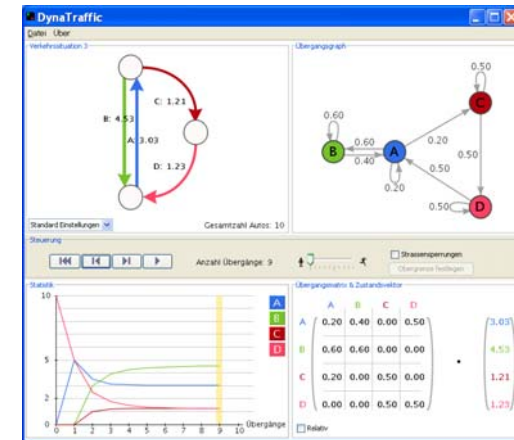
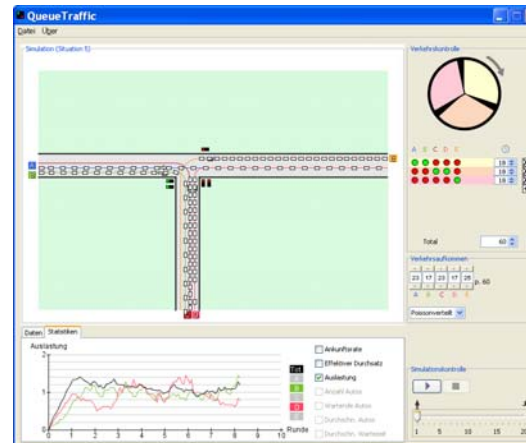
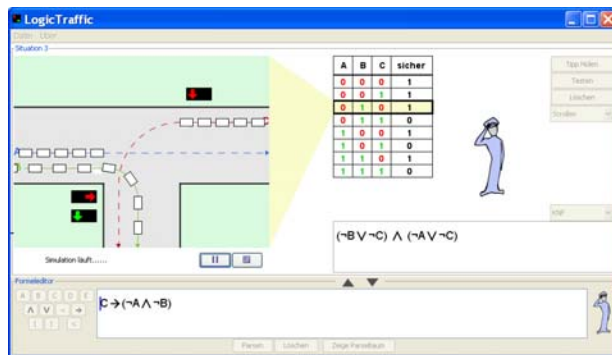


Interactive Learning Environments for Mathematical Topics

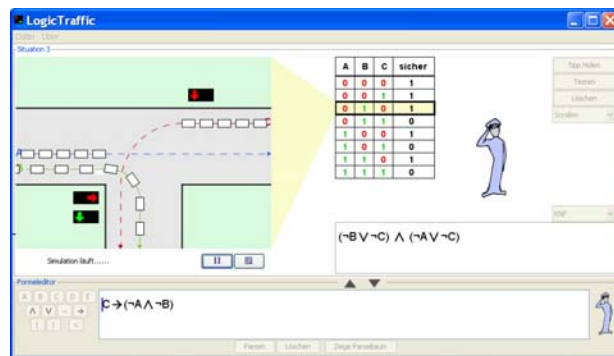
Doctoral examination

Ruedi Arnold

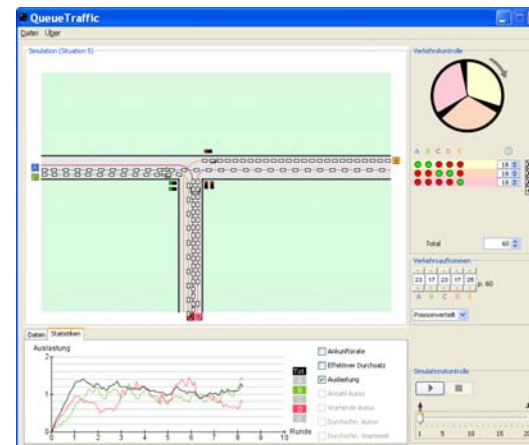


Interactive Learning Environments for Mathematical Topics

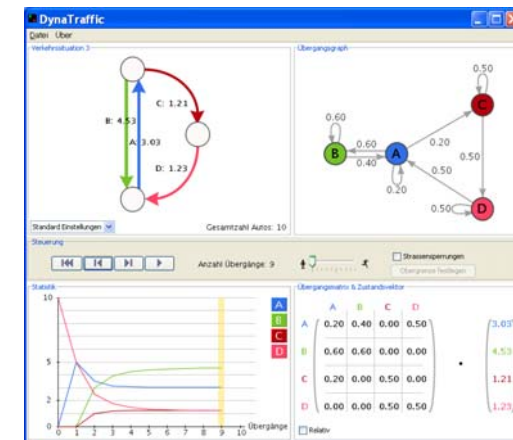
InfoTraffic is a collection of learning environments



LogicTraffic



QueueTraffic

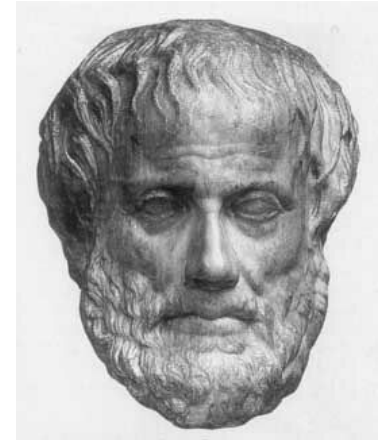


DynaTraffic

Motivation: Logic in General Education

Problem

- Comprehension of logic is fundamental
- Today little significance in school practice



