# An Exploratory Investigation of Change in Students' Subjective Perception of Informatics

Claudio Mirolo

University of Udine – Dept. of Maths, CS and Physics
via delle Scienze 206, 33100 Udine, Italy
claudio.mirolo@uniud.it

**Abstract.** This paper discusses an exploratory, small-scale investigation of students' perception of informatics from an uncommon perspective, i.e. by addressing change between patterns representing frequencies of associations of keywords and ideas as they emerge from a questionnaire administered to particular groups of subjects. The analysis is aimed at identifying trends of change across subsequent instruction levels as well as in connection with extracurricular outreach programs.

**Keywords:** perception of informatics, secondary education, outreach

## 1 Introduction

It is often claimed that students hold misconceptions about the nature of informatics, that they tend to identify it with programming, and that outreach activities do have the potential to trigger some positive change of perspective. These issues have been investigated from different perspectives, but the results are not yet conclusive [13]. In the space of this paper we can only mention few such works and refer to the related literature for a broader picture. In particular, the alleged mismatch between the students' and the computer scientists' views of our field is the subject of [3, 6, 1, 13], and the perceived role of programming is considered in [6, 10]. As to the impact of outreach programs, most authors report successful outcomes, e.g. [4, 2], but others suggest some caution [13, 5].

In order to contribute to the debate on these topics, the present exploratory study tries to address the matter from an uncommon angle, namely by focusing on how the patterns of ideas spontaneously linked by students to the sphere of informatics evolve across different levels of *general* (i.e. offering a very limited exposure to computing) school instruction, as well as in which way they may be different from those of the freshmen who enrol in an informatics program at university. In addition, we analyze under the same perspective possible effects of the outreach programs offered to the classes involved in our projects. The data were collected through a compact questionnaire with two open-ended questions, asking for short definitions of *informatics* and *programming* according to the respondent's subjective perception, together with five multiple-choice questions where one or more terms or statements could be chosen from a given list of options. The same questionnaire was administered as a *pre-test*, and also as a *post-test* for the school students who took part in the outreach activities.

## 2 Aims and Scope of the Investigation

According to the helpful terminology introduced in [13], here we consider aspects of students' *views*, whereas much related work, e.g. [6, 1], is concerned with *attitudes* (manifestations of interest, motivation) and *intentions* (to study or work in the computing field). Explorations of students' (pre-)conceptions are commonly run through interviews [14, 8]. A notable exception is [9], whose spirit and approach are close to ours but focused on programming. Since subjective perceptions—or views—are elusive, only similarity and diversity of patterns fall within the scope of this work. In particular, the analysis is by no means aimed at assessing the effectiveness of the outreach activities in terms of students' learning. The observed patterns are however a precondition for more in-depth inquiry to explain the underlying phenomena. More specifically, we address the following (operationalized) research questions:

RQ1. How does the students' subjective perception of informatics *change* across subsequent levels of (lower and upper) secondary instruction?
RQ2. Is there any diversity of perception between students attending general schools and university freshmen who choose informatics as their *vocation*?
RQ3. How central is *programming* for informatics in the students' perception, i.e., how frequent is the association of programming with informatics?
RQ4. To which extent does the subjective perception of informatics change, at least provisionally, after exposition to short-term *outreach* activities?

The investigation was carried out in 2014–16 and involved two 7th-grade (K7: age 12–13) middle school classes; two 10th-grade (K10: age 15–16) and two 12th-grade (K12: age 17–18) classes of a *general scientific* high school (the last secondary grade is K13). It is worth noting that informatics is not a subject of study in these kinds of schools, where the students are only expected to learn some digital literacy through the use of ICTs across different curricular subjects. Some projects in cooperation with teachers, based on [12] (K7, K10) and [11] (K12), have indeed offered the opportunity to collect a set of data regarding the students' perception of the field before and after the proposed experiences. In addition, for the sake of comparison we have also collected the answers of freshmen who have chosen to study informatics at university. The different group sizes are as follows: 39 students of level K7, 46 of level K10 and 47 of level K12 took part in the pre-test; of these 34, 42 and 39, respectively, took also part in the post-test. Of the university students, 43 come from general scientific high schools. Although not representative of a large population, the findings of this exploratory study may be of some interest in that they offer the opportunity to replicate similar experiments in different contexts and as a further step towards the development and validation of appropriate instruments to investigate students' perception of informatics [7].

