Self-Assessment of Freshmen Students' Base Competencies

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***Abstract*—Not all incoming students are sufficiently well endowed with those base competencies (such as self organization, analytical thinking or communication skills) that are prerequisite for acquiring complex new knowledge as well as coping with the study process itself. As lecturers, we have to be aware of our incoming students' base competency profile, in order to pick them up where they are and help them develop whatever they need to study successfully. To investigate the students' initial skills regarding their base competencies, we developed a self-assessment focusing on selected self competencies, practical and cognitive skills as well as social competencies that are crucial to study computer science or related topics. In this paper, we present our assessment approach and its design. An initial evaluation in which 320 students were involved indicates that deficits in base competencies can be made tangible for students. Based on the deficits we identified, we are going to optimize our courses to meet freshmen students' needs in a better way.**

Keywords — Soft skills; Basic competencies; Assessment; Computer Science Education, Freshmen students

I. Motivation

The students which enroll as freshmen at Munich University of Applied Sciences, Faculty of Computer Science and Mathematics, are an extremely heterogeneous group, regarding their cultural, educational and professional background. However, regardless of their background, only about a third of them meets study requirements rather easily. In detail, in the introductory classes in maths and software development, which form the foundations and prerequisites for advanced studies later on, less than a third manages to achieve a grade between 1.0 and 3.0 in the end-of-term exams, on a scale of 1 (best) to 5 (worst/failed). The remaining approximately 70 percent get a grade worse than 3.0, fail the exam, postpone taking the exam to the end of second term (hoping that until then, enlightenment has struck), or drop out completely.

From past teaching experience, we strongly suspect that in many cases, the observed difficulties in acquiring new knowledge in maths, computer science and engineering, are usually not caused by a lack of intellectual capacity, but rather by significant deficiencies in certain base competencies (i.e., self, practical and cognitive as well as social competencies). Moreover, past teaching experience shows that whenever we got close enough to individual students to identify gaping holes in their base competencies, and were able to help students to close these gaps sufficiently, these students metamorphosed from almost-dropouts to graduates with at least satisfactory exam results.

So far, this kind of detection and mending of base competency deficiencies has mainly been guided by the lecturers gut feeling, and focused only on a rather small subset of students who had the misfortune (or good luck?) of drawing the lecturers eagle eye on them in the blurring crowd of freshmen.

Happy about our initial individual success, we now try to increase the impact of our approach. To achieve this, we evolved our somewhat intuitive deficiency detection into a more systematic set of tools, which helps us to identify the initial level of selected base competencies that are crucial for successfully studying computer science or information systems and management. Thus, we now have the means to assess the initial base competencies of *all* incoming freshmen students at our faculty.

One element of this toolset is the self-assessment questionnaire presented in this paper. It was developed in the context of the project "Fit for the Future" funded by the German government[1], which aims to improve learning conditions, reduce drop out rates and, in general, increase the attractiveness of studying at a university for freshmen with heterogeneous backgrounds.

The self-assessment is complemented by a written test, which covers basic academic skills that hopefully have been previously acquired at school. In this test, we focus on reading skills in English and German, fundamental maths, basic computer skills as well as the ability to think both logically and analytically.

In addition, students undergo a number of selected group exercises that serve two purposes: while they facilitate getting into contact with fellow students, they offer the observing university staff certain insights into the participants' social skills.

II. Goals and Benefits

Both students and lecturers alike benefit from the results of this self-assessment. On the one hand, students are assisted in reflecting their personality and basic competencies, and in identifying potential for further personal development. Being aware of a student's specific base competency profile and comparing it with whatever is expected, lecturers and other counseling university staff can offer personalized recommendations for measures that help students to cover their individ-

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ual needs. For example, a university could offer specifically designed prep courses for skills that are highly relevant but often missing, such as self organization, time management, or scientific writing.

On the other hand, lecturers are provided with a rough idea of their students' existing skills at the very beginning of term. Thus, they know right from the start what they can build on, and what skills have yet to be developed in the majority of students to prepare the basis for advanced topics later on. Knowing this, lecturers can develop new teaching methods, which take the strengths and weaknesses of their classes into account and, in addition, foster those skills that still need improvement. In all probability, this initially will require some major efforts and lots of extra didactic work on the lecturers' side. However, with increasing experience and didactic expertise, this eventually will boil down to selecting an appropriate approach out of ones well filled portfolio of already prepared teaching methods. Such an approach should employ different channels of learning, to satisfy the various needs of the heterogeneous set of students.

If carried out on a regular basis, such a self-assessment offers short feedback cycles to all parties involved. On the one hand, lecturers are enabled to appraise the effectiveness of their teaching methods. On the other hand, students can keep track of their personal development. If this shows satisfying progress, the awareness of having improved is a major factor in keeping up high efforts and motivation. However, if personal development proves to be slow or non-existent, at least the student's critical situation is revealed before it is too late to remedy the situation.

III. Related Work

An essential preparatory step for developing this self-assessment was the selection of those base competencies that are crucial for studying computer science, as described in [2].

In addition, we evaluated different assessment approaches as used in human resource management, such as the technique of bipolar property modeling [1] and the complementary estimation aid (KEH – Komplementäre Einschätzungs-Hilfen) developed by Eberle [3].