Analysis: Commonly taught in abstract manner and reduced to mathematical set of formulas

Modus Ponens
 $((p \rightarrow q) \wedge p) \vdash q$

Solution: We offer a new approach to propositional logic based on real-world experience



LogicTraffic

Make Intersections Safe

The screenshot shows the LogicTraffic software interface. On the left, a traffic simulation is running, showing cars at an intersection. A red arrow points to a car in the top lane, and a green arrow points to a car in the bottom lane. The simulation is labeled "Simulation läuft....".

In the center, a truth table is displayed with columns A, B, C, and sicher. The table contains 8 rows of data, with the 7th row highlighted in yellow.

A	B	C	sicher
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

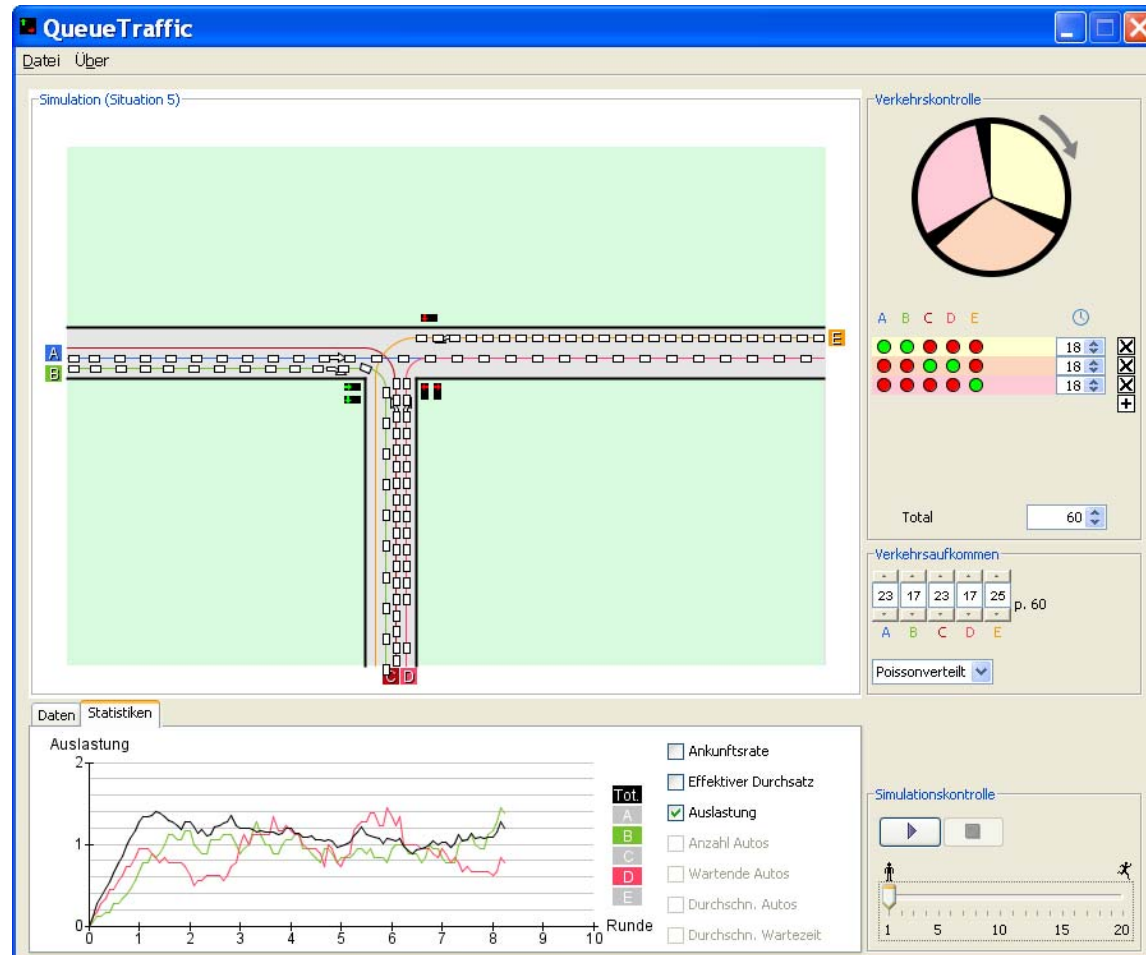
To the right of the truth table is a cartoon character of a person in a blue uniform, looking thoughtful. Below the truth table is a dropdown menu set to "DNF" and a text box containing the formula $(\neg A \wedge \neg B) \vee (\neg C)$.

At the bottom, there is a "Formeleditor" (Formula Editor) with a keyboard interface and a text box containing the formula $(\neg A \wedge \neg B) \vee (\neg A \wedge \neg C) \vee (\neg B \wedge \neg C)$. Below the text box are buttons for "Parsen", "Löschen", and "Zeige ParseBaum".

Propositional logic: truth table, Boolean operators, equivalence of formulas...

