Measuring Learners' Interest in Computing (Education): Development of an Instrument and First Results

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Abstract. So far, there is hardly any empirical research on the question of what raises or influences the interest of school learners in computer science or computing education. Aspects to be considered are for example pedagogical decisions of the teacher concerning contexts, phenomena, situations, or concepts to which a lesson or a lesson sequence refers, planned learner activities and many others. This paper analyses a model for describing interest in physics on its transferability to computer science, reports about the development of an online questionnaire for investigating the computing-related interests of school learners and gives results of a first empirical pilot study (based on N=141 datasets). Based on the participants' answers concerning socio-demographical aspects, the computing interest of different groups of learners was analyzed. A higher level of computing interest was found at male pupils, learners who indicated that they were striving for a computing-related job, that computing was their favorite school subject, or that they had good or very good school marks in mathematics or computing.

Keywords: Learners' Interest, Computing Interest, Secondary Education, Questionnaire, Empirical Study, Explorative Study.

1. Introduction

Among other things, school education shall be directed to "the development of the child's personality, talents and mental and physical abilities to their fullest potential" [1]. This includes the development of *interests*, perhaps even long-term domain interests, which may lead to a professional career in the particular area after graduation from school in the future. The pedagogical-psychological literature (e.g. [2, 3]) assumes that interest as an element of the learning potential influences the activities of learners and, finally, together with other factors, affects their competencies and personality development. Because of the importance of interest in the design of teaching-learning processes, the description, modelling and development of interest has already been investigated intensively, e.g. in the fields of educational and natural sciences. Krapp and Prenzel give an overview of the research field in the area of pedagogical psychology [4]. According to them, interest is a multidimensional, psychological construct directed to a particular object whose operational definition requires cognitive and emotional categories. Interest can arise from the interaction of an individual with its environment and is influenced by his or her values and feelings. Individual interest, which is anchored in the personality structure of the individual, and situational interest generated by external factors can be distinguished. From a school perspective, teachers would like to see learners to be interested in their lessons and the course of lessons as well as in the addressed concepts and activities. The goal of generating or maintaining interest in mathematics, computing, science or technology is also of interest for many countries and leads worldwide to various educational initiatives, such as www.stemedcoalition.org, www.stemnet.org.uk or www.mintzukunftschaffen.de, because the STEM business field (science – technology – engineering – mathematics) is regarded as very important for the economic development.

Since interest in computer science or computing as a school subject have so far hardly been empirically investigated, this paper aims to contribute to its description and investigation. So, the rest of this paper is structured as follows: in section 2, we analyze a model for structuring interest in physics for its transferability to computer science. In section 3, we describe the development and the structure of our questionnaire for investigating computing interests, followed by results of a first pilot study we carried out in 2016 in section 4. The paper ends with conclusions and outlook in section 5. A detailed documentation of the study can be found in [5].

2. Structuring Computing Interest

An important work in the field was carried out in the subject physics. In the so-called *IPN[1] interest study in physics*, learners' interest in the school subject and the academic discipline physics were measured and analyzed in different grade levels of lower secondary education with an extensive questionnaire over a longer period of time [6]. This study was based on a three-dimensional interest model with the dimensions *concepts*, *contexts* and *activities*. On this basis, the study investigated the prior knowledge and interest in various topics of the school subject physics as well as in different sub-areas of the academic discipline and the learners' interest in learning more about it. The sub-areas were sketched by means of a short text in order to give learners, who did not yet have any or no physics lessons on the respective topic, the possibility to answer the questions. In addition, leisure and future job interests were measured on the basis of questions about media usage during leisure time as well as by discussion topics in the circle of friends.

In an international study on the *Relevance of Science Education (ROSE)* [7] among other things, ranking lists of the most interesting and uninteresting topics were created – from computer science perspective, the finding that the topic "How computers work" was the third-most interesting one for boys in this science-related survey is especially recognizable. Further areas of interest related to computer science were not reported.

For computer science, there is a study on "student wishes in computer science" [8], which is closer related to the focus of the paper at hand – also carried out at the IPN. The wishes of pupils concerning computing education at school were investigated

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based on the computing curriculum of the federal state of Schleswig-Holstein (Germany) valid at the time of the study as well as on the recommendations for educational standards for lower secondary computing education of the German Informatics Association (GI) [9]. The topological structure of computing interest (as in the IPN interest study in physics) was not investigated.

