SETTING-UP A RESEARCH CLUB FOR HIGH SCHOOL STUDENTS: AN ENGINEERING EDUCATIONAL CONCEPT BASED ON INCREASING BOTH INTEREST AND SELF-EFFICACY

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ABSTRACT

In the fall of 2019, the research club changING started as an outreach program in the Cluster of Excellence SE^{2}A. While the cluster deals with interdisciplinary research topics to explore technologies for sustainable and environmentally friendly aviation, the associated research club offers students from the 10th grade onwards the opportunity to gain insights into engineering. The target group here is primarily young women, who are heavily underrepresented in this career field. The research club is experience-oriented and offers high school students the opportunity to explore engineering, its systems, technologies, applications, and social and cultural significance by participating in different projects at various engineering institutes in the Cluster. During their four years of participation in the club, which is voluntary, students are challenged to discover, create, construct, and solve problems. In the process, students learn different engineering concepts and skills. Currently, three batches (75 highschool students) actively participate in the program, accompanied by engineering Bachelor students who serve as mentors. This paper presents the

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structure of the research club which is based primarily on theories of the emergence and development of individual interests and self-efficacy expectations. A well-known model depicting the development of individual interests is the four-phase model. This model is considered the basis for the structure of the research club program. In this paper, the most important factors in the set-up of the research club and the expected results as well as the many lessons learned are presented.

1 INTRODUCTION

In recent years, numerous initiatives have been developed to promote interest and understanding of technology. The everyday life and the social contacts of young people are increasingly characterized by technical devices. However, young people are usually not actively engaged with technology as such, as they are neither concerned with materials nor with the functionalities or the original use of the devices, as various interest studies show [1]. This discrepancy between a life in the midst of technology and simultaneous technology remoteness in terms of interest and understanding has various causes, which have been investigated in the studies on technology socialization [2]. Since October 2019, the research club has therefore been pursuing, among other things, the goal of promoting young people's interest in technology and science and providing insights into the professional field of engineers. In the next sections the conceptual framework is presented followed by the methodological approach and structure of the research club.

2 CONCEPTUAL FRAMEWORK

2.1 Emergence of Individual Interests

An overview of current theories of interest can be found in the review article by Renninger and Hidi [3]. In their review article, they define the characteristics of interest and emphasize that these are the characteristics that a majority of scientists in this field would agree with. Accordingly, interest is a motivational variable that meets five criteria points [3]. According to Krapp [4], interest occurs when the distinguished -cognitive, affective, and value-related components are experienced.

2.2 Development of Individual Interests

A well-known model that depicts the development of individual interests is the four-phase model by Hidi and Renninger [3]. It describes the first phase of interest development as triggered situational interest. The triggered situational interest can then move into the second phase, the maintained situational interest. The third phase can develop from the second phase and is characterized as emerging individual interest. The fourth phase is a well-developed individual interest. Each of these four phases is connected with certain affects, more or less pronounced knowledge of the subject and the value estimation of its content, i.e. the cognitive, affective and value-related components of interest. These components describe a form of cumulative interest development, provided that this process is externally supported and maintained. Without external support, any phase of interest

development can break off prematurely, with interest regressing to the level of an earlier phase or disappearing altogether.

2.3 Self-Efficacy

Closely linked to the experience of competence, which is set as a basic need for interest development, is the self-efficacy expectation [6]. Self-efficacy expectations are defined as "beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" [6]. The term self-efficacy beliefs refers to one's confidence in one's competence to initiate and complete even difficult actions. The belief that one is capable of organizing and executing certain behaviors or achieving certain goals influences one's choice of future activities, efforts, and perseverance.

2.4 Gender Roles and Career Choice

Studies show that the lack of personal contact with people in the engineering sciences and the lack of role models are among the most important reasons why so few female high school graduates choose to study engineering. In addition, many young women are afraid of confirming negative stereotypes [7].

From the point of view of developmental and learning psychology, career choice is not an isolated event, but a developmental process that is prepared by experiences during childhood. During this process, vocational interests, judgments about occupations, and expectations regarding the compatibility of an occupation with personal prerequisites and life plans are formed. Priorities are also formed, such as those expressed in Gottfredson's [8] postulated compatibility of an occupation with the criteria of "gender type", "social prestige" and "personal interest".

It is undisputed that career choice is significantly influenced by gender. Herzog et al [9] writes: "Professions have a face in which traits of social prestige and gender difference are drawn, which is why different professions are open to a girl than to a boy". According to Gottfredson [8], the public presentation of gender roles actually forms the most important occupational choice criterion. The choice of a gender-untypical profession therefore requires a great deal of self-confidence and a great willingness to compromise. Accordingly, Gottfredson emphasizes how important it is in today's society not to further reinforce the limitations in the self-perception of young people as well as in their perception of the professional world, but to keep the spectrum of acceptable professions open and to raise awareness of inappropriate processes of limitation.