QueueTraffic

Control and Analysis of Intersections



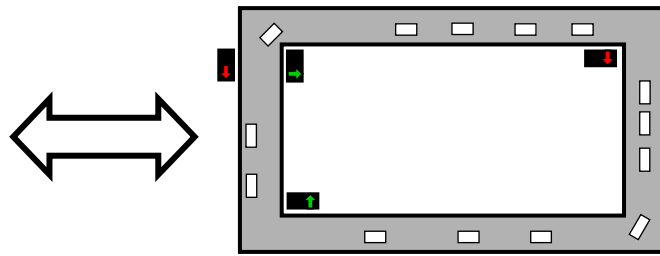
Queuing theory: throughput, utilization, Poisson distribution, arrival process, ...

DynaTraffic

Analysis and Prediction of Traffic Distribution



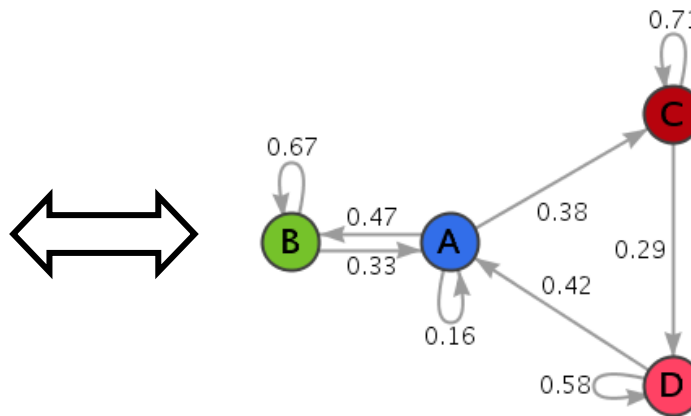
Everyday situation



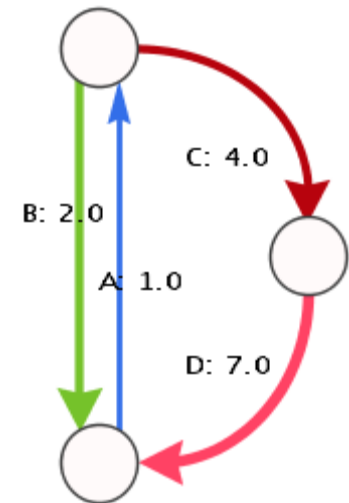
Simple model with cars

	A	B	C	D
A	0.16	0.33	0.00	0.42
B	0.47	0.67	0.00	0.00
C	0.38	0.00	0.71	0.00
D	0.00	0.00	0.29	0.58

Transition matrix



Transition graph



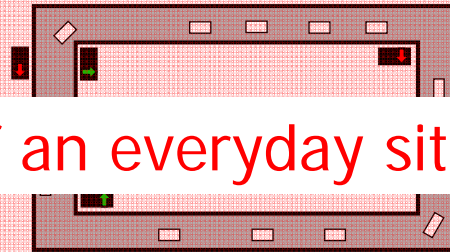
Abstract model without cars

DynaTraffic

Analysis and Prediction of Traffic Distribution



Everyday situation



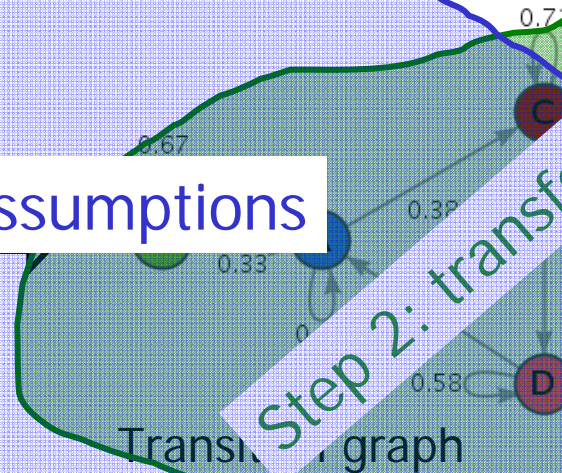
Simple model with cars

Step 1: model of an everyday situation

	A	B	C	D
A	0.16	0.33	0.00	0.42
B	0.47	0.00	0.00	0.00
C	0.38	0.00	0.71	0.00
D	0.00	0.00	0.29	0.58

Transition matrix

Step 3: define assumptions

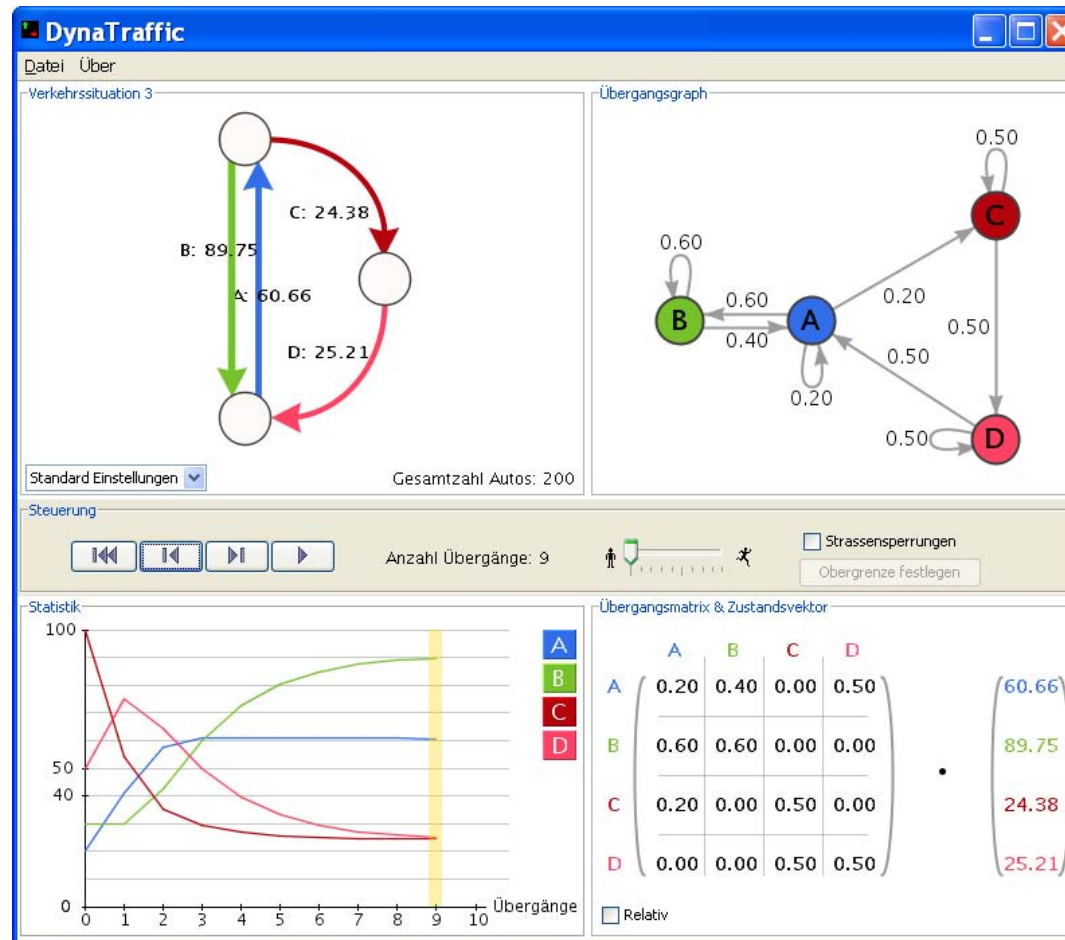


Transition graph

Step 2: transformation of the model

Abstract model without cars

DynaTraffic



Markov Chains and Dynamic Systems: steady-state, transition matrix, periodic states, stochastic matrix, ...

InfoTraffic & Computers in Education

ICT as a Tool

