Secondary Education Meets Tertiary Education – a Concept How to Motivate Young People for Computer Science

Gerd Holweg[1], Robert Pucher[2], Fritz Schmöllebeck[3], Marlies Ettl[4]

Abstract

The stereotypical career choice of young people leads to typical female and male professions, resulting in a low rate of women in STEM fields (Science, Technology, Engineering, Mathematics). Especially Computer Science in Europe is dominated by men. In 2010 a cooperation between the University of Applied Sciences Technikum Wien (UASTW) and the Hertha Firnberg Schools for Business and Tourism (HFS) was started with the aim to motivate primarily girls for a career in Computer Science or science in general. In this cooperation, secondary education meets tertiary education in a newly developed format. In this paper measures are described, the concept's advantages and disadvantages as well as outcomes are discussed.

1. Introduction

An integral part of today's education system is the identification and promotion of learners' potentials. Enrichment of often one-sided education programs with broader offers can prepare young people for more flexible, occupational possibilities. These include e.g. the integration of technical subjects into economic and sociological trainings and vice versa [1]. Young people are primarily interested in topics they know and won't decide for topics they don't know. As an example of promoting technical interest, the UASTW pursues programs for kindergarten kids learning how to handle simple robots, school pupils of all age are prepared for Robocup-Junior challenges [2].
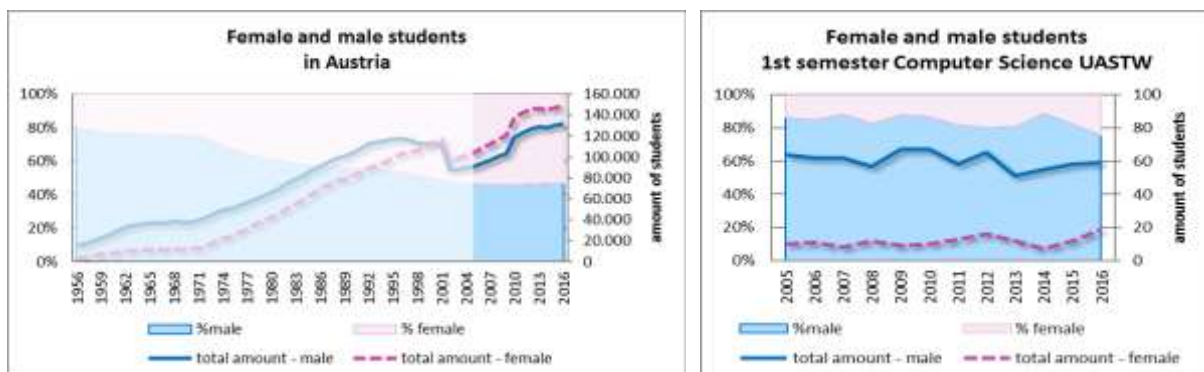

Fig. 1: female and male students - left: all over Austria [3]; right: term 1, computer science, UASTW

One more aspect being addressed is the extremely low rate of women in technical professions and studies. Fig.1 shows that female students all over Austria passed their male fellows in the nineties, whereas the percentage of female students in Computer Science at the UASTW is very constant around low 11% to 24%. Reasons as well as general measures to overcome this gap have already been discussed [4][5]. In 2010 an innovative curriculum for secondary education (pupils of age between 14 and 19) was developed by the HFS in cooperation with the UASTW that attracts both girls and boys, equally interested in IT, science, business and languages, and fosters interest in research. The HFS is traditionally visited primarily by girls because of the original focus. On the other hand, the UASTW lacks the presence of technically interested females. The guiding principle "*If girls don't come*

[1] Department of Information Engineering & Security, University of Applied Sciences Technikum Wien, Austria
[2] Department of Computer Science, University of Applied Sciences Technikum Wien, Austria
[3] Department of Electronics and Telecommunications, University of Applied Sciences Technikum Wien, Austria
[4] Hertha Firnberg Schools for Business and Tourism, Austria

to science, bring science to the girls" has been adopted at a very early stage – and it is still a leading maxim in the cooperation.

