The Education Column

BY

Juraj Hromkovič

Department of Computer Science
ETH Zürich
Universitätstrasse 6, 8092 Zürich, Switzerland
juraj.hromkovic@inf.ethz.ch

Informatics in Swiss Primary Schools
A Case for Interdisciplinarity

Dennis Komm
Pädagogische Hochschule Graubünden, Chur, Switzerland
Department of Computer Science, ETH Zurich, Switzerland
dennis.komm@phgr.ch

Bernhard Matter
Pädagogische Hochschule Graubünden, Chur, Switzerland
bernhard.matter@phgr.ch

Abstract

We introduce an ongoing project as a collaboration of a technical university and a pedagogical university (i.e., a university of teacher education) to foster informatics competencies in Swiss primary schools (KG–6). The focus lies on teacher education and on enabling the teachers to link informatics competencies to other subjects.

1 Introduction

The 21 German-speaking cantons of Switzerland agreed on a curriculum called "Lehrplan 21" (referred to as *LP21*) for obligatory school, which contains a module *media and informatics* aiming at a steady build-up of informatics competencies such as data encoding and processing and algorithmics [1]. While this is good news for us as educators, the time budget for the module is very limited. It is consequently without any alternative to teach informatics skills interdisciplinarily – but this in turn means confronting (future) teachers with informatics who do not have a corresponding background themselves. Accordingly, future teachers need training in how to foster informatics skills in other subjects; and this should be a pillar of their education.

In this article, we introduce a project called *IGif* (roughly a German acronym for "*fostering basic informatics competencies interdisciplinarily*") that aims at approaching this issue. In particular, we describe how future primary school teachers are sensitized for the matter at "Pädagogische Hochschule Graubünden" (*PHGR*, university of teacher education Graubünden).

It has been pointed out that informatics has many points of contact with other disciplines, specifically with mathematics [2–4]. Moreover, basics of computer science are getting more and more important for almost all sciences. Teaching informatics competencies interdisciplinarily is therefore very natural. IGif is specifically tailored towards teacher education under the Swiss curriculum LP21, but we hope to spark similar initiatives in other countries.

The term "informatics competencies" is clearly defined by LP21 in this context, with the term *competency* referring to Weinert [5]. The three LP21 informatics competencies state that the students [1]

- **MI.2.1.** are able to represent, structure, and evaluate data from their surroundings;
- **MI.2.2.** are able to analyze simple problem statements, describe feasible solution strategies, and implement them as computer programs; and
- **MI.2.3.** understand the design and functionality of information processing systems and are able to apply processes of secure information processing.

These three main competencies are further subdivided into *competency steps* suited for the corresponding level of the students. For instance, competency step MI.2.1a (having target group KG–2) states that the students

> "are able to organize things by self-chosen properties so that they are able to find an object with a given property efficiently (e.g., color, shape, or size)."

In the subsequent section, we describe IGif in more detail. In Section 2.1, we sketch the outline and give a concrete roadmap; note that the project is ongoing as this article is published. In Section 2.2, we describe the specifics of the vocational semester in which the project is implemented. Section 2.3 is devoted to our experiences with a first iteration of the project where the focus laid on synergies between mathematics and informatics. In Section 2.4, we state the future plans for IGif. We conclude in Section 3.

2 The Project IGif

The project was launched in January 2019 for a time span of two years as a collaboration of PHGR and ETH Zurich. One half of the costs is state-financed, and this half is matched by the two universities. PHGR and ETH Zurich have a history

of collaboration with respect to informatics education by having launched similar projects and further education workshops in the past. Future projects such as joint-degree study programs are planned.

A very central point of the project is the diversity of the people that are involved – first of all, the complementing expertises of a pedagogical university and a technical university are combined, and second, different departments of PHGR are involved.

2.1 Outline and Roadmap

PHGR educates future primary school teachers. The corresponding bachelor degree course takes six semesters of which the fifth takes a special role – this is the *vocational semester*, where the students visit a school and teach in front of a class. In this process, they are supervised by a tutor, usually a highly experienced teacher.

IGif aims at giving these students in the fifth semester and their tutors an overview of the LP21 informatics competencies, and supply the former with ideas of how one or more of these competencies can be addressed as part of their vocational semester – and of course within their lessons as primary school teachers once they finished training.