- For everyday tasks (office, Internet, entertainment, ...)
- For specific tasks (accounting, math, publishing, ...)

ICT as a Medium

- Support teaching and learning
- Two main modes
 - Communication with other humans
 - Topic-specific educational software

ICT as a Subject

- Important concepts of computer science like programming, algorithms, propositional logic, queuing theory, or networks

InfoTraffic & Computers in Education

ICT as a Tool

- For everyday tasks (office, Internet, entertainment, ...)
- For specific tasks (accounting, math, publishing, ...)

ICT as a Method

InfoTraffic:
Interactive Learning Environments (ILEs)
for important concepts from computer science and math

ICT as a Subject

- Important concepts of computer science like programming, algorithms, propositional logic, queuing theory, or networks

Didactical Concepts behind InfoTraffic

1. Content based on Fundamental Ideas

Propositional logic, queuing theory, and Markov chains are fundamental ideas according to Schwill [1]

- Different applications
- On different cognitive levels
- Historically and in the longer perspective relevant
- Connection to everyday language and actions

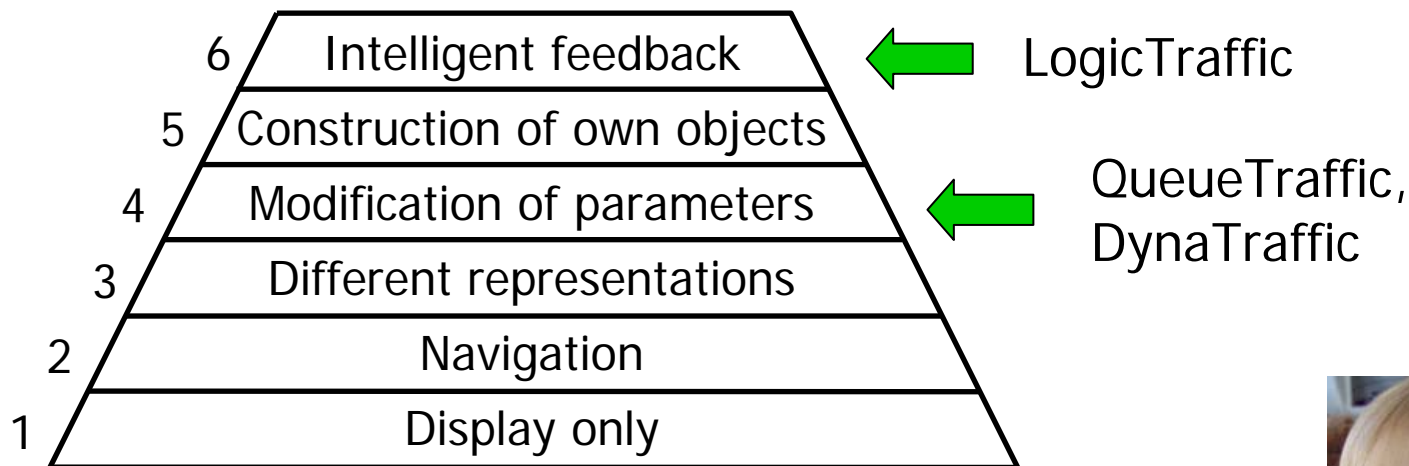
⇒ It's important and therefore worth the effort!