## 3 Analysis of the Answers

The aforementioned questionnaire has two sections. The first is about the subjective perception of *informatics* (open definition + 2 closed-ended questions);

the second is about the perception of *programming* (open definition + 3 closed-ended questions)—not proposed to middle schoolers. Given the space limits, in what follows we will mainly focus on the first two questions:

1. Based on your perception, provide a short definition of "informatics".
2. What is informatics primarily about? Choose three terms that appear most relevant to you from the following list: *algorithms*, *complexity*, *information*, *programming*, *applications*, *computer*, *models*, *simulation*, *automation*, *communication*, *multimedia*, *systems*, *calculation*, *data*, *problems*, *technology*.

We first introduce some preliminary processing of the survey data. Then, we go through the research questions introduced in Section 2 and outline the most insightful findings. The treatment of the open answers is inspired by the phenomenographic analysis and is very similar to that found in [9]. The following steps summarize the *inductive process* to code key terms occurring in the students' texts:

- Identification and annotation of relevant keywords;
- Removal of text copied from other items of the questionnaire;
- Revision of definitions to look for synonyms (to be assigned a unique code) and uses of a same word with different meanings (to be coded differently);
- Organization of key terms into areas with some relevant shared feature;
- Merging of sporadic codes into codes associated to broader ideas;
- Checks for consistency and further minor refinements of the coding.

The outcome of this process is a two-layer coding structure where 36 key terms (between parentheses) are organized into 12 areas:

1. problem-solving (problem-solving, problem approach, task complexity)
2. abstraction & modeling (abstraction, modeling & simulation, virtual machine)
3. automation & workflow (automation, task efficiency, data massiveness)
4. data & information (data/information, data collection & analysis, data processing)
5. algorithms & procedures (algorithms, algorithm logic, procedures & processes)
6. programming & language (programs & programming, task accuracy, formalism)
7. computation flow (computation, instructions & stepwise flow, input/output)
8. design & development (design & products, artifact function, artifact structure)
9. nature & evaluation (mathematical features, scientific features, evaluation)
10. computer-centered (computer, computer operating, hardware architecture)
11. I/C technology (information technology, applications, network & communication)
12. user-centered features (instrumental use, task-oriented tools, learning & sharing)

In addition to a direct examination of tables and histograms, the $\chi^2$-test is a suitable tool to analyze *differences* between patterns of counts. To this aim, we can construct two-column contingency tables representing pairs of patterns to contrast—e.g., the corresponding figures of the pre- vs. post-test, of K12 classes vs. university freshmen, etc. Since the $\chi^2$-model may be too inaccurate for figures capturing sporadic events, in order to build meaningful contingency tables we need to aggregate categories sharing related features into macro-categories. More specifically, for the open-ended definition of informatics the aggregation introduces a third coarser layer: *technological tools* (areas 11 and 12 above),

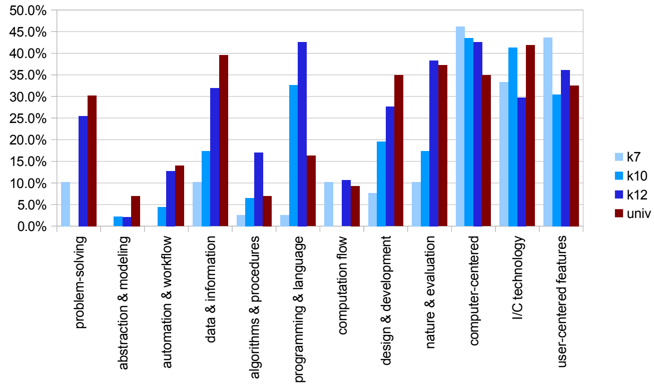


**Fig. 1.** Key terms occurring in the definitions of informatics. Percentage of students who have used one or more key terms in each area in the pre-test at the K7, K10, K12 and university entry (informatics) levels.

