoben vom Rufe der
   Tugend, sich so in deine Arme wirft.....

Constructivist Learning

- So: virtual worlds can immerse students in interactive simulations of real world activities

- Constructivist view: own versions of domain knowledge (personal constructs, mental models)

- Or pave their own paths towards the knowledge

- Design: Simulations that inspire experimenting

activity	→	simulation	→	visualisation		
		↑		↓		
		verify / falsify	←	**learner**	↔	hypotheses
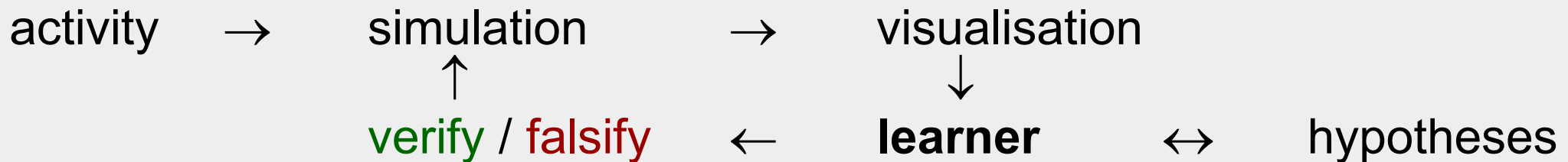
Problem Statement:
How Much Interactive Freedom?

Instruction

Design of activities
Choice of tasks
Feedback, hints
Reflection tools
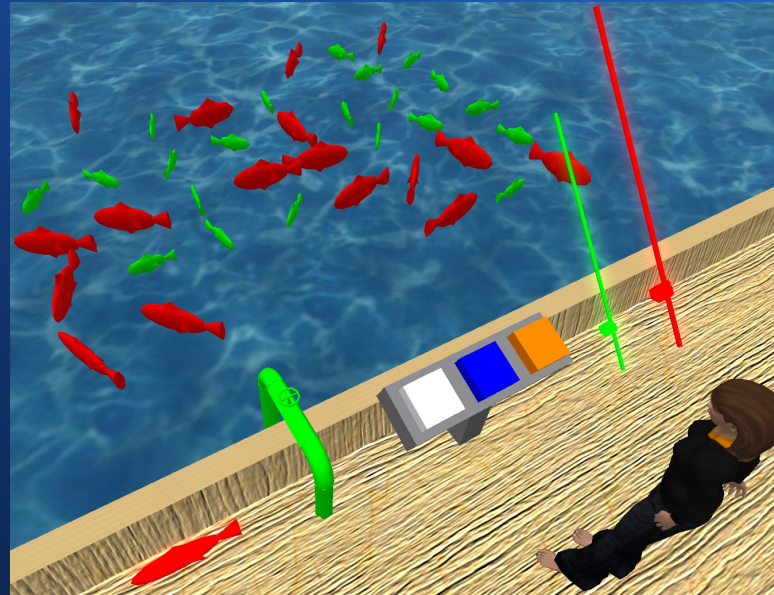
Construction

Experimenting difficult [1]
Self-regulation skills
Lost in possibilty space
Designer: Restrict freedom

[1] de Jong & van Joolingen (1998): Scientific discovery learning
with computer simulations of conceptual domains. *Review of Educational Research*, 68(2).

Study Case

Virtual Factory in *Second Life*

Applied Artificial Intelligence

Steering, e.g. Pursuit
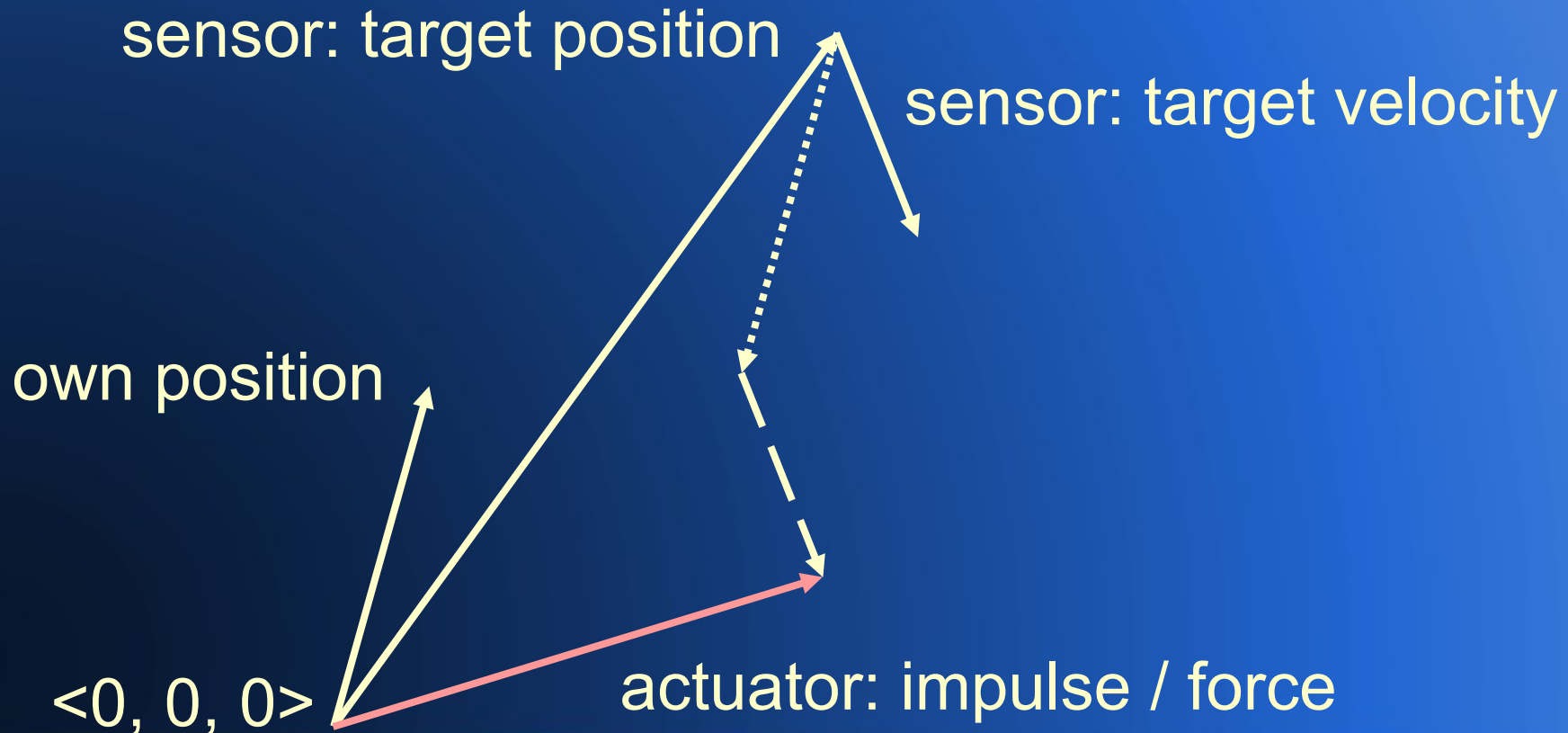
sensor: target position

