Evaluating the impact of RoboCupJunior on pupils' abilities

Martin Kandlhofer and Gerald Steinbauer

Institute for Software Technology,
Graz University of Technology
Email: mkandlho@ist.tugraz.at

WEROB 2013 – Workshop on Educational Robotics
01.07.2013

SI AT
EUROPEAN TERRITORIAL COOPERATION
Investing in your future
Operation part financed by the European Union
European Regional Development Fund

Introduction and Motivation

- robotics in education gained increased attention, e.g. *RoboCupJunior (RCJ)*
- few systematical evaluation in a larger context is given

our plan:

- empirical study on the impact of RCJ on pupils' abilities
- assessing technical and social skills
- covering a one-year period and broad population

our aim:

- gathering solid and valuable empirical data
- European-/world-wide assessment

⇒ support of RCJ community required

Problem Statement and Research Questions

- investigate the impact of participation in RoboCupJunior on young students:
  - technical skills
  - attitudes and interests regarding science, technology, social aspects

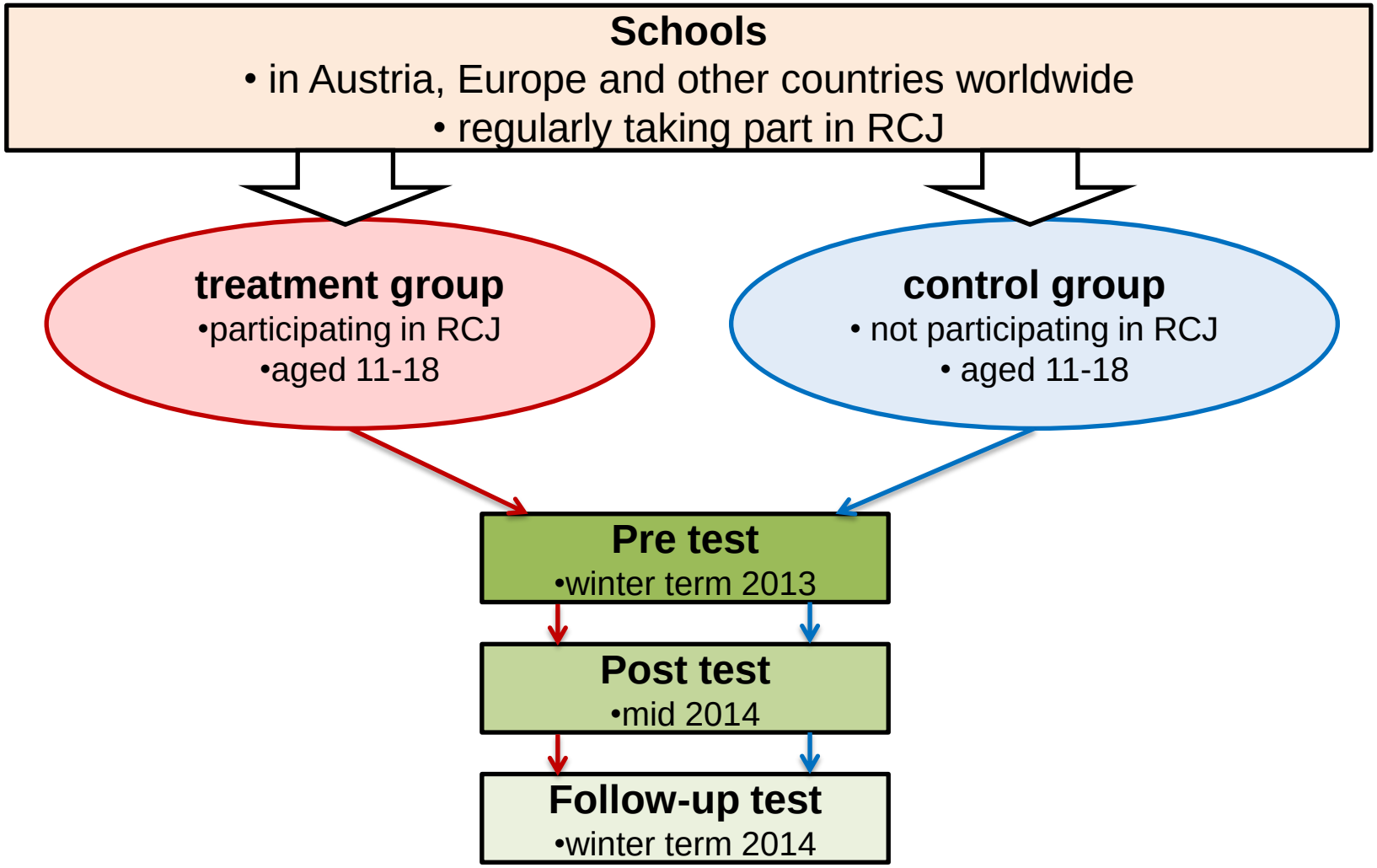
1. *Do young students who participate in RCJ for the first time improve their technical skills?*
2. *Do young students who participate in RCJ for the first time change their attitudes towards science, technology and social aspects?*