2. Methods & facts

The newly developed formats *Computer Science Management* (CSM) (starting in 2010) and *Communication and Media Design* (KoMd) (successor, starting in 2014) are novelties in many ways. Up to that time pupils at the HFS have been taught primarily in business, tourism, catering, management, intercultural competence and languages (http://www.firnbergschulen.at/ausbildung). The UASTW on the other hand purely offers studies in the technical field (https://www.technikum-wien.at/en). Together, a curriculum was developed that offers the above mentioned broad range of educational fields adding topics of computer science. School pupils are prepared in a way which enables them to skip the first year of computer science at the UASTW (details on the Austrian Educational System are published in [6]). While CSM was a school pilot project, the curriculum had to be revised for KoMd to fully fulfil the specifications of the Austrian Federal Ministry of Education, but contents are very similar. The CSM program had been supervised and evaluated scientifically [1][7][8].

2.1. Key priorities of the education program

A key aspect of the curriculum is the broad hybrid training, offering a wide range of professional choices to pupils for tertiary education. The vision is a society that communicates science to youth in a gender inclusive way in order to realise the full potential of girls and boys to follow STEM related careers (Hypatia Vision [9]). The primary objective is on computer science topics, the broad scope becomes visible by Fig. 2. Table 1 gives an overview over STEM subjects.
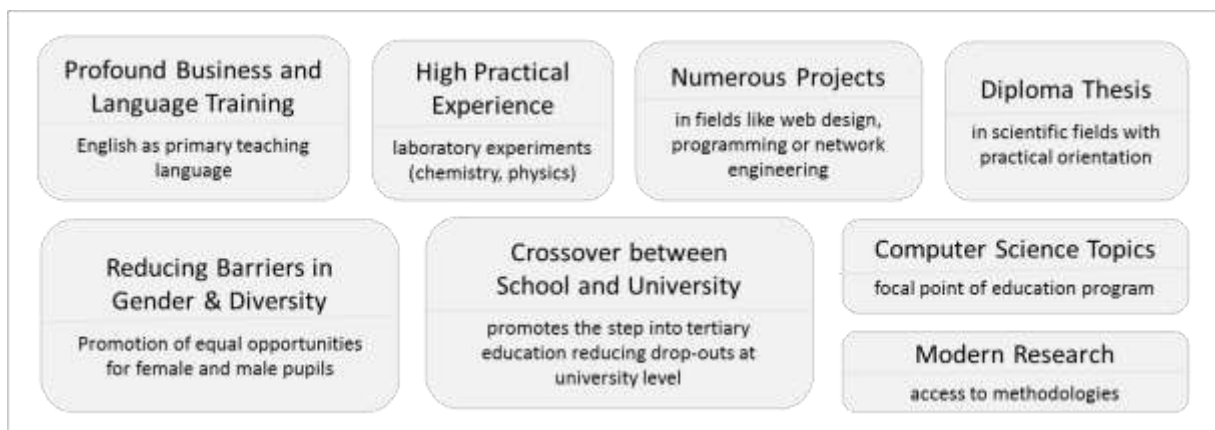

Fig. 2: key priorities

Table 1: science and IT subjects in CSM and KoMd

CSM and KoMd subjects in STEM related fields / weekly hours		
areas	hours	content
Information and Office Management	4	Text Processing, Spreadsheets, Presentation Techniques
Science	20	Science, Science Laboratory, Scientific Work
Mathematics	10	Mathematics
Communication and Media Design	26	Image, Audio&Video Processing, Photography, 3D Animations, 3D Printing, Print Design, Interview Techniques, IT-Projectmanagement, Webdesign, Webprogramming, Webusability, CMS, Network Technologies and Security
Applied Computer Science	10	Programming, Robotics, Hardware, Operating Systems, Database Systems, Object Oriented Programming, IT-Law

2.2. Practical implementation

The whole program became successful through accompanying measures:

Courses at the UASTW: Pupils are guests at the UASTW once a week and get instructed in science topics for a period of five years. They get to know how exciting science and student life can be at a university. For most pupils, this is a highlight of their education, feeling like "real" students and giving them privileges their fellows in school miss (shown in Fig. 3).