sensor: target velocity

own position

actuator: impulse / force

<0, 0, 0>

Instructions in a Virtual Factory

Instructions in a Virtual Factory

Instructions in a Virtual Factory

Instructions in a Virtual Factory

Construction: Crafting, Puzzles
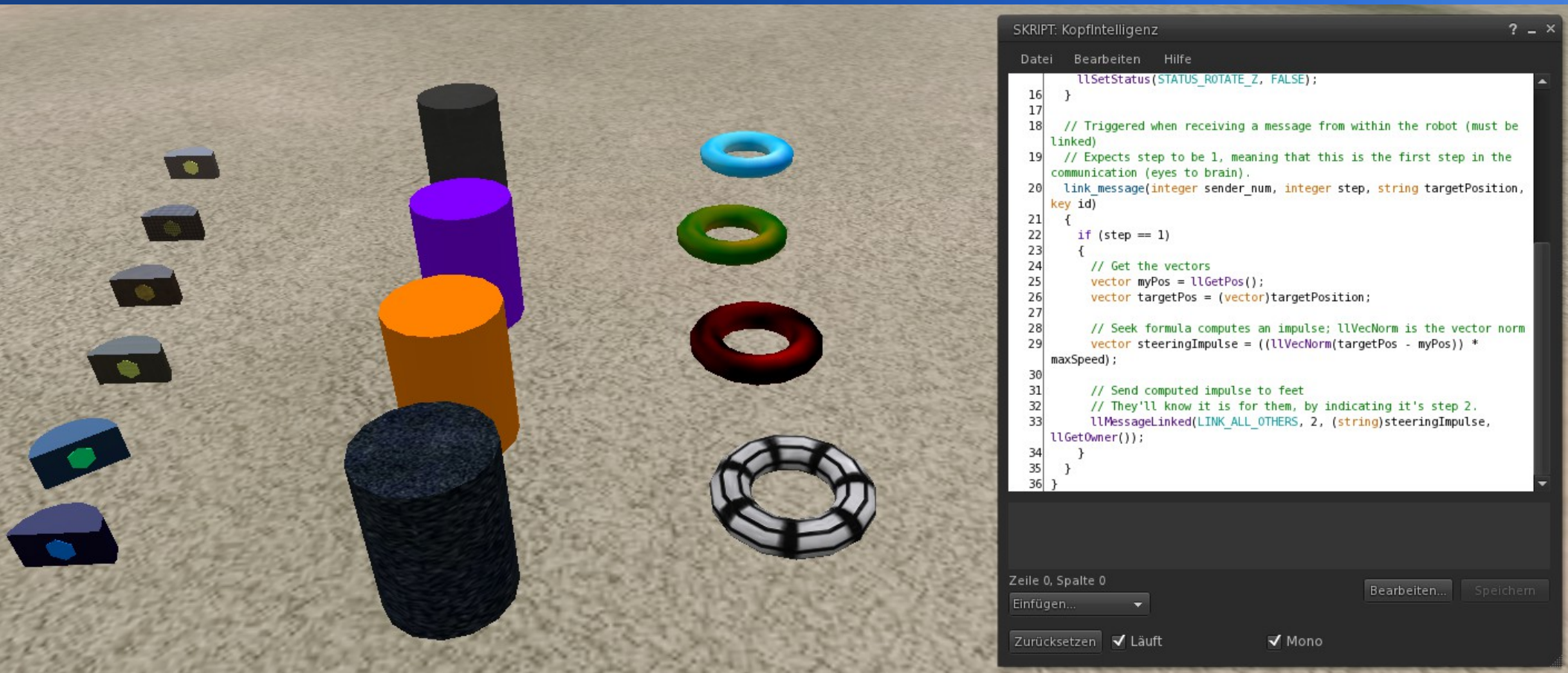
Creativity & Inventions