To ensure that our test design is sound in itself and up to current standards, we closely investigated general test design literature such as [7].

The Cologne University of Applied Sciences developed a self-assessment (called *KompetenzPass*) which focuses on methodical, social and self competencies, such as working methods, intercultural sensibility or time management. This self-assessment concentrates on competencies that are important for the general study process itself. However, it does not include more specific competencies that we deem to be crucial for studying computer science [5].

Richard Turley designed a quality study to identify competencies that differentiate between exceptional and non-exceptional software engineers. He identified 38 competencies by interviewing managers of a major computing firm and conducted a survey among 129 software engineers who were working in this firm. Turley focused on skills and techniques which are relevant for job performance. Therefore only ten of the competencies he identified are appropriate for our approach, whereas the remaining ones are too specific [11], [12].

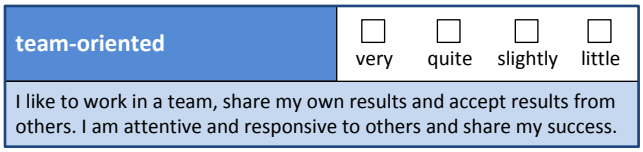

Fig. 1. Example assessment with a unipolar scales model.

IV. Assessment Design

When designing our self-assessment approach, we analyzed several existing assessment questionnaires for advantages and disadvantages of their respective designs.

A. Unipolar vs. Bipolar Scales Model

Many self-assessments available in literature are set up using a unipolar scales model. This means that each aspect will be rated individually and in an isolated way, on a scale from *very* to *not at all*, or similar, as shown in the example in Fig. 1. Usually, in this kind of assessment, there is an obvious "best" answer. As a consequence, it is rather difficult to resist the temptation to gloss over minor deficiencies, and give a truly honest answer. This tendency to give slightly complaisant answers rather than realistic ones does not necessarily indicate that participants try to cheat. Rather, it is an unconscious product of a certain eagerness to please, which is a common trait of human beings in their social environment. Nonetheless, results generated from unipolar self-assessments tend to be rather euphemistic, and thus are only of limited use for our purposes.

To avoid this problem, we designed our self-assessment as a bipolar scales model. That is, we matched the relevant base competencies identified in [2] into complementary pairs of positive competencies, e.g., self secure vs. self critical, intuitive vs. logically thinking, or independent vs. team-oriented, as shown in the example in Fig. 2. To avoid misunderstandings, every competency is explained by a short sentence, describing how a person fulfilling this competency would think or act.

On the left/right of these complementary competencies, we denote the behavior traits that occur if the adjoining competency is prevalent, while its balancing counterpart is lacking completely. This kind of extreme singular competency is quite often experienced as negative.

In the bipolar scales model, assessment participants have to position themselves somewhere on a scale between two positive poles. By adding extremes, it becomes obvious that a "too much" of one competency usually implies a deficiency in its positive complementary competency. As a consequence, in this bipolar scales model, there is no obvious ideal answer that can be identified by following a certain pattern. Therefore, students realize that this self-assessment is not a question of

	obstinate	self-contained				team-oriented				over dependent
	⟵	I like to decide and act myself, based on my own knowledge and/or my beliefs.				I like to work in a team, share my own results and accept results from others. I am attentive and responsive to others and share my success.				⟶
	exclusively	very	quite	slightly	little	little	slightly	quite	very	exclusively
normally	○	○	○	○	○	○	○	○	○	○
easily adoptable	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
emergency	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
I don't know ☐										

Fig. 2. Example of a pair of complementary competencies.

wrong or right behavior, which reduces the risk that they feel inadequate in any way.

To summarize, this kind of assessment requires a lot more self-reflection of subjects than a unipolar one, but renders results that are much closer to reality. Note that the non-existence of an obvious ideal answer not only affects participants, but also the lecturers that design these assessments. When designing a "model student" whose base competencies fulfill all our expectations, we have to carefully trade off each required competency against its complement.

B. Choice of Scale Number and Stages

An important question in assessment design is the choice of an appropriate scale, in particular the number and associated meaning of stages.

In our design, we ask students to denote their competencies on a four-stage scale, labeled *very*, *quite*, *slightly* and *little* for each competency. We opted for a four-stage scale, measuring the intensity of every single competency, for two main reasons: First, a scale which measures the intensity gives students a notion of the steepness of a grade. Second, a four-stage scale avoids a distortion of the results by students who tend to choose the middle of the scale. Thus, we ensure that students have to explicitly decide where they position themselves within each pair of competencies.

In case a student wants to characterize him-/herself by one of the competencies only, he or she can check the category *exclusively* for this competency. This choice indicates that the complementary competency is lacking completely.

At the bottom line, we offer the possibility *"I don't know"*. This option should be chosen if students do not understand a particular competence, or are entirely unable to make up their mind on how to characterize themselves. This is necessary to avoid a distortion of results by students who evade a true decision by just checking an arbitrary option. Instead, students can indicate openly that a particular pair of competencies has been omitted [6], [7].