This leads to the question: What would be possible facets of computing interest? For this purpose, the structure model used in physics is subsequently examined with regard to its suitability for the description of computing interest.

Relevant concretizations of the two dimensions *concepts* and *activities* provide the *content* and *process fields*, as they are, for example, defined in the educational standards for computing education in lower and upper secondary education of the GI [9, 10], as well as in computing curricula of Germany's federal states (e.g. [11]). A similar structure can also be found, for example, in the K12 Computer Science Framework, which was developed in cooperation of ACM, Code.org, CSTA and others (see k12cs.org). This work distinguishes between the *concepts* "computing systems", "networks and the internet", "data and analysis", "algorithms and programming" as well as "impacts of computing" and the *practices* "fostering an inclusive computing culture", "collaborating around computing", "recognizing and defining computational problems", "developing and using abstractions", "creating computational artefacts", "testing and refining computational artefacts" and "communicating about computing". Computing interest can develop in terms of computing concepts as well as in terms of computing activities such as "coding" or "programming".

There is also various research on the dimension of *contexts*, which details this in terms of computer science. On the website of the German project "computer science in context" (www.informatik-im-kontext.de, see also [12]) there are several examples of possible computing contexts, such as "intelligent houses" and "social networks". The aim of relating lessons to contexts is to link different aspects of a subject in a larger overall perspective, but also to show learners how the competencies to be acquired relate to their everyday lives. Starting point of school lessons can be, for example, certain everyday situations with a connection to computer science, which can then serve to open up the larger context. In connection with such situations, various phenomena of computer science may occur [13], which may require explanation and which can initiate questions and research interests. This way, everyday situations and computing phenomena can generate interest.

Another area that could be investigated with regard to computing interests is the media usage behaviour of learners. According to the annual German JIM (youths – information – multimedia) studies, it can be assumed that nearly all young people have access to smartphones [14], as well as to digital devices of a wide range of other categories. The goal to use digital media competently, but also to understand and to help shape the "digital" world, is a core statement of overall concepts for "education in the digital networked world" (e.g. [15, 16]). Digital media such as the MIT AppInventor (appinventor.mit.edu) enable shaping through app development in a simple, visual way. Digital media of a different kinds can create interest of pupils by themselves, by related computing phenomena [13] or by embedding them in subordinate contexts [12]. Since digital media from the point of view of computer science are either computing systems (e.g. a learning app, an eBook reader) or digital representations of information (e.g. a learning video, an eBook), there is no need to extend the above-mentioned structure model here. In the course of the discussion about education in the digital networked world, it was argued that systems, phenomena, artefacts and contexts of the digital world should be analyzed from an application-oriented, from a technological and from a socio-cultural perspective – in order to enable full participation in view of understanding as well as the ability to contribute. The application-oriented perspective can already be found in the structural model in two places: as "using" as possible activity as well as with regard to the "application object", a computing system, which is a possible subject concept. The technological perspective is formed by computing concepts and activities and is thus also included. Finally, the socio-cultural perspective can be found in the content field "Informatics, man, and society" [9] and/or "Impacts of Computing" (k12cs.org), where everyday contexts are the starting point for further consideration.

In conclusion, there is much evidence that the structural model used in the IPN interest study in physics could also be viable for computer science.

3. Investigating Interest in Computing

The above considerations were the starting point for the development of an online questionnaire for the exploratory investigation of computing interest and its piloting in some groups of learners of different school forms [5], as will be described next.

3.1 Structure of the Questionnaire

The decision for an online questionnaire was made in order to be able to reach a potentially larger group of participants, essentially regardless of location. The structure of the questionnaire was orientated at the IPN interest study in physics [6], computing interest was analogously differentiated in interest in the school subject and the academic discipline. A translated version of the questionnaire is available at *http://udue.de/csinterest*. At first, the participants were asked how many semesters they have already had computing as a school subject or whether they intended to select the subject in the future and thereby differentiated.