PHGR contains six departments, namely *Language*, *Design*, *Music-Rhythm-Theater*, *Mathematics*, *Nature-Human-Society*, and *Sports*, responsible for teacher education within the respective subjects. The students teach a subset of these subjects in their fifth semester; ideally, they see potential to make connections to the LP21 informatics competencies for each single one of them. This constitutes the ultimate goal of the project.

IGif is split into three phases. *Phase 1* began in January 2019 and ended in August of the same year; the main goal was to bring together PHGR lecturers of mathematics and ETH computer scientists in order to design a workshop for the students and their tutors. Firstly, the computer scientists would introduce the mathematicians to the LP21 informatics competencies and what they imply in detail. While this first phase was also launched for PHGR lecturers of *Nature-Human-Society* in parallel, we will only focus on mathematics in this article.

Phase 2 started in September 2019 and was carried out until roughly the end of 2019. It constitutes the first iteration of the project, which we describe in Section 2.3.

In *Phase 3*, at least two more (and ideally all) departments will be involved in the project – the target group being the students in vocational semester 2020 and their tutors. The internal meetings and workshops between the corresponding PH lecturers and ETH computer scientists have already been launched.

2.2 The Vocational Semester

A semester at PHGR takes twelve weeks. In the fifth semester – the vocational semester always taking place in autumn – the students teach different subjects for nine weeks at some primary school. We give a coarse overview of the vocational semester; the actual schedule is a little more complex due to the three languages spoken in canton Graubünden, a small group of students who only study Kindergarten education, and schools in different cantons (with different autumn school breaks) being involved.

The students visit the schools in two blocks; the first visit takes four weeks, the second one five weeks. The semester starts in August with a one-week-long introduction to the vocational semester, followed by the first block of teaching by the students supervised by their tutors. In October, there are two weeks for the students to return to PHGR one of which is for reflection and the second one serves as introduction to the second block of teaching.

We conducted workshops for all students before both the first and second block, which we describe in the following subsection. Note that, while these workshops were mandatory, the students did not necessarily have to implement IGif in this first iteration.

2.3 A First Iteration – Mathematics and Informatics

It is not surprising that mathematics takes a leadership role in building up informatics competencies outside of informatics classes. Both disciplines belong to the *structural sciences* [6] and often treat the same topics – with informatics making algorithmic aspects of problem solving more central. This fact is also very visible in context of LP21. More specifically, among the mathematics competencies we find MA.1.A.2, stating [1] that the students (again KG–2)

> "are able to arrange the numbers between 1 and 100 [...],"

which is very closely related to the aforementioned informatics competency step MI.2.1a.

The first part of phase 1 with PHGR's mathematics department started with internal meetings of a team of six PH mathematics lecturers and two ETH computer scientists. After a brief overview of the LP21 informatics competencies by the computer scientists, the team started with the design of a workshop for vocational semester 2019.

Before the first block of visiting the primary schools, the students were introduced to the project by the team and also given an overview of the LP21 informatics competencies. After that, the PHGR lecturers presented an example of how a

mathematics lesson could be "enriched" to also address one of these competencies. Specifically, the obligatory math teaching material contained an exercise that asked

> "How can one find out which one of two given numbers is larger?"

The proposed enrichment of this exercised stated

> "Design a '*machine*' that sorts two given natural numbers by their size. The machine is only allowed to make yes / no decisions."

After this example, which the students were also asked to solve themselves, they continued to work in small groups and to find other enrichments to use within their lessons. The groups consisted of roughly 10 to 15 students each and were supervised by one team member. It should be noted that the mathematics schedule is very strict in that the students have to cover certain topics in certain weeks. Thus, a student who knew she or he would be teaching mathematics in, say, the second week of the vocational semester, also knew exactly which parts of the teaching material would be covered. For other subjects, there is more freedom with respect to what should be taught in a given week.

In order to ensure that the effects of the project are sustainable, it is crucial that the students are motivated to actually implement into their lessons what they have learnt. We have therefore conducted an informal survey to assess how sensitized and motivated they (and their primary school students) were after the first block of teaching. Note that not all students had taught mathematics at this point, and among those who have, some may not have implemented the project due to lack of time or interest. Among others, we asked the following questions, which were answered anonymously. As some students already implemented the project and some did not, they were divided into two groups and asked either Q3a or Q3b.

- **Q1.** Informatics concepts should be taught interdisciplinarily in primary school.
- **Q2.** The project IGif can make a valuable contribution.
- **Q3a.** The primary school students were motivated.
- **Q3b.** The primary school students are expected to be motivated.