*conceptual tools* (areas 1, 2, 4, 5, 9), *computer programming* (areas 6, 7, 10), and *engineering processes* (areas 3, 8). Similarly, for the following multiple-option question the macro-categories are: *technologies*, *problems & abstraction*, *data handling*, and *programming*.

**Research question RQ1.** Only the data of the pre-test are relevant to get a picture of the *usual* state of affairs. Figure 1 shows the histogram of the percentages of students whose definitions of informatics refer to at least one key term in a given area. The relative frequencies of keywords referring to concrete aspects of the technology sphere (areas 10–12) appear to be quite stable over time, whereas we see a regular increase of terms relating to more conceptual topics (notably, in the areas 1, 4, 5, 8, and 9), including programming (area 6).

**Research question RQ2.** The answers to the first two survey questions consistently indicate that the weight of *programming* in the perception of informatics rises across instruction levels. However, this trend is broken (relative frequency halved) when we consider the perception of university freshmen coming from general scientific high schools. Said otherwise, the emphasis on programming is significantly reduced in the perception of those students who think of informatics as their vocation. Another differentiation lies in the higher incidence of the abstract concepts of *algorithm* and *information* in the freshmen's answers to question 2 (+68%). A $\chi^2$-test on the contingency tables built as outlined above confirms that the evidence of diversity is strong ($p\text{-}value = 0.005$) relative to the options selected to answer question 2 by the K12 vs. the freshmen groups.

**Research question RQ3.** The options selected to answer question 2 reveal, even more strikingly, the central role that *programming* plays in the students' perception, especially in the high school (about 93% of K12 respondents!). Further clues in support of the relevance attributed to programming come into view by contrasting the outcome of the post-test against the pre-test. We can indeed observe that the choice of *programming* is highly stable if compared to the other options, i.e., it is confirmed by 79% of the students who selected it in the pre-test. Similarly, a reference to key terms related to programming is also stable in the definitions provided by high school students (77% for K10 and 65% for K12). The answers to questions 5–7 (not reported here) give also some insight about the perceived *nature* of programming—mainly an engineering view.

**Research question RQ4.** Based on the options chosen to answer question 2, a $\chi^2$-test provides no statistical evidence of significant change of perception for K7 ($p\text{-}value = 0.484$) and K10 ($p\text{-}value = 0.472$) classes. On the other hand, the evidence of change is strong for the students of the K12 level ($p\text{-}value = 0.003$). The influence of outreach activities is then unclear at least in the case of young students. However, by focusing on the categories *problems & abstraction* vs. *technologies*, the increase of the options falling in the former and the decrease of those falling in the latter emerge as consistent traits for all the considered groups. Since a similar trend can be observed in the pre-test across subsequent instruction levels, the exposition to outreach programs seem to have the effect of anticipating the recognition of some conceptual aspects of the computing field.

Moreover, the patterns observed in the post-test are in some sense closer to the patterns relating to freshmen than those observed in the pre-test. The value of $\chi^2$ can be interpreted as a *distance* of the patterns in the two columns of a contingency table—the lower the value of $\chi^2$ the closer the patterns—and such a distance is always smaller in the post-test. As a final point, the answers to the first two survey questions have also been subjected to cluster analysis by applying the standard general model, but no remarkable clusters have been revealed. This may mean that the students didn't share stereotypical views of informatics conveyed by their teachers.