- Appropriate level of difficulty at the right time
- Appropriate degree of instruction vs. construction
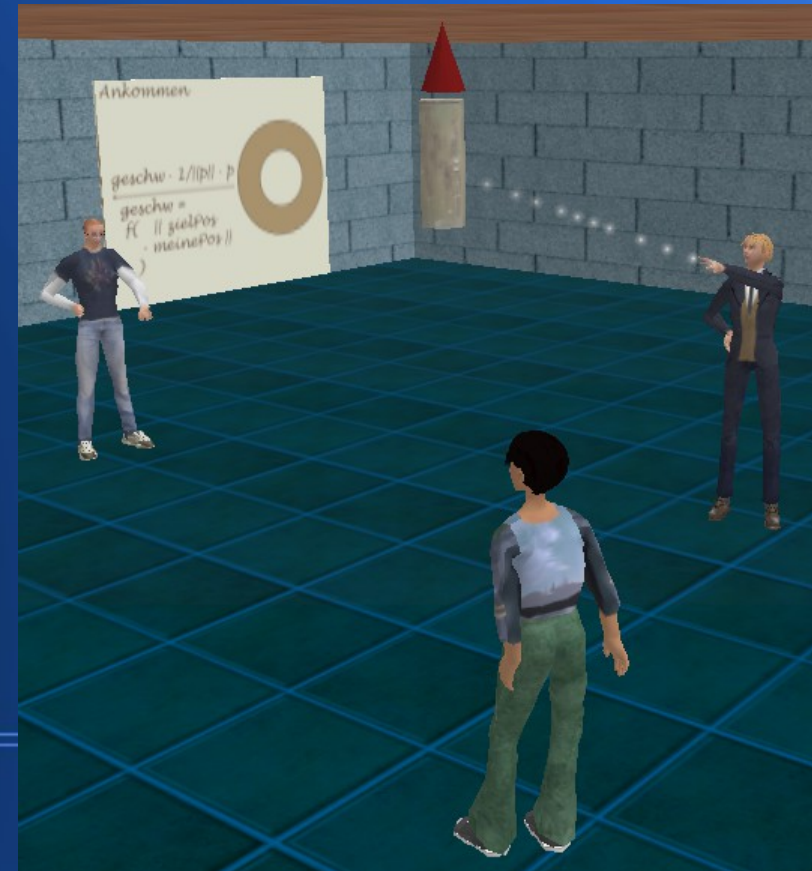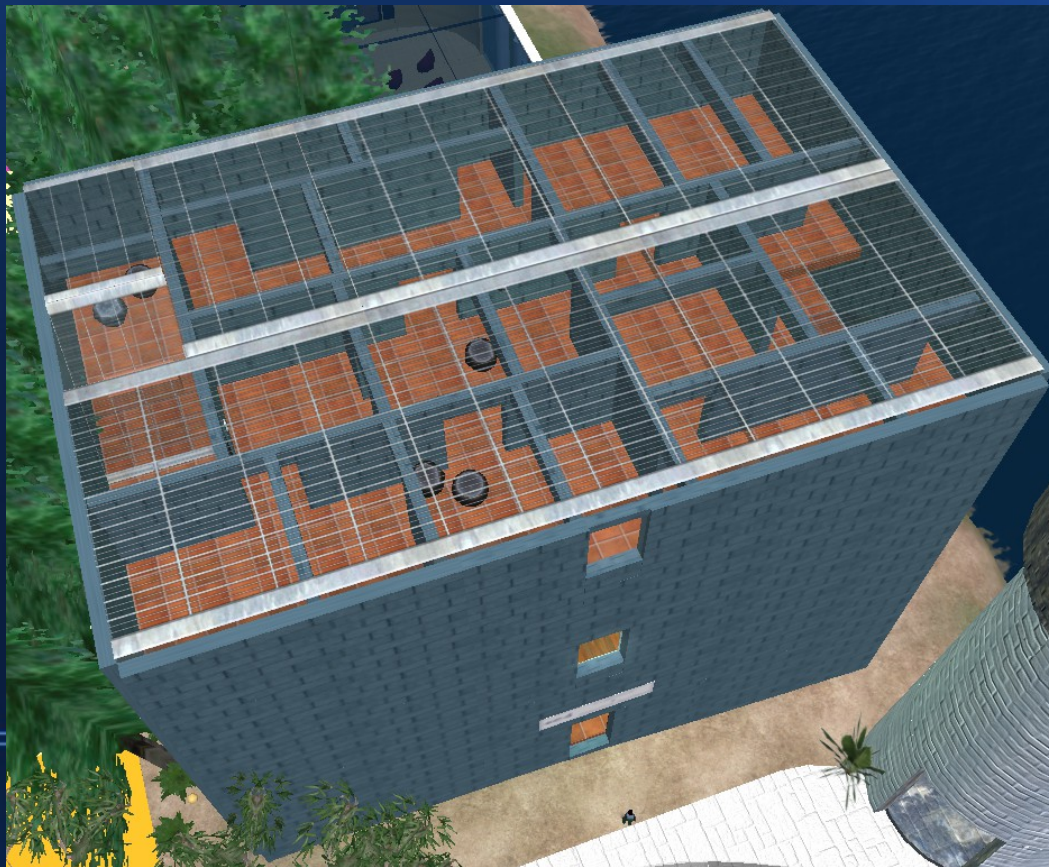
Design Approach