C. Situative Assessment of Competencies

Usually, it is extremely difficult to position oneself on a bipolar scale, as this always implies a decision for only one of two positive competencies. In practice, a person's competency usually is not located at exactly one position on the bipolar scale, that holds true in any situation the person might ever be in. Moreover, different situations require different competencies. Accordingly, the choice and intensity of one of two complementary competencies usually depends on situative requirements. Quite often, a combination of both sides is needed to achieve optimum results.

As an example that comes up on the news in regular intervals, consider the complementary competencies of *assertiveness* vs. *willingness to compromise*, in the setting of salary negotiations between employers and trade unions. Obviously, to achieve a result that is acceptable to all parties involved, either side will have to stand firm on some issues, but give in a little on others. Thus, ideally, the parties involved should be able to cover a range of stages between both positive competency poles.

To reflect this issue in our self-assessment, we ask students to consider each pair of competencies in three different situative contexts, labeled *normally*, *easily adoptable* and *emergency*.

In the line labeled *normally*, students check the radio button that best characterizes their normal behavior, i.e., the basic state inherent in their personality. In the line labeled *easily adoptable*, students denote the range in which they can move rather effortlessly between complementary competencies, depending on situative requirements. Finally, the line *emergency* indicates which extra resources a student can call upon if stakes are really high.

EXTREME	COMPETENCY	COMPLEMENTARY COMPETENCY	COMPLEMENT'S EXTREME
obsessive	self-organized	spontaneous	*volatile*
I plan a course of action on my own and put it into practice myself.		I follow my own impetus and live for the present.	
meticulous	accurate	efficient / goal-oriented	*negligent*
I perform my tasks scrupulously.		Whenever I do something I balance cost and benefits.	
autistic	focused	able to multitask	*diverted / ineffective*
I concentrate wholeheartedly on one task, without getting distracted.		I am able to perform multiple tasks at the same time.	
hard on myself	self-disciplined	serene	*indolent / pleasure-seeking*
I resolutely overcome my weaker self and resist the temptation to do something I should not do.		I keep my inner balance, accept things as they are and live on the sunny side of life.	
grim / stubborn	perseverant	flexible	*distractible*
I pursue a goal enduringly and imperturbably over a longer period of time, until I have achieved this goal.		I adapt myself to changing circumstances, external conditions or requests.	
being a loner	intrinsically motivated	willing to follow instructions	*submissive / obedient*
I have a goal that is important to me, give myself incentives and like to make an effort to achieve this goal.		To achieve my goal, I am willing to comply with external guidelines and follow instructions.	
insecure	self-critical	self-confident	*stubborn*
I know myself very well and am able to reflect on my own behavior. I am open to criticism and would like to develop myself further.		I am self-secure, aware of my own strengths and won't be unsettled.	
self-sacrificing	reliable	egoistic in a healthy way	*selfish*
I abide by agreements and make the required effort, even if this is extremely high for me.		I value a balanced way of living, find the due proportions and am able to say "No" to inappropriate demands.	
ceaselessly asking	reflected	able to take a decision	*improvident*
I analyze events and facts myself.		I decide for myself.	
disbelieving	scrutinizing	unbiased	*gullible*
I meet any information with a certain skepticism and like to get to the bottom of things.		I am trusting, open-minded and willing to get into new experiences.	
uninspired	systematic	inventive	*chaotic*
I consequently work off given instructions and apply well known methods.		When tackling a task, I work off the beaten track, finding innovative solutions.	
petty-minded / numb	logically thinking	intuitive	*rash*
I develop my thoughts step by step, regarding cause and effect.		I trust my gut feeling and act on instinct.	
out of touch with reality	thinking in an abstract way	thinking concretely	*oafish / slow on the uptake*
My perception of the world is a theoretical one. I look for general laws and principles.		I take in the world by experiences that I make myself, gather impressions and think in examples.	
hairsplitting	analytic	thinking holistically	*superficial*
When I look at things, I search for individual elements, and like to get to the bottom of things.		I look at things in their entirety and like to maintain an overall view.	
unable to understand graphics	able to read	able to understand graphics	*illiterate*
I am able to read a given text and to understand the described facts.		I can perceive a given graphic/diagram and understand its meaning.	
unable to process graphics	able to write	able to visualize	*illiterate*
I am able to express a given information in my own written words.		I am able to visualize a given information.	
prattling / obtrusively talking	eloquent	auditory perceptive	*monosyllabic / taciturn*
I am able to express myself verbally, and to apply basic rhetoric.		I am able to grasp spoken words, and to understand their meaning.	
obstinate	self-contained	team-oriented	*over dependent*
I like to decide and act myself, based on my own knowledge and/or my beliefs.		I like to work in a team, share my own results and accept results from others. I am attentive and responsive to others and share my success.	

TABLE I
PAIRS OF COMPLEMENTARY COMPETENCIES, AND THEIR DESCRIPTIONS. EACH SHADED LINE CONTAINS A PAIR OF COMPLEMENTARY COMPETENCIES AS WELL AS THEIR RESPECTIVE EXTREMES.

Adding the notion of a range of competence stages that can be activated if necessary, makes it a lot easier to position oneself in the *normal* line. Now, it is possible to decide on one's home base, without implicitly renouncing its complement.