[1] A. Schwill. Fundamental ideas of computer science. EATCS-Bulletin, 53:274-295, 1994.

Didactical Concepts behind InfoTraffic

2. High Level of Interactivity

Schulmeister [1]: 6 levels of interactivity



Attractive for the „Nintendo Generation“ according to Guzdial and Soloway [2] (animation, different possibilities for interaction)



[1] R. Schulmeister. Taxonomy of Multimedia Component Interactivity. A Contribution to the Current Metadata Debate. Studies in Communication Sciences. Studi di scienze della comunicazione., 3(1):61-80, 2003.

[2] M. Guzdial and E. Soloway. Teaching the nintendo generation to program. Comm. of the ACM, 45(4):17-21, 2002.

Didactical Concepts behind InfoTraffic

3. Different Representations

Offering different representations: thinking can happen in three different media according to Bruner et. al [1]. Supplemented by a fourth representation by Hartmann et. al [2]

Symbolic - symbol

„tree“

Iconic - picture



Enactive - action



Virtual-enactive – simulated action



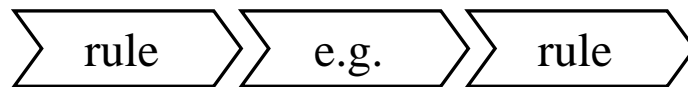
[1] J. S. Bruner, R. R. Oliver, and P. M. Greenfeld. Studies in Cognitive Growth. Wiley, New York, 1966.

[2] W. Hartmann, M. Naef, and R. Reichert. Informatikunterricht planen und durchführen. Springer, Heidelberg Berlin New York, 2006.

Didactical Concepts behind InfoTraffic

4. Use of e.g.-rule-e.g.-rule Method

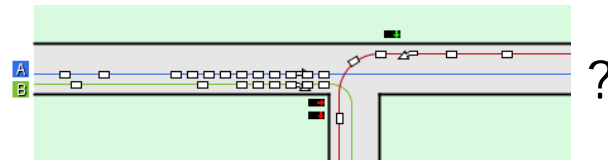
Teaching often based on the rule-e.g.-rule technique, according to Bligh [1]



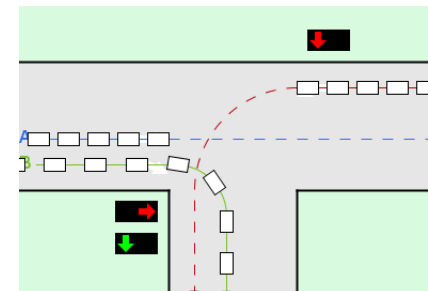
1. For abstract content better use e.g.-rule-e.g.-rule:



Introduce Queues as M/M/1 system or as



2. References to prior knowledge based on an **example from everyday life**

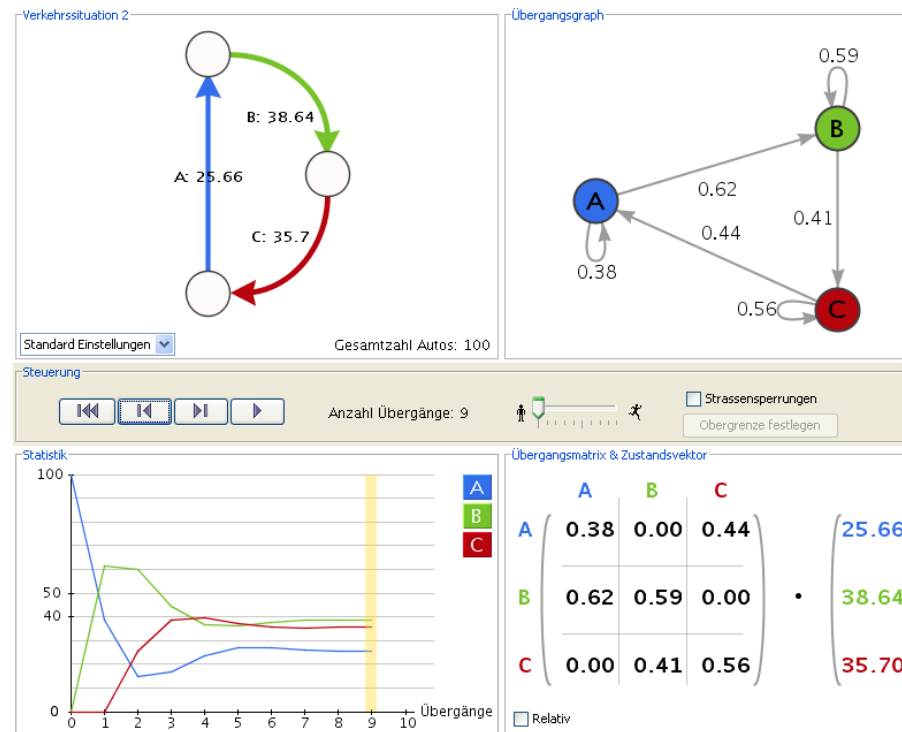


[1] D. A. Bligh. What is the Use of Lectures? Penguin Books, 1972.