Construction Spaces

Set of Tasks

- *Seek* computes a vector to a target position

- *Flee* computes a *Seek* vector and reverses its orientation

- *Pursuit* computes a *Seek* vector to an anticipated future position of the target

- *Arrive* computes a *Seek* vector with deceleration

- *Evade* computes a *Flee* vector from an anticipated future position (reversed *Pursuit*)

Increasing Difficulty [2]
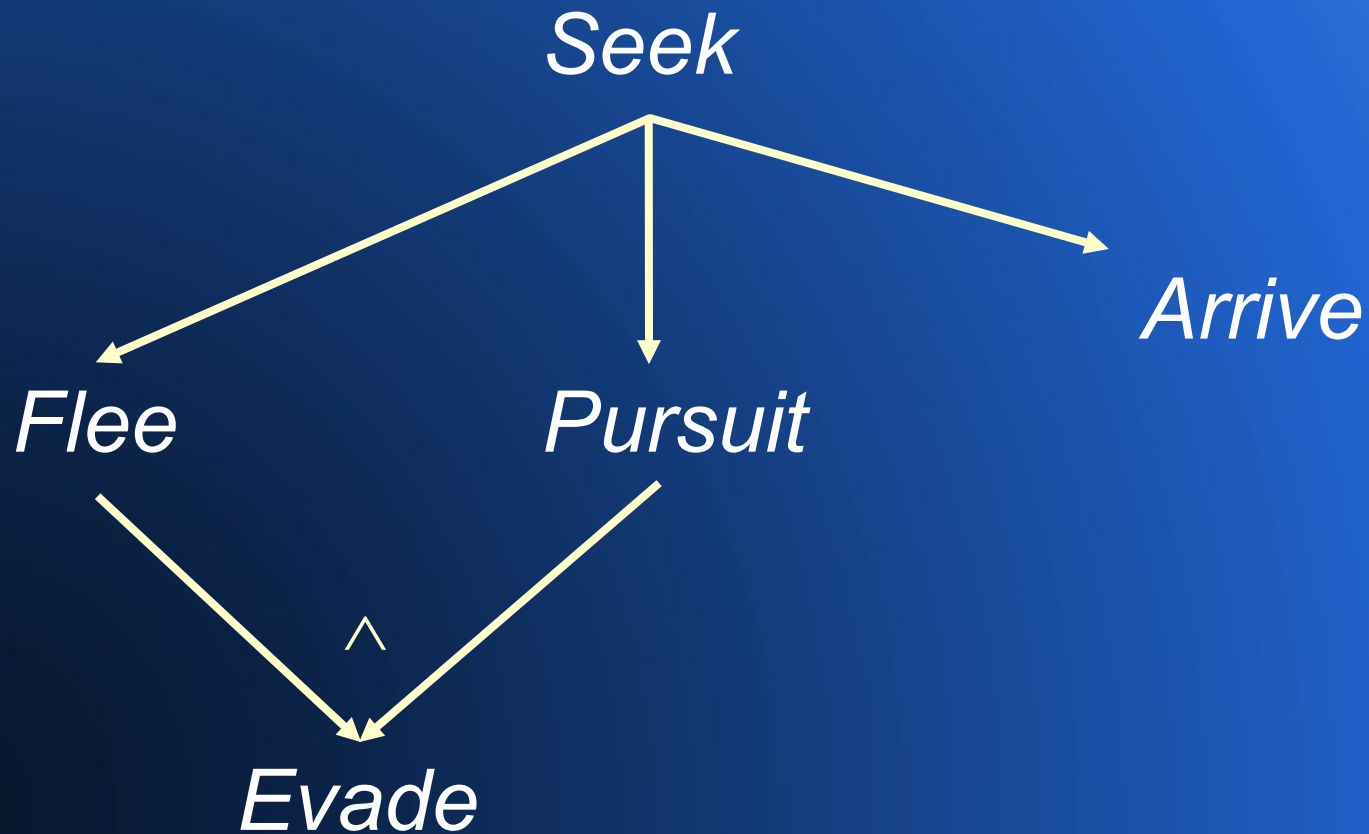
[2] cf. Albert & Held (1999): Component-based knowledge spaces
in problem solving and inductive reasoning. In Albert & Lukas (eds.): *Knowledge Spaces*.