As lecturers, we gain important information from these ranges as well, which helps us to adjust our teaching methods to the specific needs of a class. For example, if according to the *easily adoptable* line, the majority of students can easily understand graphics, but only few have sufficient *reading abilities*, it would be advantageous to explain difficult subject matters visually rather than textually. If we would assess competencies only in the students *normal* basic state, preferences would be scattered across a wider range of our scale, thus making it more difficult to find a common denominator that suits the majority of our students.

D. Competences Focused in Self-Assessment

All in all, we investigate 36 competences, matched into 18 complementary pairs that focus on self, practical, and cognitive competencies, as well as the social competency of being a team player. The latter one is rather complex in itself, thus requiring the presence of a set of other, simpler self and social skills.

27 of these 36 competencies were included in our initial selection of competencies that we deem to be relevant for successfully studying computer science [2]. The remaining competencies were added during assessment design, to build pairs of corresponding complements.

Table I lists all pairs of competencies we focus on in our self-assessment, including corresponding descriptions as well as extremes. Note that the original self-assessment form is in German.

E. Usage Instructions at Assessment Execution

When carrying out the self-assessment, we offered a short explanation of how the self-assessment should be filled in, before self-assessment forms were distributed. As an example, we provided the following description of a virtual person called "Martin", and illustrated how this person would fill in the self-assessment, so that it mirrors his specific skills for a certain pair of competencies.

- Martin has no problem to defend his own point of view. Thus, he usually is *slightly assertive*.
- If necessary, he can easily pay attention to and respect the concerns of others. Therefore, he is only *a little bit assertive* and even *able to enter into a compromise* with somebody else.
- If it is really important, Martin even backs off from his point of view and makes concessions to others. However, if Martin thinks that his very own principles are endangered, he temporarily can be *quite assertive*. Thus, if need be Martin is able to expand his comfort zone to both sides.

Figure 3 illustrates how this example person is assessed in our situative bipolar scales model.

F. Quality Assurance

To validate the feasibility of our self-assessment approach, we tested it successively on small groups of students. Learning from their feedback and analyzing first results, we continuously improved the assessment design and introductory usage instructions.

When carrying out our self-assessment, we met the following current standards [9] that are established for assessment execution.

All students had to complete the same self-assessment at the same time, in the same room within one hour. To motivate the students to undergo this kind of self-assessment, we shortly explained our project and the benefits of the self-assessment. In addition, a manual summing up usage instructions was handed over to each student before the self-assessment started. As a matter of course, we pointed out that all assessment results will be processed anonymously and privacy issues will be observed at all times. Students were requested to fill in the questionnaire on their own. While working on the self-assessment, students had the possibility to ask questions that might occur.

Like KODE, a diagnostic procedure for competencies developed by Erpenbeck et al. [4], our self-assessment draws conclusions from implicit experiences in certain situations and contexts. Therefore, exact results regarding the reliability and validity of our self-assessment are limited. Nevertheless, we can draw conclusions on the process-oriented and social validity because competencies can be followed along the time axis [13]. Thus, after several self-assessments with freshmen and students from higher semesters at Munich University of Applied Science, we expect to be able to give a comprehensive picture of the students' base competency profile. Furthermore, we expect to be able to tell which teaching methods help to develop the competencies which are necessary to graduate with a satisfactory exam result.

V. Results

All freshmen students entering Munich University of Applied Sciences, Faculty of Computer Science and Mathematics in the fall of 2013 underwent the self-assessment and accompanying initial knowledge tests at the beginning of their studies in the first week of October 2013. Thus, we gained about 320 self-assessments and knowledge tests, respectively.

These assessments and tests have been evaluated, providing us with a summary of results across the whole set of students, so that lecturers get a notion of the actual skill profile of their class. Furthermore, for each student we relate the individual results of self-assessment and knowledge test, thus validating whether the individual self-perception of skills coincides with external observation. Currently, we are in the process of analyzing test results, and looking for deficit patterns, i.e., lacks of skills that usually occur in a certain combination.

In addition, each individual student's result is compared to a predefined model student profile that we, the lecturers, specified before designing these tests. On this basis, we provide our students with recommendations for individual measures. For example, we suggest specific prep courses, which will help

	un-compromising	assertive				able to compromise				yielding
	◁	I bring to bear my own point of view and am able to overcome any resistance.				I am able to make concessions to others and show tolerance.				▷
	exclusively	very	quite	slightly	little	little	slightly	quite	very	exclusively
normally	○	○	○	⊗	○	○	○	○	○	○
easily adoptable	☐	☐	☐	☒	☒	☒	☒	☐	☐	☐
emergency	☐	☐	☒	☐	☐	☐	☐	☒	☐	☐
I don't know ☐										

Fig. 3. Filled example of a pair of complementary competencies.

to improve those competencies that are not yet sufficiently developed.

To get an overview of all our freshmen students, we analyzed about 250 pairs of self-assessment and knowledge test so far. In this analysis, we focus on those 27 competencies that we deem to be relevant for successfully studying computer science [2]. The nine competencies that were added during our assessment design process, to create complete pairs of corresponding complements, are deliberately omitted in our analysis.

A. Comparison of Cohort Results with Model Student

First, we compare the results of our tested cohort with the predefined model student.

To visualize this data we use a radar chart, showing both the predefined model student and the median of the real students' data in one diagram (see Fig. 4). This chart reveals that students rate 12 of their competencies as being equal to what we expect from a model student. For example, students evaluate themselves as being as self-contained, efficient and focused as our model student. In four competencies, self-assessments even exceed our expectations.