Didactical Concepts behind InfoTraffic

5. Corresponding Views

Multiple visualizations of the same content, automatically updated allows different approaches to the content, depending e.g. on the students' cognitive preferences and capabilities

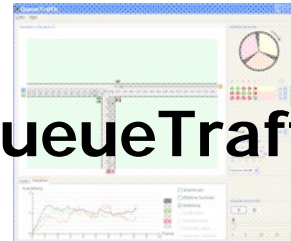


Summary of Didactical Concepts behind InfoTraffic

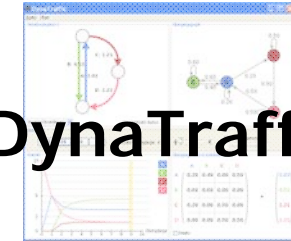
Didactical Concept



LogicTraffic



QueueTraffic



DynaTraffic

Fundamental
Idea covered



Level of Interactivity

6

4

4

Different
Representations



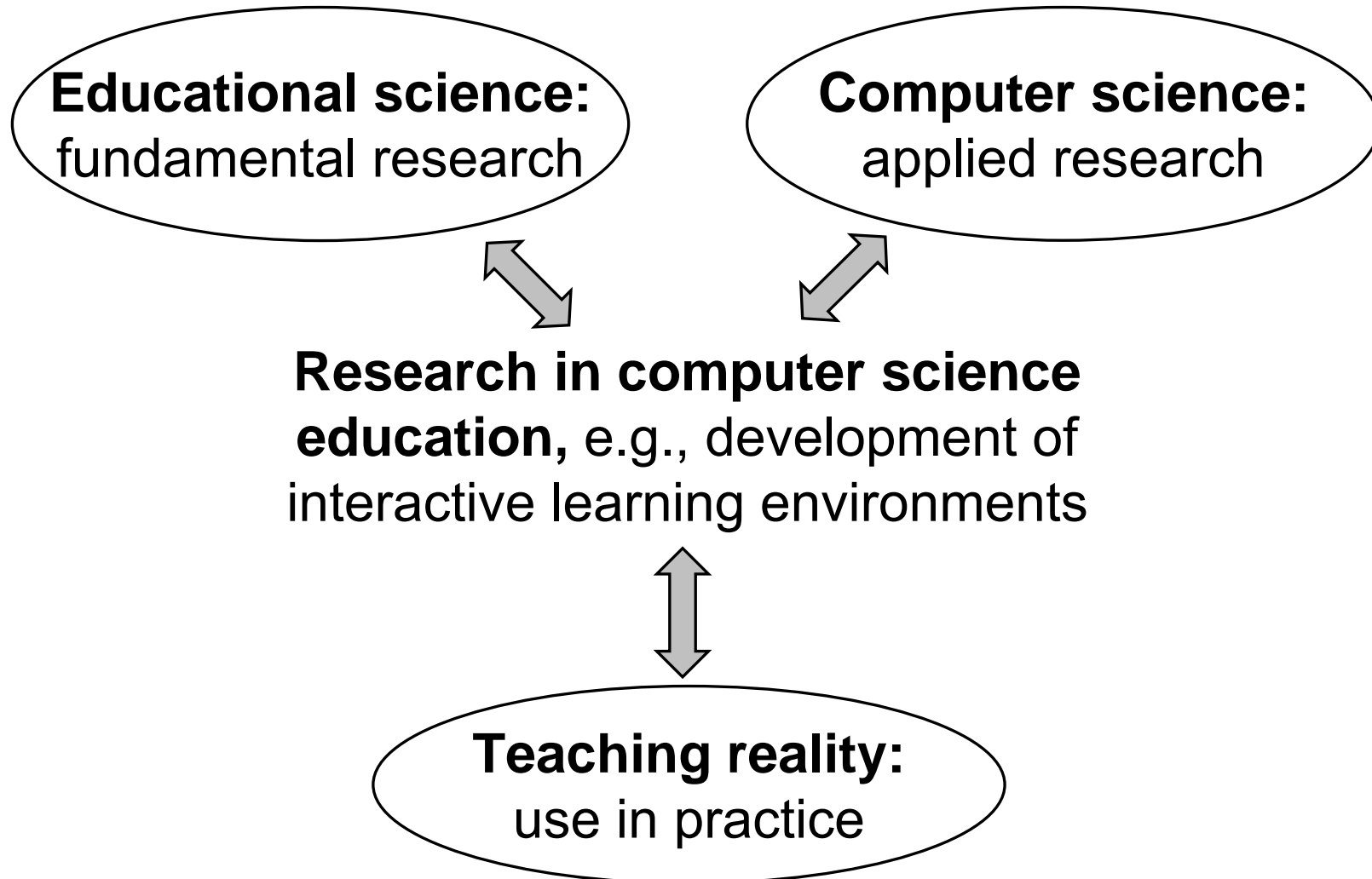
Begin with example
from everyday life



Corresponding Views



Evaluation of InfoTraffic Interdisciplinary Research



Evaluation of ILEs from the Perspective of Educational Science

Classical scientific evaluation of effectiveness of learning environments is not appropriate [1,2]:

