Postprint

This is the accepted version of a paper presented at *International Conference on Learning and Teaching in Computing and Engineering (LaTiCE) 2014, 11-13 April 2014, Kuching, Malaysia.*

N.B. When citing this work, cite the original published paper.

A glimpse into the cultural situatedness of computer science

Some insights from a pilot study

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Abstract—To what extent is students' understanding of computer science culturally situated? This, possibly philosophical question, has come to the surface at Uppsala University, Uppsala, Sweden, where many Chinese students study computer science together with the local students. We did an exploratory study using email interviews to see if our intuitions could be relied on. We collected data from Chinese students studying in master programs and analysed the data using a phenomenographic perspective. A complex intertwined relationship between the content of their learning (the WHAT) the ways in which they went about studying (the HOW), the aims of their studies (the WHY), and the competencies developed from the intercultural context they studied in (the WHERE) was observed. In this paper we offer some insights from the results of the pilot study and discuss how they have shaped our on-going study in the field.

Keywords-computer science education; cultural context;

I. INTRODUCTION

Computer Science (CS) education at the university level introduces a student to the subject and to a culture that is unique to the discipline. Knorr-Cetina [1] refers to this as the epistemic culture of a scientific community that is generated from the practices and knowledge producing activities in a discipline. CS itself is characterized as a hard and applied science that is pragmatic and concerned with the creation of products and techniques [2]. However, the theories, concepts, and practices of CS vary across institutions and a key issue for universities is how students learn and apply them in their own practice.

When Asian students choose to study abroad, they bring with them the values and norms of their own upbringing and cultural backgrounds. Social culture is rooted in traditions, values, and social practices and seeks meanings through shared beliefs and communication [3]. These processes are complex and research shows [4-6] that they influence the motivation and learning strategies of Chinese students.

Little is known, however, on how culture influences, and is influenced by the understanding and learning of the subject area of CS. The interaction of disciplinary learning with cultural and sociocultural practices creates possibilities for researchers to explore variations in learning and teaching CS in a culturally diverse environment. An awareness of such variations is helpful, and essential, to the conduct of CS research and the development of policy in education institutions that teach CS.

In general, research within CS education aims to reveal how students understand concepts within the subject area, as well as how they go about learning these concepts. The aim is two-fold: (a) to enhance our understanding of how students understand concepts within CS (and, in this way, to also get a broader perspective on CS as such); and (b) to offer a tool to improve education in CS, at schools and universities. In recent years, the forces of internationalization of education programs and the globalization of the job market have led to the increase of international students in higher education institutions [7]. These forces have created opportunities for intercultural interactions in CS classrooms and opened new avenues for research in intercultural contexts in computing education.

There are some examples of research on the experiences of international students when they study CS. The complex relationships between what the students strive to learn and how they understand CS concepts, when taking an internationally distributed course, are highlighted in [8]. To understand how the students experienced computer systems and acted in their learning situation, the what, the why, the how and the where of their learning was studied from the students' perspective. The *what* aspect concerned the students' understanding of concepts within computer systems (network protocols). The *why* aspect concerned the students' objectives to learn computer systems. The *how* aspect concerned how the students went about learning. The *where* aspect concerned the students' experience of their learning environment. Three objectives that the students in the international project-based course in computer systems strived for have been identified in this study as: academic achievement; project and team working capacity; and social competence [8]. Some other research [9, 10] explores learning in cross cultural learning situations. These studies highlight the importance of students' appreciation of different communication patterns and the awareness of different cultural value systems, beliefs, and perceptions in the age of global computing and software development.

Several problems have been identified in interactions between learners from different social cultures in studies of user interface design, usability evaluation, interaction with World Wide Web, information systems, computer supported

collaborative learning, open-ended group projects, and online learning [11-14]. Some of these studies have reported issues related to cross cultural teaching in universities and the learning of Asian students in the IT field.

There is a paucity of research done on CS education in China, but an overview of undergraduate computing education can be found in some papers [see 15, 16]. Two publications from Uppsala University discuss the effects of internationalization on changes in learning and teaching of CS [17], and on Chinese exchange students' perceptions of their learning environment [18]. However, within CS education research, the interactions of Chinese students with university level CS disciplinary culture and their culturally situated social experiences have not been explored as yet. Therefore, the long term goal of our research is to add to the knowledge base of such literature by empirically studying the experiences of Chinese students studying master level CS at Uppsala University, Uppsala, Sweden.

As experienced teachers, used to meeting and teaching student cohorts of mixed cultural origin, we got the impression that there are cultural differences in the understanding of what computer science means *per se*. These differences were noticeably both between the Chinese and the local students, but also over time, among the Chinese students, as they integrated into the local community with its norms and values. We also noticed the development of competencies in the students from living and learning in the intercultural context in Sweden.

In order to see whether our intuitive insights would lend themselves for further investigation, we decided to do a pilot study on Chinese master students' experiences of learning and living in Uppsala. As the field is interesting, but mainly unexplored, we made our study with the explicit aim of getting insights for, or refute the idea for a later larger study with more focused research questions. The data was collected in 2008, but was not analyzed. Now, we have analyzed this data using a framework that mainly draws upon phenomenographic learning theory.