Increasing Degree of Construction [3]

$$Seek_1 \rightarrow Seek_2 \rightarrow Seek_3$$

$$Arrive_1 \rightarrow Arrive_2 \rightarrow Arrive_3$$

$$Flee_1 \rightarrow Flee_2 \rightarrow Flee_3 \quad Pursuit_1 \rightarrow Pursuit_2 \rightarrow Pursuit_3$$

$$\wedge$$

$$Evade_1 \rightarrow Evade_2 \rightarrow Evade_3$$
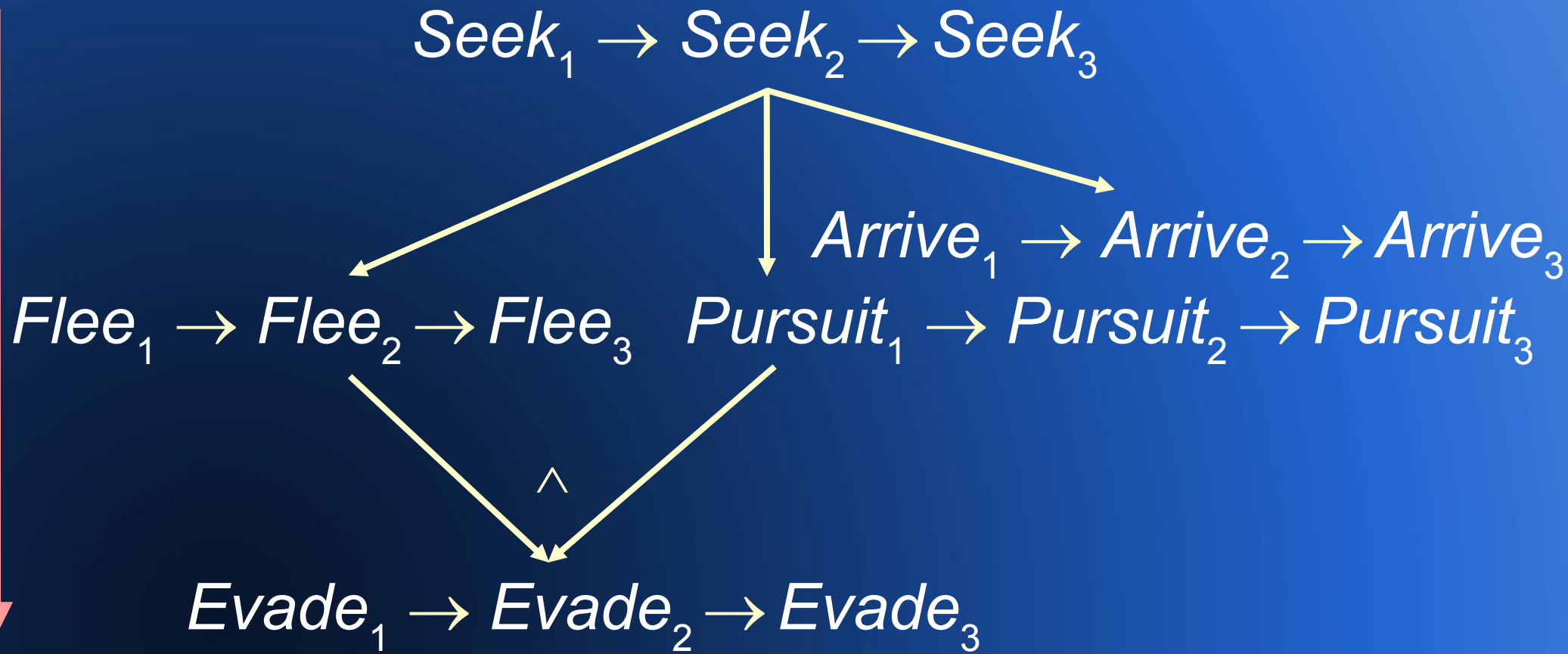
[3] cf. Collins, Brown & Newman (1987): Cognitive Apprenticeship. Technical Report #403, Center for the Study of Reading, University of Illinois.

Manipulating → Constructing [4]

[3] cf. Schulmeister (2003): Taxonomy of Multimedia Component Interactivity. *Studies in Communication Sciences*, 3(3).

Evaluation

in the classroom

Setting & Hypotheses

- 12th grade, age 17–18, 11 male, 1 female
- 4 sessions, 90 minutes each, teams of 2
- Introductions, *Seek*$_1$, after that tasks assigned individually, traversing the construction space
- Hypotheses
  - Always medium challenge
  - Experimenting behaviour
  - Increasing degree of construction $\rightarrow$ creative ideas