- “Complexity of real learning and teaching situations sets tight limits to experimental research. This leads to the case that most comparisons of teaching methods and teaching media show no significant results, and the few significant results contradict each other.” [1]
- “Difficulties in generalizing statements from evaluations regularly tempt methodologists into calling for further differentiation and control in the methodical design. This leads to the construction of utterly artificial learning environments, whose evidence thus loses its validity for real life situations.” [2]
- “...we do not need any of those ‘careful studies of the impact of ... on ...’.” [2]

[1] G. Reinmann. Nur “Forschung danach”? Vom faktischen und potentiellen Beitrag der Forschung zu alltagstauglichen Innovationen beim E-Learning. Arbeitsbericht Universität Augsburg, Nr. 14, 2006.

[2] R. Schulmeister. Grundlagen hypermedialer Lernsysteme: Theorie - Didaktik - Design, 4., überarbeitete und aktualisierte Auflage. Oldenbourg Wissenschaftsverlag, 2007.

The Approach of InfoTraffic

Current trend in educational sciences: focus more on design, development, and use [1,2,3]

Engineering Science Approach

- Pragmatically combine the best findings available
- Directly concerned with practical impact. “Understanding how the world works and helping it ‘to work better’ by designing and systematically developing high-quality solutions to practical problems.” [2]

[1] Design-Based Research Collective. Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher*, 32(1):5–8, 2003.

[2] H. Burkhardt and A. H. Schoenfeld. Improving Educational Research: Toward a More Useful, More Influential, and Better-Funded Enterprise. *Educational Researcher*, 32(9):3–14, 2003.

[3] F. Fischer, M. Waibel, and C. Wecker. Nutzenorientierte Forschung im Bildungsbereich: Argumente einer internationalen Diskussion. *Zeitschrift für Erziehungswissenschaft*, 8(3):427–442, 2005.

Impact of InfoTraffic on School Practice

swisseduc.ch Home · Info · Kontakt · Suchen

Informatik » LogicTraffic: Aussagenlogik zur Sicherheit bei Strassenkreuzungen

Informatik auf SwissEduc [This page in English](#)

InfoTraffic

- Software-Download
- Software starten
- Java installieren
- Rückmeldungen
- Publikationen

LogicTraffic

- Screenshots
- Unterrichtsmaterial**

QueueTraffic

- Screenshots
- Unterrichtsmaterial

DynaTraffic

- Screenshots
- Unterrichtsmaterial

Unterrichtsmaterial zu LogicTraffic

Verfasst von *Ruedi Arnold*



Fachgebiet	Boole'sche Aussagenlogik
Schultyp	Gymnasien, Berufsschulen, Technikerschulen, Fachhochschulen, Universitäten, etc.
Voraussetzungen	keine
Dauer	2-4 Lektionen

Worum geht es?

Die Lernumgebung LogicTraffic illustriert Aussagenlogik anhand einer alltäglichen Situation und ermöglicht ein explorativ-intuitives Erlernen der Grundkonzepte von Aussagenlogik.

Downloads zu "Unterrichtsmaterial zu LogicTraffic"

- Einführungsvortrag 'Kleiner Ausflug in Logik und Verkehrssteuerung' [PDF \[399 KB\]](#) · [Powerpoint \[609 KB\]](#)
- Handzettel 'Aufgabe Wahrheitstabelle' zum Einführungsvortrag [PDF \[49 KB\]](#) · [Powerpoint \[73 KB\]](#)
- Anleitung zu LogicTraffic [PDF \[57 KB\]](#) · [Word \[109 KB\]](#)
- Aufgaben zu LogicTraffic [PDF \[64 KB\]](#) · [Word \[90 KB\]](#)
- Lösungen zu den Aufgaben zu LogicTraffic [PDF \[61 KB\]](#) · [Word](#)

Freely available online along with teaching material on a popular educational server

Used many times in high schools and teacher education courses



Impact of InfoTraffic

Anecdotal Evidence

“Logik ist cool!” (Spontaneous statement of a high school student after having attended an introductory presentation to LogicTraffic)

“Poissonverteilung ist viel zufälliger, nicht wie bei einem Fließband, wenn jede Sekunde ein Teil aus der Maschine kommt.” (High school student after having solved exercises with QueueTraffic)

“Ich habe fast den gesamten Inhalt in meinen Informatikunterricht integriert, das heisst, ich habe die Schüler (13-19 Jahre) auf die Möglichkeiten/Grenzen von Simulationsprozessen hingewiesen und Ihre Simulationen testen lassen.” (High school teacher after using QueueTraffic)

“I really believe that interactive learning with devices such as LogicTraffic is the best way for today's generation of students to learn.” (American university professor using LogicTraffic in his classes)

Pragmatic Recommendations for Development of ILEs [1]

The screenshot shows the LogicTraffic software interface. It features a central simulation area with a traffic light and a car. To the right is a truth table with columns A, B, C, and sicher. Below the simulation is a formula editor with the formula $C \rightarrow (\neg A \wedge \neg B)$. At the bottom, there are buttons for 'check', 'apply', 'clear', 'fill truth table', 'make formal', and 'make informal'.