Those who have or had taken the subject were asked for their *interest in computing as a subject*. For this purpose, an instrument for the subject social sciences [17] was adapted to computing. With this instrument, students' attitudes towards the subject are measured using a four-level Likert scale from "strongly agree" to "strongly disagree". This scale has also been used in further questions, the decision for four levels was taken to encourage the participants to a decision [18]. Statements to be rated in this section were e.g. "It is fun for me to deal with computer science" or "Computer science helps me to develop as a person". The pedagogical design of the lesson was disregarded here.

These items were followed by a block on the *decision to take computing classes* in the past or the future. Also with a four-level Likert scale different answer options could be rated here, such as "because I would like to help myself with problems with my smartphone, tablet or computer" or "because I want to know how I can encounter dangers on the Internet, which target my data and my privacy".

The following section provided statements on the *importance of computer science in their own leisure time*, concerning e.g. their own research interests, discussions in the family or friends' circle with a relation to computing, as well as their active pursuing of computing topics in journals or media reports. In order to be able to adapt the following questions in the best possible way to the respective age group, the participants' current grade level as well as the type of their school were questioned next.

In the next section, the participants were asked about their interest in certain computing-related *contexts and situations*. Contexts and situations used for the study were derived based on theory: already tested contexts of "Computer science in context" [12] were used as well as information about the media usage behavior as reported in the KIM and JIM studies [19, 14]. In this case, learners in lower and upper secondary education were given common and separate items. Examples used were "attack by malware on the computer", "friendship recommendations in social networks" (both lower secondary education), "computer games", "mobile devices" (all participants), "home automation" (upper secondary education), and others. In each case, the learners were first asked about their prior knowledge (four-level response from "very much" to "very little" and about their interest to look on the respective situation or context from an application-oriented, technological, socio-cultural and creating perspective [15]. Related items referred to the learners' interest "how to create computer games", "how social networks function internally", "what effects the distribution of malware might have" or "how to use search engines properly". Furthermore, the participants were questioned whether the respective topic had already been dealt with in the classroom, as well as for the extent to which their interest was induced by computing education at school, the media, their circle of friends, plans for a future job or their own leisure activities.

The last section consisted of statements on various *concepts and activities* within computing education, which were collected from a choice of curricular documents [9, 11, 20]. Among other things, the participants were asked for their interest to plan programs, to know how hard- and software work together, how the discipline computer science develops, or how to use computing terms correctly. The questionnaire ended with sociodemographic questions about age, sex, their latest marks in mathematics and computer science (three-level: very good to good, average, rather bad), their favourite school subject and their future career plans. Pre-test investigations showed that it took about 30 minutes to answer the questionnaire.

3.2 Data Collection and Evaluation

The online questionnaire was created using the "LimeSurvey" software (www.limesurvey.org). An invitation letter with an explanation of the planned study, a pdf version of the questionnaire as well as a link to the online version were distributed via existing e-mail lists for computing teachers in the German federal states of Baden-Wurttemberg, North Rhine-Westphalia, and Rhineland-Palatinate. Furthermore, some regional schools with personal contacts of the authors were also included. The data collection phase took place in the second half of June 2016. A total of 172 datasets were collected, of which 18 were incomplete. In addition, 13 records had to be excluded from the evaluation because of obviously nonsensical answers, so that the sample had a total size of $N=141$.

The evaluation was carried out using the statistical software IBM SPSS v. 22 for the production of descriptive statistics as well as for the comparison of the interests of different groups of persons (separated by gender, favourite subject computer science, computer-related job wishes, assignment to lower or upper secondary education, (very) good marks in mathematics, (very) good marks in computing. For this, among other things, the “Mann-Whitney-U-Test” [21] appropriate for ordinal data was used.

4. Results of a First Pilot Study

4.1 Descriptive Statistics

In the section concerning *subject interest* six out of eight items were answered between 56% and 73% with “totally agree” or “agree”. Percentages given in the following always are the sum of the values of the approving or rejecting categories. The participants expressed a generally positive attitude towards computing. However, nearly 60% of the respondents said that it is (rather) true that computer science is indifferent to them. The majority of respondents (57%) rejected (positive) statements regarding a positive effect of dealing with computer science on their own personality development.