Worksheets

Recorded Learning Paths (2D)
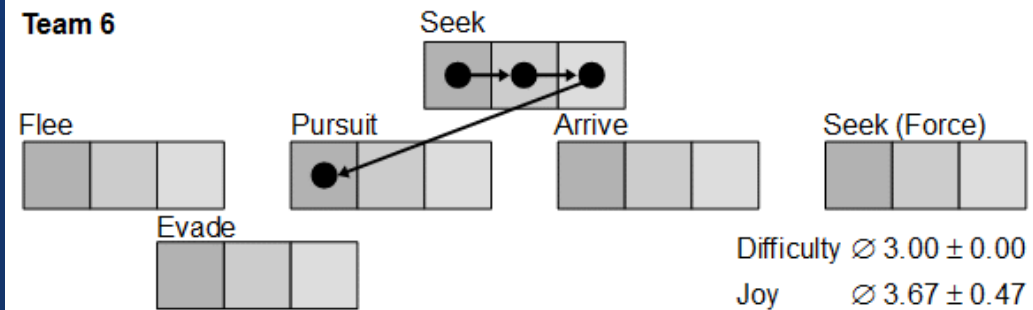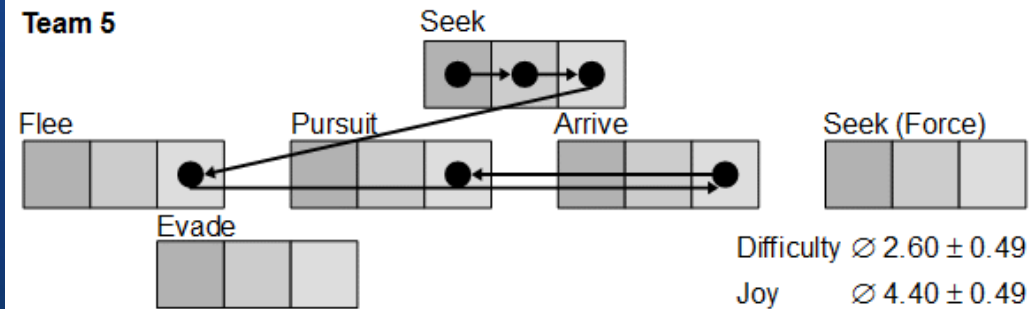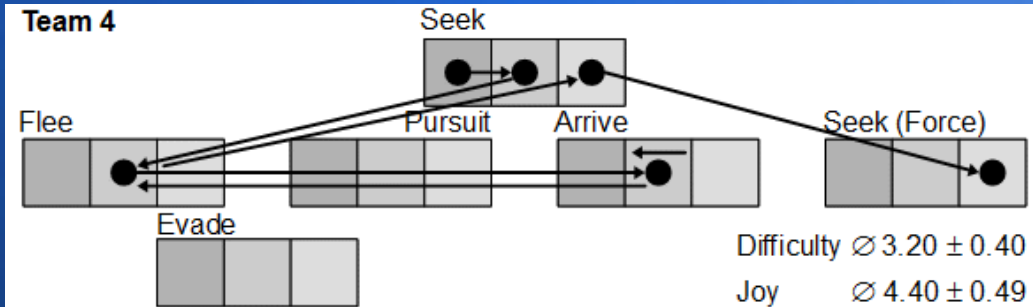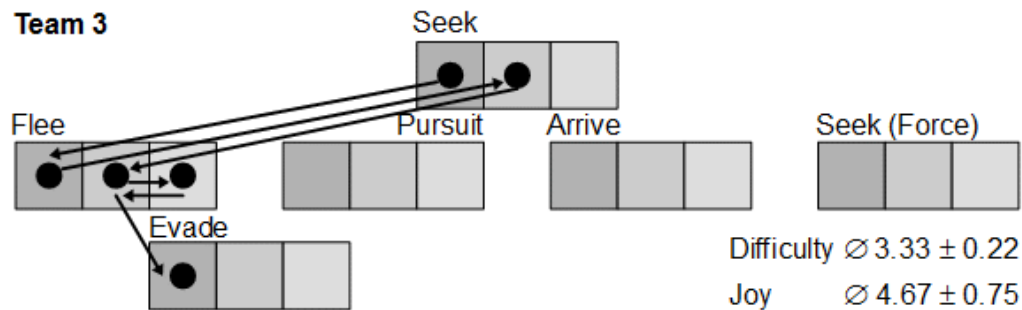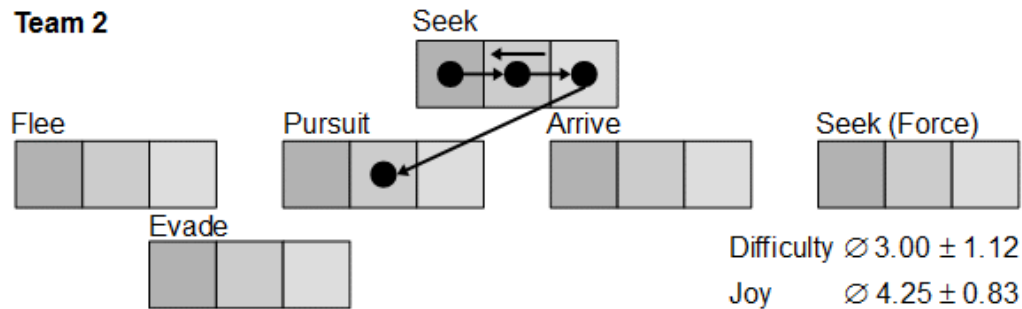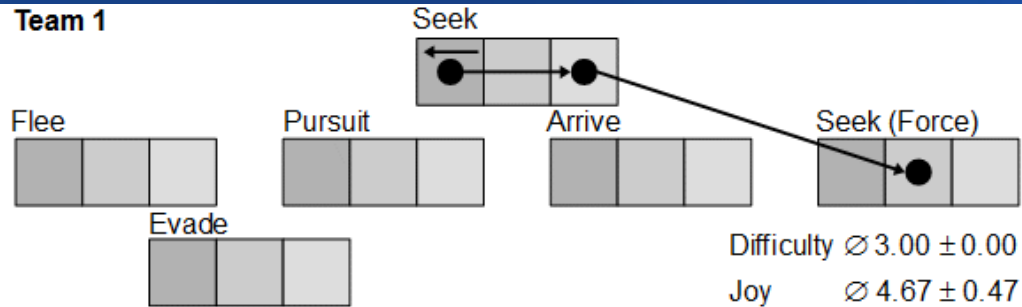