Furthermore, students assess themselves as being more reflected, better able to visualize information and to understand graphics, as well as being more skilled in holistic thinking than we require in our freshmen students.

However, students should improve in several competencies, as they assess themselves to be less skilled in these areas than we expect. These include the abilities of being self-organized, accurate, perseverant, intrinsically motivated, willing to follow instructions, self-critical, systematic, being eloquent as well as the ability to write.

In addition, to gain more insight into the heterogeneity of our cohort, we analyze the top 20% as well as the bottom 20% of the students' self-assessments. The median profile of the top 20% students fulfills our expectations in almost all competencies. Only the ability to read is assessed as being lower than our expectations (see Fig. 5).

In contrast to this, Figure 6 shows that the median of the bottom 20% students only meets expectations for 10 competencies out of those 27 that we identified as being relevant for successfully studying computer science. Thus, the vast majority of required competencies still needs to be developed.

B. Relating Self-Assessment and Knowledge Test

After this general overview of the students' self-assessment, we relate each self-assessment to the corresponding knowledge test of the same individual. (We introduced aliases for our students, in order to be able to relate different tests of a single person to each other, even over time, without having to be aware of the person's identity.)

As mentioned before, this knowledge test covers five areas of basic academic skills: German and English reading comprehension, fundamental maths, basic computer skills and methodical competencies in logical and analytical thinking. Among others, the mathematical part focuses on reducing a fraction, word problems or solving equations. Little brain-teasers such as finding the odd graphic out of five, doing some modeling in order to find a solution, or understanding an issue shown in a given graphic, are exemplary tasks for testing methodical competencies.

We deliberately designed some of the tasks in our knowledge test in such a way that they cover selected competencies in our self-assessment. For example, the knowledge test comprises assignments which require reading skills, understanding of graphics or the application of abstract thinking. Thus, we now are able to compare the specific results from both tests. As a side effect, we gain insight into how adequately students were able to assess their own skills.

To facilitate the comparison of the two kinds of data, we converted points from the knowledge test into grades that correspond to the stages of our self-assessment. That is,

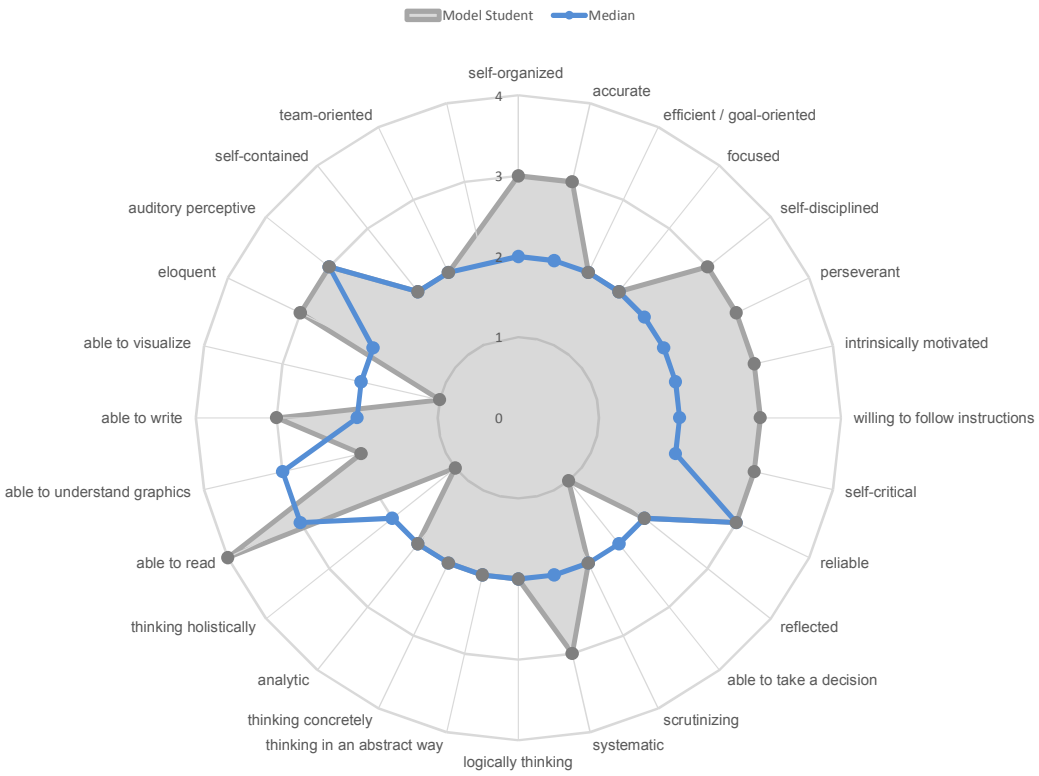

Fig. 4. Comparing median student of our cohort to model student

grade 1 corresponds to little skill in this area, whereas grade 4 indicates that the competency in question is developed very highly.

As a first example, we focus on the ability to understand graphics, where students assessed themselves as being on a higher competence level than we expect. Secondly, we examine the ability to read, where our students evaluated themselves as being less skilled than we require. Here, we distinguish between English and German reading skills.