Research Questions (cont.)

3. *What are the differences regarding the improvement of technical skills of young students who participate in RCJ for the first time compared to young students who do not participate in RCJ?*

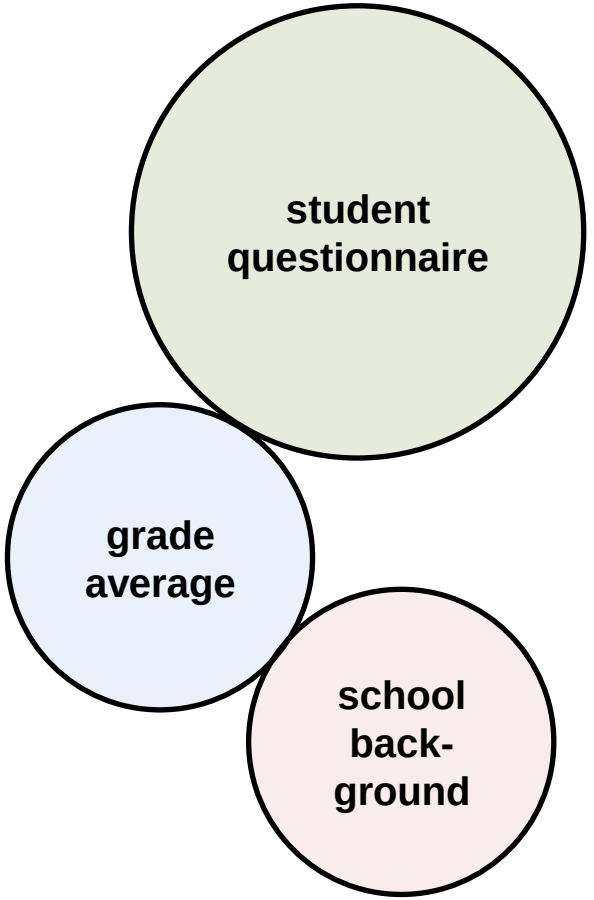
4. *What are the differences regarding the change of attitudes towards science, technology and social aspects of young students who participate in RCJ for the first time compared to young students who do not participate in RCJ?*

Methods and Concept



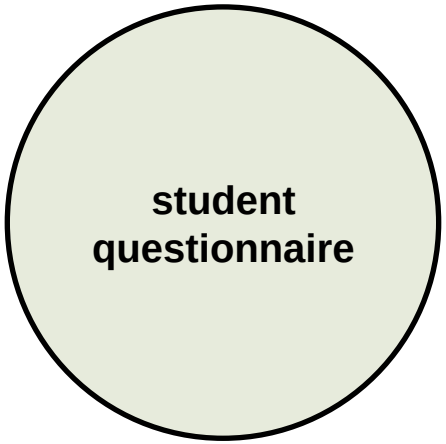
Overview of Instruments

- **student questionnaire** (pre-/post-test)**:**
  - technical skills
  - attitudes on science, technology, social aspects
  - using online tool (‘SurveyMonkey’)
- **student’s grade average:**
  - average marks at pre-/post time
- **background information on school:**
  - integration of robotics, curriculum



Student Questionnaire

- standardized instruments;
- already used in other theses and studies
- combination of different instruments



1. **demographic information**
    - age, gender, grade level,…
2. **technical skills** (36 items; multiple-choice questionnaire)
    - science skills [Cruz 2010]:
    - programming skills [Clark 2004]
3. **attitudes and interests** (86 items; 4-5 point Likert scale)
    - science related attitudes and interests (TOSRA) [Fraser 1981]
    - teamwork [Goodman 2000, Griffith 2005]
    - self esteem [Rosenberg 1965]
    - social skills [Hansen 1997]
    - goal setting skills [Hansen 1997]

What kind of support do we need?