Identity Cards	Computer Accounts	University Facilities	Infrastructure & Laboratory Equipment	Electronic Campus Information System
allow to enter the university building whenever wanted	allow to logon to any computer available to students	like canteen, Xerox machines or library can be used	can be used for learning and private interests	free access, offers e.g. free ebooks

Fig. 3: benefits at the UASTW

Team teaching: In some science courses two teachers are involved – one from the HFS and one from the UASTW. This guarantees that academic competence is handed over to school teachers. Currently two lecturers of the UASTW are permanently employed in a part time manner. This kind of team teaching is unique in Austria and gives pupils not only a first impression of the university environment, but also a good preparation for academic training later in student life.

Notebook classes: Pupils are asked to acquire a notebook computer (tablets or smartphones are not eligible for more complex tasks) which can be used for daily routine in school as well as for learning at home. The notebooks are used in a manifold way, for text processing, calculations, internet research, programming, creating graphics, cutting video and audio, exams. This way young people get used to computers as working tools instead of instruments for playing.

eLearning: Moodle is the main resource for sharing learning content and submitting exercises. Paper books are used alongside electronic books, pdf and powerpoint documents, video and audio snippets. Electronic interactivity is promoted where direct communication comes to its limits, as e.g. email for sending individual messages, internet forums for discussing problems concerning homework, Wikis as platform for collaborative work, electronic upload of home exercises, electronic feedback to home exercises or electronic polls on smartphones. Even exams all over the year as well as the school leaving examination in the fifth class are done on computers.

2.3. Course highlights in class
Fig. 4 shows courses that have been picked out representing highlights of the educational program:

Robocup Junior:
- Pupils are encouraged to play and experiment with small robots.
- Impartation of an analytical and cross-linked way of thinking needed for programming.
- No overextension with theoretical knowledge and constant repetition of heretofore unknown methods.
- Learning of fundamentals of programming and analytical thinking in a playful way
- Participation in the international Robocup Junior tournament
  - see http://www.robocup.org/domains/5 for details
  - winner 2013 and 2014 in soccer
  - second place in team competition world championship Eindhoven.

ScienceLab:
- Takes place in the physics laboratory of the UASTW.
- Makes the whole equipment available to students.
- Lab exercises are carried out individually or in groups of two.
  - Small projects and composition of scientific posters.
  - Scientific topics come alive for young people.

TechLab and Scientific Work:
- Creating and documenting project work with a scientific claim.
- Preparation for later, academic work.
- Finding appropriate research questions, doing literature research as well as conducting surveys and interviews.
- Distinguishing between qualitative and quantitative research.

Media Design:
- Creative work in image and audio processing
- Pupils learn how to model, shape and cut videos and how to take pictures.
- Practicing in the open field as well as studio work.
- This course is accompanied by professionals from the industry.

Fig. 4:   course highlights

3. Experiences and lessons learned
Looking back on seven years of experience, results can be viewed from different perspectives.

UASTW's perspective: The cooperation fits perfectly into the UASTW's initiatives of promoting young people in computer science skills. Costs are quite low and the effort is limited, lecture rooms are already existing as well as equipment in physics laboratories and robots for the programming courses. Some more targeted goals:
- Addressing young people at an early stage (as well as teachers at school) and arousing interest in technology.
- Drawing young people's attention to educational offers of the UASTW.
- Encouraging talented and interested students.
- Offering excursions, workshops and guest lectures in schools.
- Leveraging synergies and bundling forces (joint projects, consulting diploma theses by UASTW students, participation in competitions).
- Building an interface between school and science.

HFS's perspective: The main focus of the HFS is excellent school education with equal opportunities for young men and women and a wide choice for further academic education. New is the emphasis on technical subjects in an environment dominated by female pupils. A gender sensitive school development program completes the main task, further aspects are outlined as follows:
- Innovative, future-oriented education program, attracting both female and male adolescents alike.
- The school location is to be secured in the long term by increasing student numbers continuously.
- High transfer potential for the entire school system in Austria through a unique cooperation with an academic institution.
- School internal knowledge transfer (technical fields, gender sensitive vocational counselling, increased media comprehension).
- Pupils become 'ambassadors' in other schools and on Open Days.
- IT projects make technology more tangible for all.
- Pupils decrease their threshold in choosing a degree program in technology or science.