The following histograms relate the results of self-assessments and knowledge tests for these three competencies. In detail, they visualize the number of students that have achieved a particular combination of competence level in their self-assessment, and grade in the related assignments of the knowledge test.

In Fig. 7, on the y-axis, we visualize how the students assess their ability to read, ranging from 1 (*little*) to 4 (*very*). The x-axis represents the grade students achieved in the assignments on German reading within the knowledge test. We awarded the best grade of 4 if the student achieved at least 8 points out of the possible high score of 10. Finally, the z-axis indicates how many students achieved a certain combination of skill level (self-assessment) vs. grade (knowledge test).

If students assess their own competencies in a precisely realistic way, all non-zero vertical bars will be located on the grid's diagonal. In the histogram, this ideal line is denoted in green.

Note that many of our students assessed themselves as being less skilled in this area than they really are (grey bars in Fig. 7). However, we are optimistic that these students will not be an issue, as we assume that they will study extra hard, to make up for skills that they think they don't yet possess.

On the other hand, students located on the left side of the diagonal overestimated their abilities, either by one level (yellow bars) or even two or more (red bars). These students should be advised of their misjudgments and made aware of their lacking competencies, in order to give them a chance to compensate this lack as soon as possible.

Analogously, for the English reading skill, the relationship between the results of self-assessment and knowledge test is shown in Fig. 8. The meaning of the axis corresponds to Fig. 7. The histogram visualizes that students with grades 1 to 3 estimated their own skills in a more realistic way than for the German reading skill. However, those students that are best qualified in this competency still tend to underestimate themselves.

Figure 9 relates the ability to understand graphics from our self-assessment with graphics based cognitive competencies examined by the knowledge test. Typical tasks were little brainteasers such as finding the odd graphic out of five, understanding the issue shown in a certain graphic, or doing some modeling in order to find a solution.

In this skill area, most of the students achieved grades 3 or 4 on their assignments. The vertical bar in the (4, 4)-valued corner, which is hidden by its neighbors, represents 13 students.