- feedback:
  - overall evaluation concept
  - student questionnaire
- RCJ national representatives:
  - serving as hub
  - establishing contact to schools / teachers
  - coordination
  - translation of student questionnaire
- Teachers:
  - establishing treatment- and control-group
  - conducting/supervising pre- and post-tests

Benefits of Evaluation

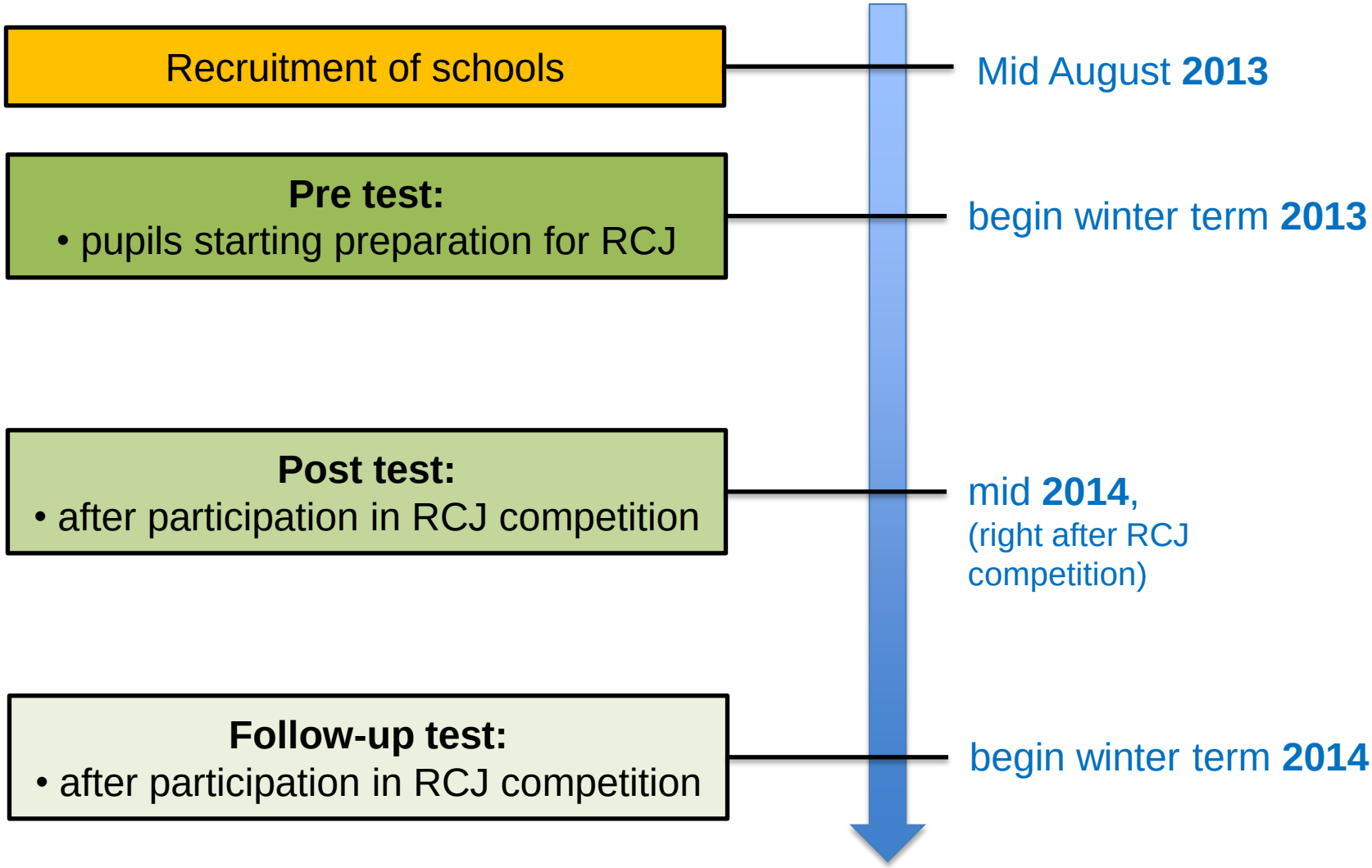
- benefits for: **schools, teachers, RCJ community**
- empirical study scientifically measuring the impact of RCJ
- strong argument:
  - funding agencies
  - sponsors
  - administration
- revealing possible areas of improvement
- participating schools will get exclusive access to data and results