Concerning their *decision on taking computing classes*, items were rather approved, which focused on help for self-help (55%), the understanding of computer science concepts (58%), or the acquisition of software application competencies (54%). Statements about dangers on the Internet, study or career decisions, experiences of siblings, friends or relatives active in the field of computer science, or expected advantages for other school subjects were (mostly) rejected or given a mixed picture.

Furthermore, *dealing with computer science in their everyday lives* was apparently of secondary importance for the participants – all respective items were (rather) rejected by 60% to 86% of the participants.

Concerning *situations and contexts*, a differentiated picture emerged: learners in *lower secondary education* (n=73) rated dealing with malicious software (on the average of the sum of all assigned positive statements: 57%), computer games (62%) as well as smartphones and tablets (53%) from the afore mentioned pedagogical perspectives (see sect. 2) as (rather) interesting, dealing with word processing (respectively negative statements: 60%) as well as social networks (54%) but of (rather) little interest. Their previous knowledge had no recognizable influence on these ratings: the participants rated their prior knowledge concerning word processing (76%), computer games (66%) and smartphones and tablets (75%) as (rather) high, their knowledge concerning the other contexts as rather low. Explicitly asked for factors affecting their interest, the participants’ answers showed that an assumed importance of word processing for potential future careers (53%) and concerning computer games its relevance in their circles of friends (66%) as well as their interest in this field as a leisure activity (59%) had a positive effect on their interest. That such interest would have been induced by computing education at school or media reports was clearly rejected – this also applies analogously for the participants of *upper secondary education*. These participants (n=68) rated their interest in the contexts computer games (average of the sum of all the associated positive statements: 66%), search engines (55%), clouds (51%), smartphones and tablets (62%), and home automation (48%; about 8% of the participants did not answer here, in the other contexts only about 1% to 3%) as (rather) high, only a few items related to the application-oriented and the socio-cultural perspective (contexts search engines, clouds, house automation) showed an undecided or slightly negative picture. In these areas, the participants said they had (rather) little prior knowledge. There is a need for further research here to investigate, whether there is a correlation. Explicitly asked for factors influencing their interest, again only few aspects very rated positively. Leisure interests with computer games (54%), relevance in their circle of friends (69%) and leisure interests (73%) with search engines. Although the participants rather agreed with the statement that it would be interesting to them to learn more about the internal functioning and the creation of search engines, it remains open at this point to which aspects their leisure/friends' circle interests relate. It would also be conceivable here that web-based searches on topics of their own interest using search engines were meant.

Asked for different *concepts and activities* of computing education, the following picture was found in lower secondary education: modelling and implementing algorithms and programs for solving problems – either alone or in cooperation with others –, understanding the functioning of computing systems as well as the correct usage of computing terms were evaluated as (rather) interesting, statements referring to socio-cultural aspects of computing, e. g. concerning secure passwords, behavior in social networks and the development of computer science as a discipline, were rated as (rather) little interesting. The same tendency was found in the group of the participants of upper secondary education. However, the software development process and software development in teams were considered as rather uninteresting, the creation of multimedia products (audio / video) was rated indifferently.

4.2 Selected Differences between Groups of Persons

In the field of *interest in computing* there were clear deviations in the approval values for different groups of participants. For example, male pupils tended to agree with the items more than female pupils, in particular with the items "I like computer science" as well as "I like computer science mainly because of the interesting topics". Participants with computing as their favourite subject agreed stronger with the items "I like to learn about computer science", "It is fun for me to deal with computer science" as well as "It is of great personal importance to me to learn something about computer science" than participants with another favourite subject. For all eight items the differences were significant. Furthermore, computing career wishes, the assignment to lower secondary education as well as a (very) good mark in computer science or mathematics led to a stronger approval.

There were no significant gender differences between the *"reasons for the choice to take computing classes"*. A favourite subject computing, a computing-related job wish and a (very) good mark in mathematics or computer science led to a higher degree of approval than in the other subgroup.