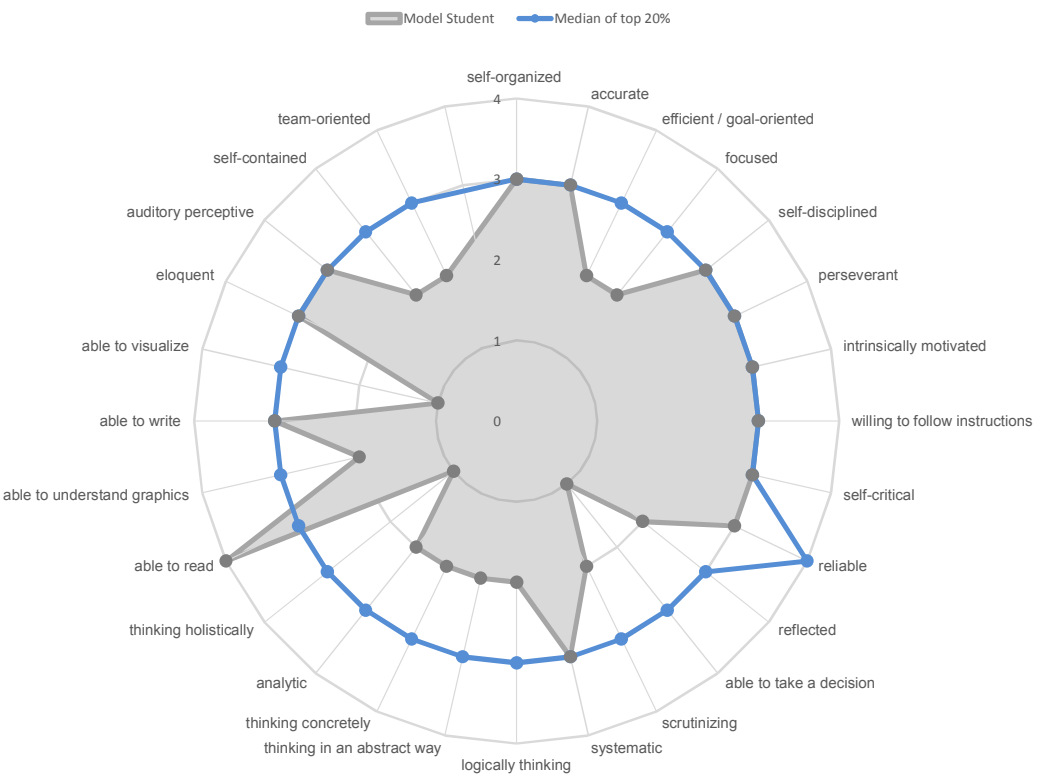

Fig. 5. Comparing median of top 20% students to model student

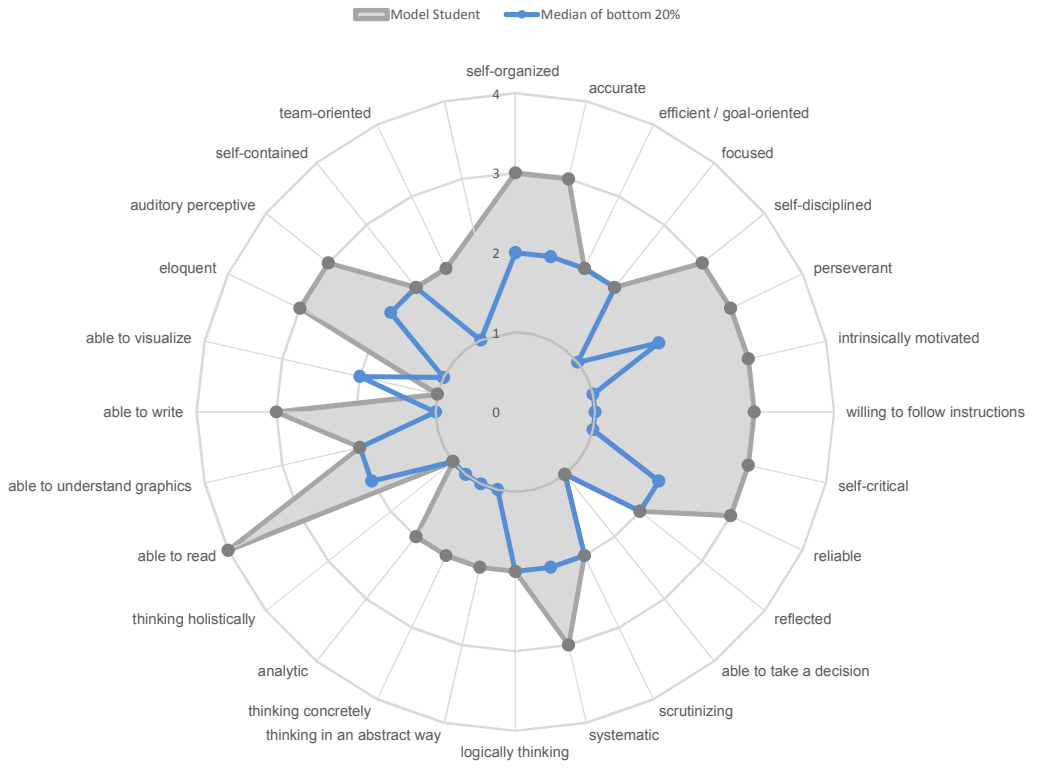

Fig. 6. Comparing median of bottom 20% students to model student

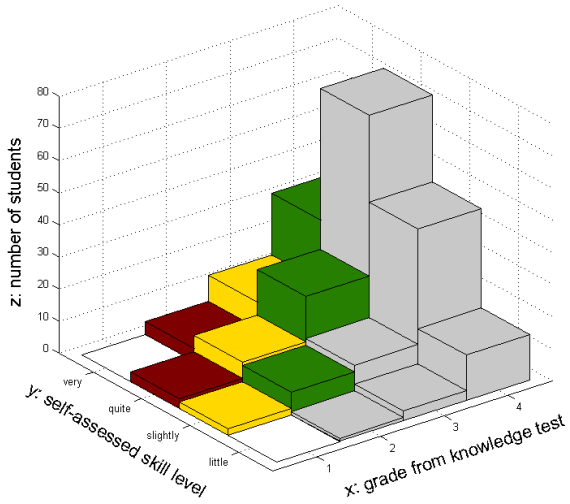

Fig. 7. German reading skill (self-assessment vs. knowledge test)

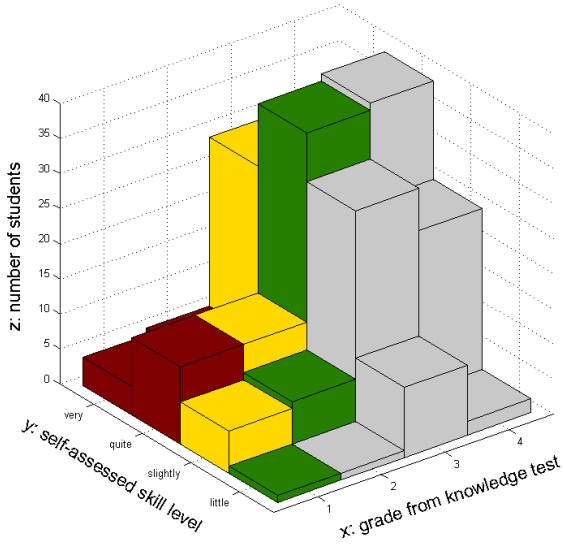

Fig. 9. Ability to understand graphics (self-assessment) vs. graphics based cognitive competencies (knowledge test)

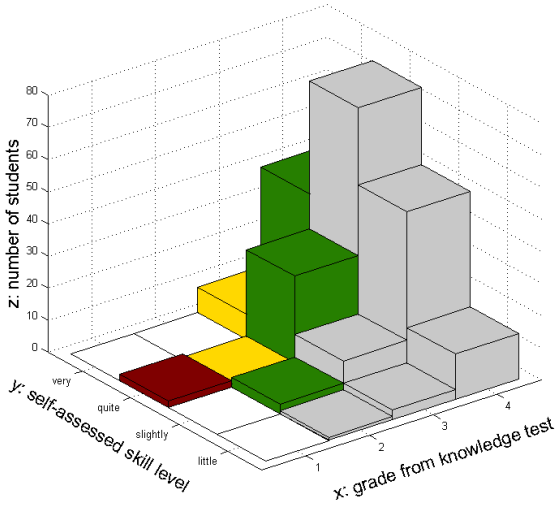

Fig. 8. English reading skill (self-assessment vs. knowledge test)

In summary, more than 25% of our students overestimated their own competencies in this area, with 10% thinking that their skill is two or more levels higher than indicated by the grade that they earned in the knowledge test. On the other hand, over 45% of our students underestimated their skills in this area.