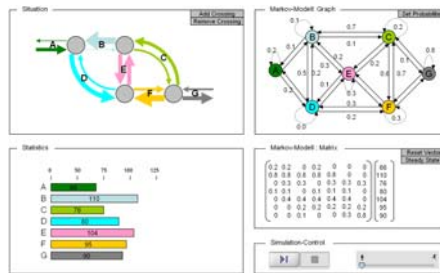
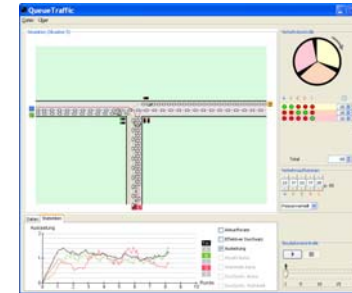
A	B	C	sicher
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0



[1] R. Arnold und W. Hartmann. Pragmatische Empfehlungen zur Entwicklung von interaktiven Lernumgebungen. INFOS 2007, 12. GI-Fachtagung Informatik und Schule, Siegen. GI-Lectures Notes in Informatics, pp. 171-182, September 2007.

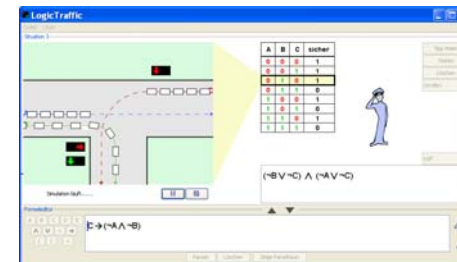
Contributions of this thesis

A real-world-based approach to propositional logic, queuing theory, and Markov chains



Guidelines for pragmatic and interdisciplinary engineering of ILEs

A virtual-enactive introduction to topics from math and computer science



“Logik ist cool!” Increasing the significance of logic in general education

The End - Thank you

Relevant publications

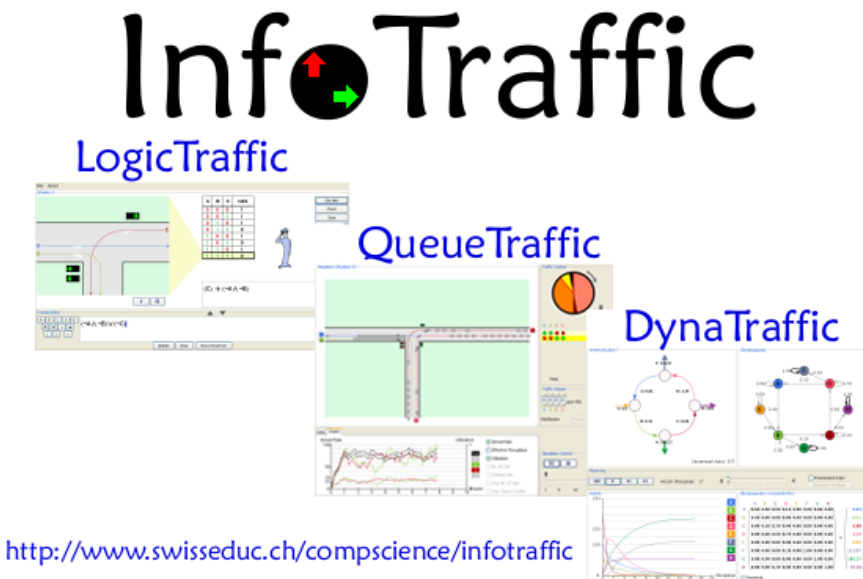
R. Arnold and W. Hartmann. **Pragmatische Empfehlungen zur Entwicklung von interaktiven Lernumgebungen**. In Proceedings INFOS 2007, 12. GI-Fachtagung Informatik und Schule, Siegen, Germany, September 2007.

R. Arnold. Demonstration abstract: **Introducing Propositional Logic and Queueing Theory with the InfoTraffic Interactive Learning Environments**. In Proceedings of ACM ITiCSE 2007, Dundee, Scotland, June 2007.

R. Arnold, M. Langheinrich, and W. Hartmann. **InfoTraffic - Teaching Important Concepts of Computer Science and Math through Real-World Examples**. In Proceedings ACM SIGCSE Technical Symposium, pages 105–109, Covington, Kentucky, USA, March 2007.

R. Arnold and W. Hartmann. **LogicTraffic – Logik in der Allgemeinbildung**. Hauptbeitrag Informatik-Spektrum, 30(1):19–26, 2, 2007.

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Werner Hartmann

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Hasan Karahan, Anna-Nina Simonetto,
Lea Simonetto, Xiaoping Yin