Joy, Difficulty, Learning Styles
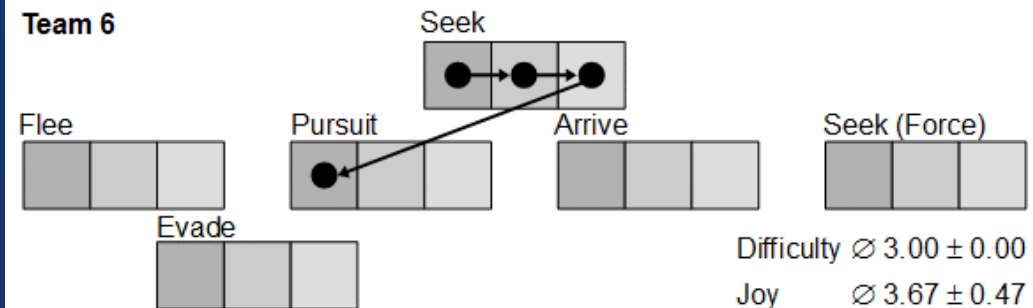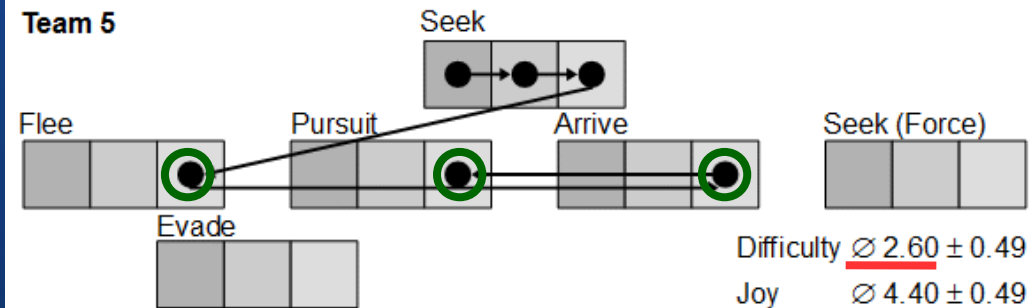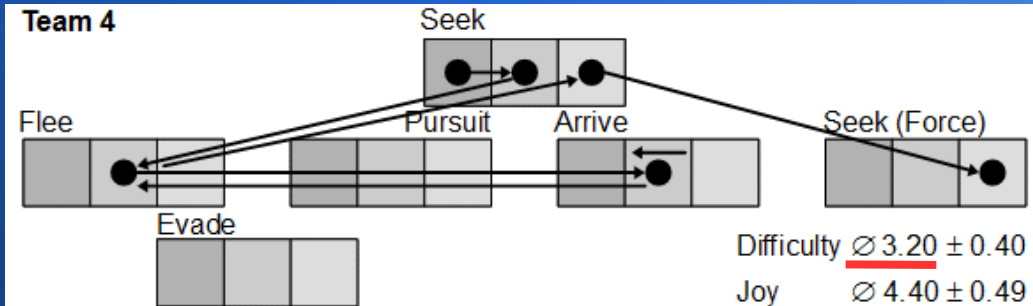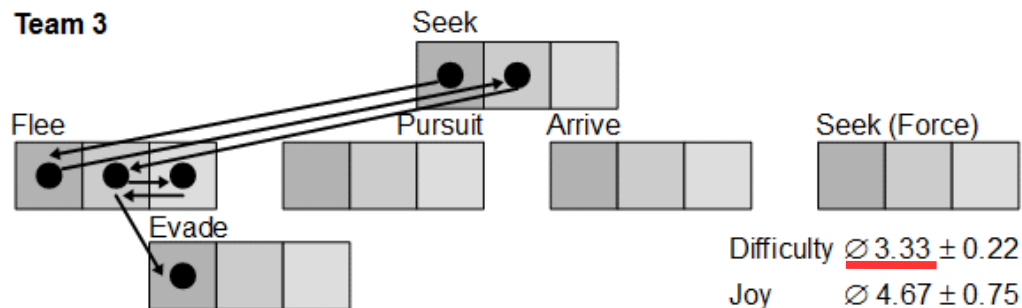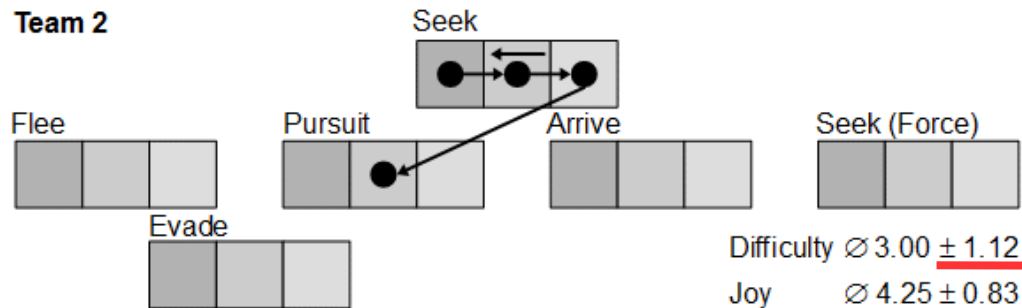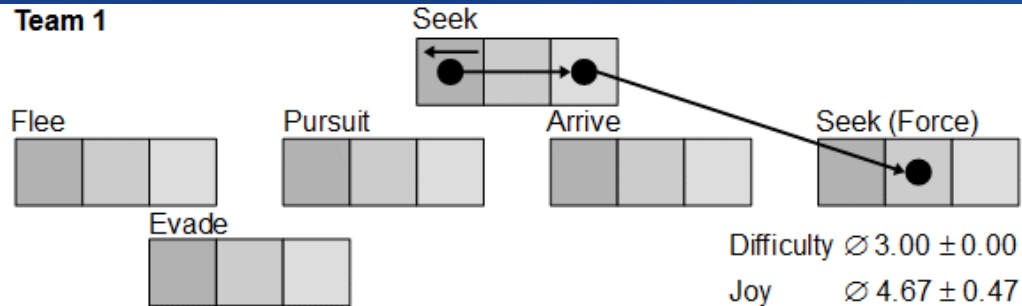
Qualitative Results