The answers were supplied on a Likert scale from 1 ("do not agree") over 2 and 3 ("do rather not agree" and "do rather agree") to 4 ("do strongly agree"). The results are depicted in Figure 1. Note that not all students answered all questions. The large majority agrees with statement Q1, i.e., with that interdisciplinary informatics lessons should indeed be part of primary school education, which indicates

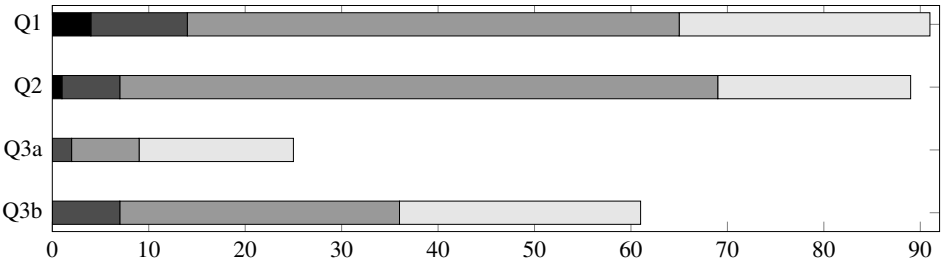

Figure 1: Answers of students in their vocational semester to questions Q1–3; answers were given on a Likert scale from 1–4; here, black corresponds to 1 (“do not agree”), light gray to 4 (“do strongly agree”).

a high intrinsic motivation: 26 students strongly agree and 51 rather agree, while 10 rather disagree and 4 disagree. Furthermore, as the answers to Q2 show, the project was perceived positively by most of the students as a means to actually help to facilitate the corresponding competencies: 20 strongly agree and 62 rather agree, while 6 rather disagree and 1 student strongly disagrees.

The answers to Q3 hint at the students (a) having a positive impression of the motivation their primary school students have after the lessons, and (b), if they have not yet implemented the project, are optimistic in this regard. From the students who already implemented the project, 16 strongly agree and 7 rather agree that the primary school students were motivated while 2 rather disagree. From those who have not implemented the project yet, 25 strongly agree that the students are expected to be motivated, 29 rather agree, and 7 rather disagree.

2.4 A Second Iteration – Involving more Departments

With phase 3 of IGif being launched at the beginning of 2020, first meetings with the departments *Language*, *Design*, *Music-Rhythm-Theater*, and *Sports* have been conducted. The challenge for this phase is that bridges between, say, *Design* and informatics are less obvious than those between *Mathematics* and informatics. However, first meetings show that there are many fruitful directions to pursue.

As a result of the positive feedback from phase 2, we will not change much of the underlying concept. However, there are some crucial differences, mainly that only *Mathematics* has a fixed schedule of which topics have to be taught in certain weeks. This gives students more freedom in choosing a subject that they want to relate to informatics, and also which topic they want to touch upon within the subject. Moreover, we have arranged that implementing the project will be mandatory for all students in vocational semester 2020.

3 Conclusion

We introduced an ongoing project that aims at fostering informatics competencies in primary school as a collaboration of PHGR and ETH Zurich. The first iteration had the goal to sensitize and motivate students in their vocational semester to facilitate informatics competencies in mathematics lessons. An informal survey we conducted suggests that the students see the importance and are motivated to adapt their lessons accordingly. To investigate how sustainable the project is, we will conduct another survey after the students will have worked as teachers in primary school for a couple of years.

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References

[1] Lehrplan 21 Online. `https://www.lehrplan21.ch`. Last visited February 11, 2020.

[2] U. Hauser and D. Komm: Interdisciplinary education in mathematics and informatics at Swiss high schools. *Bulletin of the EATCS* 126, The Education Column, 2018.

[3] U. Hauser, D. Komm, and G. Serafini: Wie Mathematik und Informatik voneinander profitieren können – Teil 1: Abstraktionsfähigkeit. *Informatik Spektrum* 42(2):118–123, 2019.

[4] U. Hauser, D. Komm, and G. Serafini: Wie Mathematik und Informatik voneinander profitieren können – Teil 2: Variation der Problemstellung und Modularisierung. *Informatik Spektrum* 42(2):124–129, 2019.

[5] F. E. Weinert: Konzepte der Kompetenz. OECD, Paris 1999.

[6] C. F. Weizsäcker: Die Einheit der Natur. München 1971.