- Public work and image campaigns help to make this school type known to the public.

Personal experiences: Since some teachers have academic as well as school classes, they have a view on both worlds. School and academic world are very different, even if the same topics are taught. School pupils need much longer than academic students for solving IT-exercises, handling individual belongings is much more important. IT enthusiastic pupils are very rare and most would choose other school types. But pupils are very proud of the educational program they live in. When they speak about IT projects they did and the variety of events they have in school, one can feel their enthusiasm and the good spirit. Pupils really like to come to the UASTW once a week and feel like real academic students.

Knowledge transfer: Efficient communication policy with external stakeholders is a major contribution to the sustainability of the measures and the creation of public awareness. Research is brought to schools, provides impulses for school teachers and management, and motivates a new generation of potential researchers to choose educational pathways in the university sector. Team teaching guarantees knowledge transfer in otherwise academic domains from university to school. Within school, projects transport knowledge between classes (e.g. coach sessions in technical subjects given to language classes). This way pupils learn about topics they have not chosen as their key educational areas.

Trends in student numbers: The educational program started in 2010 with 11 female and 6 male pupils. With 5 female and 1 male finalists the dropout rate among male students was higher than those of their female counterpart. In the meantime, the gender rate for beginners is 50:50. This is remarkable, showing that the educational program attracts girls and boys alike. Nevertheless, the most outstanding students of all ages are female. The interest of the pupils in the educational program has increased year by year, the quality of the students' testimony also increased – in contrast to the other classes of the school location.

4. Conclusion and future developments

The cooperation's main goal is to inspire girls for technic-scientific topics, potentially followed by a study at the UASTW. Although none of the finalists entered the UASTW so far, the cooperation is a win to win situation and the UASTW could acquire some (female) students motivated through word-of-mouth recommendations. Due to standardization efforts, the curriculum of KoMd was not as close to the UASTW studies as CSM was. There is legitimate hope that schools in Austria will be able to gain more autonomy by 2017, and thus be able to react more closely to the requirements of the partners HFS and UASTW. Despite all obstacles, the education program could gain a great response in public. The success can be measured in constantly increasing interest of pupils and parents, and the increasing number of students starting and finishing the education program. The grades are above average and it's a joy seeing children becoming self-employed young people, who independently make their future career choice. A major contribution is made by the described education program, which makes technical topics attractive to both girls and boys alike, and provides them with a gender and diversity friendly environment.

References

[1] Gutknecht-Gmeiner, M, "Computer-Science-Management – ein innovatives Ausbildungsmodell in der Praxis", Impulse Evaluation und Organisationsberatung; Wien, 2011
[2] Pucher, R.; Hoffmann, A., "Teaching with Projects Increases the Intrinsic Motivation to Learn – The RoboCup Project", Proceedings of the CIMMACS ´11 conference, Jakarta, 2011
[3] Statistik Austria, data from http://www.statistik.at/web_de/statistiken/bildung_und_kultur/ formales_bildungswesen/universitaeten_studium/index.html (2017-03-20)
[4] Pucher, R.; et al., "Measures to Increase the Percentage of Female Students in Computer Science", Proceedings of the ICBL 2011 conference, Guatemala, 2011
[5] Salchegger, S., et al., "Warum besuchen Mädchen mit Spitzenleistungen in Mathematik so selten eine höhere technische Lehranstalt?", in Schlögl P., et al. (Hrsg.), "Berufsbildung, eine Renaissance?". Bielefeld, 2016
[6] bildungssytem.at, "The Austrian Educations System", Online: http://www.bildungssystem.at/en/ (2017-03-20)
[7] Gutknecht-Gmeiner M., "Das wär' die perfekte Schule für mich gewesen", oibf – Österreichisches Institut für Berufsbildungsforschung, Wien, 2009
[8] Gutknecht-Gmeiner M., "Computer-Science-Management – Follow-up 2011/2012"; Impulse Evaluation und Organisationsberatung; Wien, 2012

[9] Hypatia Project Vision, Online: http://www.mada.org.il/webpdf/Hypatia_vision_pan_eng.pdf (2017-03-20)