- Narratives scarce, not precise, incorrect
- Understood in instant / didn't reflect, but continued
- Problems setting up experiments & documenting
- Except when following own, creative ideas
  - Code: seek own avatar, *Arrive* circle, rotation, gravity
  - Comparison: $Seek_1$; $Flee_1$; $Seek_2$; $Flee_2$
- Tried ideas quicker than could think them through: *They played!*

Student Feedback

+ Trying out ideas (3 students)

+ Close to practice (4)

+ Direct application of knowledge/visual feedback (5)

- Too little theory (2) ← competent

- Too few coding instructions (2) ← struggling

Conclusions

- Two-dimensional model successful: Adapt to learning styles depth-first vs. breadth-first

- Experimenting works best with own ideas, but we have to support reflection in a better way

- Current work

  - Interactive learning journals (as quest journals)

  - Graphical representations of mental models

  - Automated suggestion of next actions

Thank you for your interest!

- Contact info

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- Thank you, participants!

    - Bert Schröder, Erasmus-Gymnasium Rostock

    - 12th grade Computer Science course 2012/13

$$(1) \quad \neg Seek \Rightarrow \neg Flee \wedge \neg Pursuit \wedge \neg Arrive$$
$$(2) \quad \neg Flee \Rightarrow \neg Evade$$
$$(3) \quad \neg Pursuit \Rightarrow \neg Evade$$

$$(1') \quad \neg Seek_i \Rightarrow \neg Flee_1 \wedge \neg Flee_2 \wedge \neg Flee_3$$
$$\wedge \neg Pursuit_1 \wedge \neg Pursuit_2 \wedge \neg Pursuit_3$$
$$\wedge \neg Arrive_1 \wedge \neg Arrive_2 \wedge \neg Arrive_3$$
$$(2') \quad \neg Flee_i \Rightarrow \neg Evade_1 \wedge \neg Evade_2 \wedge \neg Evade_3$$
$$(3') \quad \neg Pursuit_i \Rightarrow \neg Evade_1 \wedge \neg Evade_2 \wedge \neg Evade_3$$
$$(4) \quad \neg Seek_1 \Rightarrow \neg Seek_2$$
$$(5) \quad \neg Seek_2 \Rightarrow \neg Seek_3$$
$$(6) \quad \neg Flee_1 \Rightarrow \neg Flee_2$$
$$(7) \quad \neg Flee_2 \Rightarrow \neg Flee_3$$
$$(8) \quad \neg Pursuit_1 \Rightarrow \neg Pursuit_2$$
$$(9) \quad \neg Pursuit_2 \Rightarrow \neg Pursuit_3$$

$$(10) \quad \neg Arrive_1 \Rightarrow \neg Arrive_2$$
$$(11) \quad \neg Arrive_2 \Rightarrow \neg Arrive_3$$
$$(12) \quad \neg Evade_1 \Rightarrow \neg Evade_2$$
$$(13) \quad \neg Evade_2 \Rightarrow \neg Evade_3$$

$$(1'') \quad \neg Seek_i \Rightarrow \neg Flee_1 \wedge \neg Flee_2 \wedge \neg Flee_3$$
$$\wedge \neg Pursuit_1 \wedge \neg Pursuit_2 \wedge \neg Pursuit_3$$
$$\wedge \neg Arrive_1 \wedge \neg Arrive_2 \wedge \neg Arrive_3$$
$$\wedge \neg Force_1 \wedge \neg Force_2 \wedge \neg Force_3$$
$$(14) \quad \neg Force_1 \Rightarrow \neg Force_2$$
$$(15) \quad \neg Force_2 \Rightarrow \neg Force_3$$

Students had problems setting up discovery learning experiments (which is also one issue in de Jong and van Joolingen 1998). For $Seek_1$, some good entries document combinations: "Head 3, Foot 3, Eye 3 $\Rightarrow$ fleeing robot; Head 1, Foot 1, Eye 1 $\Rightarrow$ following robot; Head 2, Foot 2, Eye 2 $\Rightarrow$ following robot." Experiments with code parameters (range, angle, speed, name etc.) worked in practice, but