## 4 Conclusions

The main observations resulting from the analysis of the answers of the students who took part in this work can be summarized as follows:

- Perhaps not surprisingly, independently of their engagement in specific programs, the students' views of informatics get enriched with new associations of ideas across subsequent school levels—in particular of abstract ideas.
- There is some significant evidence, although not unequivocal, that the subjective perception of informatics by 12th-grade students does not match those of the freshmen who choose to study informatics at university.
- Programming is regarded as a core activity in informatics and this perception is stable and especially strong in the last high school years. Informatics freshmen, on the other hand, assign a less prominent role to programming. These findings may indirectly support the common belief that the identification of informatics and programming may be discouraging to several students.
- The potential of outreach programs to impact students' view of informatics cannot be clearly assessed. The only piece of significant evidence of change of

perception has been found in connection with the extracurricular activities proposed to 12th grade classes. However, some exposition to such programs seems at least to have the effect of anticipating the recognition of some conceptual aspects of the computing field.

The extent to which the above results can be generalized to other contexts is still to be understood; they are, nevertheless, of some interest for the reasons mentioned in Section 2. Possible directions of future work include the analysis of gender differences, the exploration of connections between the pattern observed and the content of the extracurricular programs, the investigation on and comparison with the perception of teachers; the improvement of the questionnaire.

## References


1. Anderson, N., Lankshear, C., Timms, C., Courtney, L.: 'Because it's boring, irrelevant and i don't like computers': Why high school girls avoid professionally-oriented ict subjects. Computers & Education 50(4), 1304–1318 (2008)
2. Buffum et al.: Empowering all students: Closing the CS confidence gap with an in-school initiative for middle school students. In: Proc. of the 47th SIGCSE Technical Symposium. pp. 382–387. ACM (2016)
3. Carter, L.: Why students with an apparent aptitude for computer science don't choose to major in computer science. In: Proc. of the 37th SIGCSE Technical Symposium. pp. 27–31. ACM (2006)
4. Curzon et al., P.: cs4fn.org: Enthusing students about CS. In: Proc. of IEE IV. pp. 73–80 (2009)
5. Decker, A., McGill, M.M., Settle, A.: Towards a common framework for evaluating computing outreach activities. In: Proc. of the 47th SIGCSE Technical Symposium. pp. 627–632. ACM (2016)
6. Galpin, V.C., Sanders, I.D.: Perceptions of computer science at a South African university. Computers & Education 49(4), 1330–1356 (2007)
7. Heersink, D., Moskal, B.M.: Measuring high school students' attitudes toward computing. In: Proc. of the 41st SIGCSE Techn. Symposium. pp. 446–450. ACM (2010)
8. Hewner, M.: Undergraduate conceptions of the field of computer science. In: Proc. of the 9th ICER. pp. 107–114. ACM (2013)
9. Lakanen, A.J., Isomöttönen, V.: What does it take to do computer programming? surveying the K-12 students' conceptions. In: Proc. of the 46th SIGCSE Technical Symposium. pp. 458–463. ACM (2015)
10. Lu, J.J., Fletcher, G.H.: Thinking about computational thinking. In: Proc. of the 40th SIGCSE Technical Symposium. pp. 260–264. ACM (2009)
11. Mirolo, C.: A present-day "Glass Bead Game": A framework for the education of prospective informatics teachers inspired by a reflection on the nature of the discipline. In: Proc. of the 6th ISSEP. pp. 138–149. LNCS 8730, Springer (2014)
12. Mirolo, C., Di Vano, D.: "Welcome to Nimrod" to learn CS ideas in the middle school. In: Proc. of WiPSCE 2013. pp. 61–70. ACM (2013)
13. Taub, R., Armoni, M., Ben-Ari, M.: CS Unplugged and middle-school students' views, attitudes, and intentions regarding CS. Trans. on Computing Education 12(2), 8:1–8:29 (2012)
14. Thuné, M., Eckerdal, A.: Variation theory applied to students' conceptions of computer programming. European J. of Engineering Education 34(4), 339–347 (2009)