VI. Adjusting our Teaching, Based on Test Results

The insight gained from assessment results directly influences the teaching methods we use in our introductory courses for software development in the winter term of 2013/14.

More precisely, we apply and enhance several innovative teaching methods, each demanding specific prerequisite skills and focusing on different base competencies that have to be developed. Those are organized as separate modules, thus enabling lecturers to react to their classes' individual needs.

For example, we detected major deficits in the ability to work systematically, in self-discipline and in self-organization, as well as in reading and writing skills.

To tackle the problem of lacking self-discipline and self-organization, we set assignments with different kinds of deliverables, which have to be completed every week. Thus we establish close tracking and very short feedback cycles at the beginning of first term, and then gradually slacken the reins, to help freshmen to get accustomed step by step to the greater liberties and self responsibilities of student life.

Among other things, during off-site study time, students do a short quiz on each lecture, write and hand in a short summary, get involved with programming and/or modeling assignments as preparation for lab-sessions, and read a text assignment to prepare their answers to just-in-time-teaching [8] questions.

In class, students complete just-in-time-teaching questionnaires via an online response system, execute and hand in live exercises that lectures are interspersed with, and fill in one-minute-papers [10], [14].

Furthermore, a couple of terms ago, we converted our end-of-term exams from open book style to exams where students may bring 5 sheets (size DIN A4) of notes as auxiliary resources. To help them prepare these notes, we require students to write a short summary for each topic that has been covered in class. Every two to three weeks, this summary in its current state has to be handed in, as one part of lab session assignments. Thus, we enforce again that students revise the class's content on a regular basis, rather than start summarizing

on the eve of the final exam.

To improve the students' reading and writing skills, we scan through students' summaries, trying to identify existing strengths as well as potential for improvements. Then, students will undergo a specifically designed training on the skills of systematic reading, analysis of written material, and writing a structured summary. These training sessions are scheduled for the beginning of December, to give students the chance to enhance their summaries over winter break, and on time to profit from their improvements in their end-of-first-term exams.

By carefully studying the results of self-assessment and knowledge test, we became aware of gaping holes in basic maths skills of our cohort, e.g., reducing a fraction. As a consequence, we removed any kind of maths from our initial programming samples and switched to maths-free, more tangible examples instead, such as ice cream sundaes, timers and geometric shapes (which only had to be drawn, not computed). Thus, we removed the complexity of dealing with deficiencies in basic maths. Instead, we focused on our main teaching goal, which in our case is software development.

As mentioned before, our students tend to be highly heterogeneous, not only within a specific cohort, but as well across different classes and freshmen years. Therefore, each cohort has to be considered individually. As a consequence, competencies have to be assessed at least for each freshmen cohort, and teaching methods must be adjusted in an appropriate way, to meet the cohorts specific needs. Step by step, this will broaden our portfolio of teaching methods, to suit different learning types in our freshmen students.

VII. Conclusion and Future Work

Via self-assessments, initial knowledge tests and the definition of our *model student*, we explicitly define the diversity of skills that is necessary for successfully studying computer science and related topics. In addition, we help students to become aware of their own basic skill profile right at the beginning of their studies.

Based on their respective self-assessment and knowledge test results, we recommend students to attend specific courses that address their individual needs. Munich University of Applied Sciences comprises a career center, which especially focuses on the development of base competencies and soft skills. This institution offers a comprehensive set of courses, ranging from elementary time management to workshops on scientific writing. In addition, we integrate the development of crucial skills into main classes of the regular curriculum.

Overall, we received mainly positive feedback on our self-assessments. Students appreciated the self-reflection process initiated by these assessments, and voiced that they had never even thought about such issues before. Furthermore, those of our colleagues who participated in these tests with their classes considered the results to be highly informative and very helpful. Consequently, they requested us to repeat these or similar assessments on a regular basis.

When evaluating the self-assessments, we realized that some students did not understand how to complete the self-assessment in a correct way. The main issue was that in the situative mode labeled *easily adoptable*, students did not fill in a complete interval of competence stages, but rather marked the intervals' left and right boundaries. To remedy the situation, in our next assessment iteration we will try to improve this part of instructions to make them more intuitive, e.g., by asking students to just draw a line across the complete interval.

Finally, this leads us to an outlook on our future work. We plan to carry out self-assessments and knowledge tests on a regular basis, to capture the development of our students' personal and academic progress. Visualizing the students' progress is an important means to keep them motivated. At the same time, by these assessments we the lecturers gain feedback on the effectiveness of the teaching methods that we currently develop.

Moreover, the systematic analysis of students' progress and step by step development gave us insight into the existence of certain cognitive misconceptions, which impede the acquisition of proper new software technical knowledge. The development of teaching strategies that overcome these misconceptions will be another major step on our research path.

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