In the section on *computer science in everyday life* the gender had only a medium effect on the response behaviour, although significant differences showed up: the males tended to agree with the items more than the females. The effect of the secondary level allocation was also low, with participants from the lower secondary level tending to agree more. In the other comparisons, there were significant differences especially in the items "When I get to know a new topic related to computer science at school, I try to find out more about it.", "I talk to my family about subjects related to computer science." as well as in "I speak in my circle of friends about subjects related to computer science.". There were higher levels of consent from learners with a favourite subject computer science, computer-related career plans and assignment to lower secondary education. (Very) good mathematics and computer science marks led to higher levels of approval in all questions of this section. In the case of better mathematics marks the interest in learning about computing was significantly higher. In the case of better results in computing, the difference for the item "I read in professional journals about computer science" was also significant.

In the group of participants from lower secondary education differences in interest showed up concerning the *situations and contexts* relating to computer games and word processing systems. The male participants more strongly agreed to be interested in a consideration of computer games from a technical as well as a creating perspective. This also applies to the learners with higher rated computing skills; but the interest in the technical perspective was somewhat higher among the other participants. The learners with favourite subject computer science also agreed more strongly to be interested in dealing with computer games from a creating perspective. This also applies to learners with better-assessed computing marks; the interest of the other participants in the technical perspective was partly higher though. The learners with favourite subject computer science also agreed more strongly. Mathematics marks and a desire for a computing career had only a significant influence concerning the context "word processing": a computing-related job wish led to an overall stronger approval. Furthermore, the interest in learning the productive usage of word processing systems was significantly higher in the case of better mathematics marks.

There were also differences in upper secondary education. In the field of computer games, males rated their respective prior knowledge significantly higher than females. Learners with a favorite subject computer science were more interested in dealing with computer games from all four perspectives than learners with other favorite subjects. There were no significant differences with regard to the learners' career plans. Learners with a better assessment of their computing marks were significantly more interested in the consideration of all situations and contexts from a technological perspective than their classmates with a weaker assessment.

5. Conclusion and Outlook

If one's own real-world interest was in the foreground, a higher proportion of learners answered the corresponding items positively. Objects, which were of no great importance in the learners' everyday lives, were also of less interest to them. Socio-cultural aspects – in contrast to technological and application-related ones – met with little interest. Learners in lower secondary education were generally more interested than learners in upper secondary education. A more pronounced interest was also found among learners with a computing-related career plan, favorite subject computer science and (very) good last mark in mathematics or computing. Regarding gender, the assessment of interest was often not significantly different. Furthermore, there was a relatively low interest among the participants in dealing with computer science topics during leisure time, unless a personal benefit was evident (usage of mobiles or search engines).

As another result, the study provides an instrument for assessing computing interest, which has been tested once in a pilot study and which should be refined in future work. The selection of situations and contexts needs further development, as should the statements on concepts and activities be varied more systematically according to the structure model presented in section 2. It would be desirable to learn more about the interests of pupils in future in order to be able to take them more into account in didactic decisions. The rather small interest in socio-cultural aspects in this study should lead to the examination and, if necessary, the revision of the assigned items, and to the realization that an interesting instruction can be particularly important here.

As a conclusion for practice in future computer science courses, it should be taken into account that the topics and activities should meet the interests of the students. It must be obvious to them that the topics are relevant to their personal life and useful to them today, but also in the future – not only for their careers, but also for their everyday activities.