Next Steps and Open Issues

- final version of student questionnaire (considering your feedback):
  - cultural context of items?
  - age (primary/secondary) of participants?
  - difficulty of questions?
  - programming skill assessment

- recruiting a critical mass of schools / participants by mid of August 2013
- starting pre-test begin of winter-term 2013

Schedule


Recruitment of schools
Mid August **2013**
Pre test:
• pupils starting preparation for RCJ
begin winter term **2013**
Post test:
• after participation in RCJ competition
mid **2014**,
(right after RCJ competition)
Follow-up test:
• after participation in RCJ competition
begin winter term **2014**

Discussion

Mail: mkandlho@ist.tugraz.at

References

- Ingrid Lorelei J. Cruz. ROBOTICS AS A MEANS OF INCREASING STUDENT ACHIEVEMENT IN MIDDLE SCHOOL SCIENCE. Master thesis, Louisiana State University and Agricultural and Mechanical College, 2010
- David Clark. Testing Programming Skills with Multiple Choice Questions. School of Information Sciences&Engineering, University of Canberra, Australia, 2004
- Fraser, B. J. (1981). TOSRA: Test of Science-Related Attitudes Handbook. Hawthorn, Victoria: Australian Council for EducationalResearch
- Goodman Research Group. Final report to FIRST. Cambridge, MA, 2000
- Donald Sanford Griffith. First robotics as a model for experiential problem-based learning: a comparison of student attitudes and interests in science, mathematics, engineering, and technology. PhD thesis, Clemson University, Clemson, SC, USA, 2005
- (Rosenberg, M. Society and the Adolescent Self-image. Princeton, NJ: Princeton University Press, 1965
- Hansen, W.B., & McNeal, R.B. How D.A.R.E. works: An examination of program effects on mediating variables. Health Education & Behavior. 1997; 24(2): 165-176.

Acknowledgements:

The work has been partly funded by the European Fund for Regional Development (EFRE), the federal government of Slovenia and the Land Steiermark under the Tedusar grant.

Appendix: Student Questionnaire 1/3

1) Demographic information
One question used to provide anonymous information for matching pre- and post-survey
Questions regarding which group (experimental or control group), gender, age, grade level

2) Technical skills (36 items; MCQ Tests)

2.1. Science skills (28 items)
Instrument: **Multiple-choice science questionnaire**
Developed and applied within a master thesis in 2010 (Ingrid Lorelei J. Cruz. ROBOTICS AS A MEANS OF INCREASING STUDENT ACHIEVEMENT IN MIDDLE SCHOOL SCIENCE. Master thesis, Louisiana State University and Agricultural and Mechanical College, 2010)
Derived from released items of public benchmark assessment tests in the US (Massachusetts Department of Education Released Test Items, West Virginia Department of Education Released Test Items, Virginia Department of Education Released Test Item, Ohio Department of Education Released Test Items, Riverside, EBR Test Writing Committee)
Instrument used at survey with 132 pupils (aged 11-14) . Conducted at a public middle school within the East Baton Parish School District in Baton Rouge, Louisiana
Multiple-choice (1 right answer, 3 distracters)
Topics covered (28 items):

Science as an inquiry:

- Identify independent variables, dependent variables, and variables that should be controlled in designing an experiment (Questions: 17,21,22,23,27)
- Construct, use, and interpret appropriate graphical representations to collect, record, and report data (e.g., tables, charts, circle graphs, bar and line graphs, diagrams, scatter plots, symbols) (Questions: 26)

Maths/Measurement:

- Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature). (Questions:1,3)
- Select and use appropriate equipment, technology, tools, and metric system units of measurement to make observations. (Questions:8,25)

Physical science:

- Identify and illustrate key characteristics of waves (e.g., wavelength, frequency, amplitude) (Questions:5,12,13)
- Describe and summarize observations of the transmission, reflection, and absorption of sound, light, and heat energy (Questions:6,19,28)
- Explain the relationship between an object's color and the wavelength of light reflected or transmitted to the viewer's eyes (Questions:15)
- Explain the relationship between work input and work output by using simple machines (Questions:20)
- Construct and analyze graphs that represent one-dimensional motion (i.e., motion in a straight line) and predict the future positions and speed of a moving object. (Questions:2,7,18)
- Compare line graphs of acceleration, constant speed, and deceleration (Questions: 4,9,10,16,24)
- Describe and demonstrate that friction is a force that acts whenever two surfaces or objects move past one another (Questions:11,14)