3 SETTING UP THE RESEARCH CLUB STRUCTURE BASED ON THE CONCEPTUAL FRAMEOWRK

Evaluation studies [2] point out the importance of support programs in connection with situational interests, but at the same time show that such initiatives are not sufficient for the development of individual interests. For this, continuous offers are necessary from childhood until beyond the career decision. Our research

clubchangING therefore offers regular meetings so that the development of individual interests can be ensured.

German as well as international studies [10] have shown that practical work and the production of a product with reference to the use in everyday life have an interest-promoting effect, whereby the latter is particularly motivating. For girls in particular, it is also important to deal with the social contexts of technology. Some studies [7] could prove a positive influence of technology lessons on the career choice.

The structure of the research club is based primarily on theories of the emergence and development of individual interests and self-efficacy expectations. The 4 phase model is considered as the basis for building the program of the research club. In Table 1, we show the most important factors in building the research club and the expected outcomes.

Table 1. Important Factors and the expected outcomes during the 4 years participation.

Factor/year	**1st year**	**2nd year**	**3rd and 4th year.**
Main goal and expected change.	**Generating initial interest**: According to [3], interest occurs when the different components - cognitive, emotional and value - are experienced.	**Increase interest and self-efficacy**. Interest development so-called Basic Needs that contribute to the stabilization of situational interests (cf. [3]): experience of competence, self-determination (or autonomy) and social inclusion.	**Development of own intrinsic interest** through individual projects PjBL. Impact of PjBL on **self-efficacy**. Competency expectations and the 4 sources of self-efficacy. [7]
Main Meeting type	Institute visits, basic skills, experiments, expert meetings	Same as 1st year. As well as working on self-directed projects in a MakerSpace.	Institute Projects: Students work on an authentic, real-world problem. Allows for different focus and processing methods.
Main parameters studied (measured impact)	Acceptance. Initial interest. Subgroup differences.	Change of attitude towards engineering. Increase in interest and self-efficacy.	Behavior change. Intrinsic interest and self-efficacy, study and career choice intention.

By participating in the research club, students in the 10th grade and above can experience the different facets of engineering. They can start in 10th or 11th grade and meet regularly once every two weeks. Mentoring and possible projects and workshops are offered through 13th grade. The groups are either all-girls groups or mixed groups.

In the research club, participants have the opportunity to interact socially with other technically interested young people while exploring the University and other facilities of the Cluster of Excellence SE^{2}A and experiencing research projects. Through the different meetings throughout the 4 years the participants gain background

knowledge on the topics being researched in the participating institutes, including visiting the laboratories and assisting with experimentation. They thereby get an idea of what engineers do, get a chance to ask their own research questions and gain access to tools that facilitate their project work; they may visit areas of special interest and receive assistance from experts. Adding to that, the students are accompanied by experienced mentors and get to meet potential role models. The mentors are mechanical engineering students, preferably female, and accompany the groups during the 4-year program. Beforehand, the mentors are trained by an educational psychologist (training in mentoring tasks and gender-specific language use). This is a very important success factor, especially in the recruitment of female students [7].

3.1 Recruiting participants for changING – Lessons learned

One of the main goals of the research club is to attract talented and interested high school students. However, the marginalized minority, girls and students from low socioeconomic backgrounds should also be reached and supported.

As a strategy for attracting students, measures taken include the following: Physics teachers at schools are contacted to organize a visit so that mentors can introduce the research club directly to the youth in the classroom. Youth centers are also contacted and students form different socioeconomic backgrounds get the chance to join the club. Conventional means such as newspaper articles and social media are also used. The variety of channels ensures that a very large number of young people in the region learn about this research club and get the chance to join. The students are also offered to have their participation in the research club noted in their school reports in the form of an after school activity.

4 SUMMARY

The main objective of the changING research club is to support high school students to think seriously about engineering as a career and to increase the likelihood that talented youth will consider the possibility of pursuing a career in engineering.

Furthermore, it is important to support girls to think seriously about engineering as their career field, making it easier for them to consider engineering as a career option, since the social aspects of technology and engineering are explained and shown.

The participants are being interviewed at different points through their participation at the club and the participants' interests, self-efficacy expectations and career aspirations are surveyed, differences between subgroups are identified and presumed correlations between the variables are substantiated. In order to be able to derive factors that help to formulate measures for action, it will be investigated whether and to what extent participation in the research club influences the students' relationship to engineering and technology. Using the accompanying study to document the progression of the students' career decision-making over time as well

as during their school years, it becomes possible to identify and map the influences that shaped their sense of purpose in the profession.

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