References

1. United Nations: Convention on the Rights of the Child. Adopted and opened for signature,
2. ratification and accession by General Assembly resolution 44/25 of 20 November 1989; entry into force 2 September 1990, in accordance with article 49. http://www.ohchr.org/EN/ProfessionalInterest/Pages/CRC.aspx (1989)
3. Helmke, A.: Unterrichtsqualität und Lehrerprofessionalität. Diagnose, Evaluation und Verbesserung des Unterrichts. Kallmeyer/Klett, Seelze-Velber (2012)
4. Kunter, M.; Trautwein, U.: Psychologie des Unterrichts. Schöningh, Paderborn (2013)
5. Krapp, A.; Prenzel, M.: Research on Interest in Science: Theories, methods, and findings. International Journal of Science Education, 33(1), 27-50 (2011)
6. Schwinem, S.: Schülerinteresse im Informatikunterricht (in German). Master thesis. University of Duisburg-Essen/Germany, Faculty of Business Administration and Economics (2016)
7. Häußler, P.: Measuring students' interest in physics – design and results of a cross-sectional study in the Federal Republic of Germany. International Journal of Science Education 9(1),
a. 1987)
8. Holstermann, N; Bögeholz, S.: Interesse von Jungen und Mädchen an naturwissenschaftlichen Themen am Ende der Sekundarstufe I (in German). Zeitschrift für Didaktik der Naturwissenschaften 13, 71-86 (2007)
9. Barthel, H.: Informatikunterricht. Wünsche und Erwartungen von Schülerinnen und Schülern (in German). Dissertation. University of Kiel, Germany, Department of Philosophy (2010).
10. Brinda, T.; Puhlmann, H.; Schulte, C.: Bridging ICT and CS – Educational Standards for Computer Science in Lower Secondary Education. In: ACM (ed.): Proceedings of the 2009 ACM SIGCSE Annual Conference on Innovation and Technology in Computer Science Education. ACM Press, New York, NY, USA, 288-292, (2009)

11. German Informatics Association: Educational Standards for Computing in Upper Secondary Education (in German). http://www.informatikstandards.de/docs/Bildungsstandards_SII.pdf (2016)
12. Ministry of School and Further Education of North Rhine-Westphalia/Germany: Core curriculum for computing in upper secondary education (in German). http://www.schulentwicklung.nrw.de/lehrplaene/upload/klp_SII/if/KLP_GOSt_Informatik.pdf (2013)
13. Diethelm, I.; Hildebrandt, C.; Krekeler, L.: Implementation of Computer Science in Context – a research perspective regarding teacher-training. Proceeding of the Koli Calling conference 2009, 97-100 (2009).
14. Humbert, L.; Puhlmann, H.: Essential Ingredients of Literacy in Informatics. In: Magenheim, J.; Schubert, S. (eds.): Informatics and Student Assessment. Concepts of Empirical Research and Standardisation of Measurement in the Area of Didactics of Informatics. Köllen, Bonn, 65-76 (2004)
15. Medienpädagogischer Forschungsverbund Südwest: JIM-Studie 2015. Jugend, Information, (Multi-)Media. Basisuntersuchung zum Medienumgang 12- bis 19-Jähriger (in German). http://www.mpfs.de/fileadmin/JIM-pdf15/JIM_2015.pdf (2015)
16. Brinda, T.; Diethelm, I.; Gemulla, R.; Romeike, R.; Schöning, J.; Schulte, C.; et al.: Dagstuhl Declaration: Education in the Digital Networked World (in German). https://www.gi.de/fileadmin/redaktion/Themen/dagstuhl-erklaerung-bildung-in-der-digitalen-welt-2016.pdf (2016)
17. Brinda, T.: Declaration of the Department of “Computing and Education/Computing Education” of the German Informatics Association concerning the Strategy of the German Ministries of Cultural Affairs on “Education in Digital World” (in German). https://fb-iad.gi.de/fileadmin/stellungnahmen/gi-fb-iad-stellungnahme-kmk-strategie-digitale-bildung.pdf (2016)
18. Ferdinand, H.: Entwicklung von Fachinteresse: Längsschnittstudie zu Interessenverläufen und Determinanten positiver Entwicklung in der Schule (in German). Waxmann, Münster a. a. (2014)
19. Bühner, M: Einführung in die Test- und Fragebogenkonstruktion (in German). Pearson Studium, Munich, Boston a. a. (2011)
20. Medienpädagogischer Forschungsverbund Südwest: KIM-Studie 2014. Kinder + Medien, Computer + Internet. Basisuntersuchung zum Medienumgang 6- bis 13-Jähriger (in German). http://www.mpfs.de/fileadmin/KIM-pdf14/KIM14.pdf (2014)
21. Computer Science Teachers Association (ed.): CS Standards Crosswalk with CSTA K-12 Computer Science Standards for State/District/Course Standards. http://csta.acm.org/Curriculum/sub/K12Standards.html (2011)
22. Rasch, B.; Friese, M.; Hofmann, W.; Naumann, E.: Quantitative Methoden 2: Einführung in die Statistik für Psychologen und Sozialwissenschaftler (in German). Springer (2015)