Appendix: Student Questionnaire 2/3

2.2. Programming skills (6 items)
Instrument: **Multiple-choice questionnaire**
Developed and used in a study into which types of multiple choice programming questions discriminate well on a final exam, and how well they predict exam scores at University of Canberra (David Clark. Testing Programming Skills with Multiple Choice Questions. School of Information Sciences&Engineering, University of Canberra, Australia, 2004)
Aims of this study was: to determine the significance of individual test questions; to determine which types of questions were significant; to find the subset of test questions that best predicted students' exam performances, and how good this prediction was
Multiple-choice (1 right answer, 3 distracters)
Topics covered (6 items):
Comprehension:
Trace code, find final value of variable, loops, array; Question Nr. 3,7,8
Application:
Ability to write programs and, at a finer grained level, to write a function or module to perform a specific task; Question Nr. 10
Problem Solving:
Work out what some code is doing. A popular type of question in a final exam is "what does this function do?" A variation is "under which conditions does this function perform correctly?" These tasks require the code to be analyzed. Multiple choice questions which test analysis are not as easy to devise as comprehension questions, but with a little thought some of the tracing questions can be recast into analysis questions. Questions 5, 11

3) Attitudes and interests (86 items):

3.1. Science related attitudes and interests (60 items):
Instrument: **TOSRA** (Test of Science Related Attitudes)
Fraser (1978) developed the survey to measure seven science related attitudes among secondary school students (Fraser, B. J. (1981). TOSRA: Test of Science-Related Attitudes Handbook. Hawthorn, Victoria: Australian Council for EducationalResearch)
Each scale category in TOSRA contains 10 items, for a total of 70 items in the complete instrument.
The five-point Likert scale is used with response categories ranging from Strongly Agree to Strongly
Disagree.
6 subscales used for our study (60 items):
Social Implications of Science: "manifestation of favorable attitudes towards science"
Attitude of Scientific Inquiry: "attitude toward scientific experimentation and inquiry as methods of obtaining information"
Adoption of Scientific Attitudes: measures open-mindedness, willingness to reverse opinions related to scientific investigation and inquiry.
Enjoyment of Science Lessons
Leisure Interest in Science
Career Interest in Science

Appendix: Student Questionnaire 3/3

3.2. Teamwork (5 items):
Instrument: **What Do YOU Think?** Survey
Designed by Goodman Research Group (GRG) in 2000 for FIRST to investigate attitudes and interest in science, mathematics, engineering and technology (Goodman Research Group. Final report to FIRST. Cambridge, MA, 2000)
Survey was also used in the dissertation of Donald Griffith (Donald Sanford Griffith. First robotics as a model for experiential problem-based learning: a comparison of student attitudes and interests in science, mathematics, engineering, and technology. PhD thesis, Clemson University, Clemson, SC, USA, 2005.)
Complete survey consists of 60 items organized in 10 subscales
The five-point Likert scale is used with response categories ranging from Strongly Agree to Strongly Disagree.
1 subscale used for our study (5 items):
Attitudes about teamwork

3.3. Self esteem (10 items):
Instrument: **Rosenberg Self-Esteem Scale**
(Rosenberg, M. Society and the Adolescent Self-image. Princeton, NJ: Princeton University Press, 1965.)
Scoring: 4 Point Likert-scale (Strongly agree – Strongly disagree)
Characteristics of ones self-worth or value

3.4. Social skills (5 items):
Instrument: **Social Skill Scale**
(Hansen, W.B., & McNeal, R.B. How D.A.R.E. works: An examination of program effects on mediating variables. Health Education & Behavior. 1997; 24(2): 165-176.)
Scoring: 4 Point Likert-scale (Strongly agree – Strongly disagree, Very easy – Very Hard)
Ability to make friends and get along with others

3.5. Goal setting skills (6 items):
Instrument: **Goal Setting Skill Scale**
(Hansen, W.B., & McNeal, R.B. How D.A.R.E. works: An examination of program effects on mediating variables. Health Education & Behavior. 1997; 24(2): 165-176.)
Scoring: 4 Point Likert-scale
Skills needed to direct an effort to reach a desired result

Appendix: Background

Educational robotics in Austria:

- nationwide network of RoboCupJunior regional centers