In this paper, we report the results and knowledge gained from the data of students' experiences in 2008, and take it as our starting point to discuss how they have shaped our later study in the field. In the next two sections, we present the phenomenographic perspective to learning that we adopt, and describe the related work on the intercultural competencies that we noted the students seemed to have developed.

II. Phenomenographic Approach and Perspective

A. Phenomenographic research approach

The term phenomenography denotes a research approach which aims to describe and analyze human experiences [19]. Data is collected through interviews and then analyzed to derive categories that describe the different ways in which people experience the same phenomena.

In phenomenography, the unit of research is related to how people's awareness is structured. This structure of awareness contains a *what* and *how* aspect of learning [20]. The what-aspect corresponds to the object or content of learning. The how-aspect can be further analyzed as the act of learning in terms of the learner's experience, and as the indirect object identified by the learner's motive for learning. Different ways of experiencing something are understood in terms of qualitative differences in structure and differences in meaning. To experience something implies that the learner is able to discern it from the context of which it is a part, or to discern the parts of what was experienced, and relate the whole or the parts to that context or to other contexts [20].

B. Perspective on learning context

In their seminal work on phenomenographic approach to analyzing learning, Marton and Booth [20] view a learning situation as experienced in terms of a socio-spatio-temporal location constituted of a context, a time and a place. The phenomenon that the researcher is studying is seen as interwoven and mutually influenced by the situation in which it occurs, such that a focus on the situation and the phenomenon is required to gain a holistic understanding of the learning experience.

The importance of attending to the context, when studying a learning situation, is also highlighted by Adawi, Berglund, Booth, and Ingerman [21]. They emphasize the relationship between the context as experienced by the learner and the context as created and understood by the researcher. This relationship is seen from the perspective of the individual, the collective, or the researcher. The prepared context is defined and experienced by the researcher, while the experienced context is seen as being experienced by the learner to make sense of the learning phenomenon. It is in this experienced context that we seek to ground our study and to analyze if the intercultural context that Chinese master students experience when they study CS at Uppsala University is closely linked to the object of their learning.

The context of learning experiences has been studied earlier in phenomenographic studies and has resulted in methodological frameworks that extend the traditional phenomenographic analysis approach. For example, Berglund [8] argued that the variation in students' experiences of their learning of the subject content and the variations in the experienced context are mutually constituted in a phenomenographic study. Based on this argument, activity theory was used to synthesize the analysis of the phenomenographic outcomes and to provide a holistic account of the learning in the complex course setting experienced by students learning computer systems in a globally distributed project course.

III. Definition and Models of Intercultural Competences

The acquisition of intercultural competences can be seen as part of the development of professional competencies for CS students. In today's globalised world, to remain competitive, international businesses seek interculturally competent employees who can manage cultural diversity [22, 23]. An important attribute for CS and engineering graduates is the ability to function in multidisciplinary teams and to communicate effectively [24]. The ability to interact in heterogeneous groups and the ability to act autonomously in

social contexts are key features of intercultural competencies required in many professions [25].

We note that the terms intercultural and cross cultural are often used interchangeably in the literature. In this paper, we accept the distinction that is made between 'cross cultural' as something which applies to more than one culture, and 'intercultural' which implies interaction between the cultures in question [9]. Of the many definitions of intercultural competence that have been advanced, we accept that it is the

...appropriate and effective management of interaction between people who, to some degree or another, represent different or divergent affective, cognitive, and behavioural orientations to the world. These orientations will most commonly be reflected in such normative categories as nationality, race, ethnicity, tribe, religion, or region [23].

The developmental stages of intercultural capabilities have been identified in models of cultural competencies and span the core attributes of motivation, knowledge, skills, context, and outcomes [26-29]. The underlying assumptions are that cultural differences experienced during interactions in a situation or in an environment have the potential for developing increasingly more sophisticated intercultural competences. The outcomes of intercultural interactions are seen as deeper awareness and understanding of the contexts, role, and impact of culture, the broadening of one's worldviews, and the ability to use one's intercultural knowledge, skills, and attitudes to communicate effectively and appropriately in intercultural situations [28].

IV. EXPLORING THE EXPERIENCES OF CHINESE STUDENTS STUDYING CS

The first author of this paper is the director of an international master program that accepts Chinese students. The data collection procedure consisted of email interview questions sent by him to the 2008-2009 cohorts of Chinese students studying masters in CS at Uppsala University. The second author, who lives and teaches Chinese students in Macau, contributed to the methodological framework that was adopted for the analysis of the data.

Email interviews, a qualitative inquiry method in educational research, lead to increasing reflexivity and descriptive data from the respondents [30] through iterations of follow-up questions that are sent by the researcher. Email interviews have previously been used for collecting deeply considered and rich data in a phenomenographic study of educators' conceptions of student diversity in their classes [e.g. 31]. In our case, the semi-structured email interviews provided the time and space for the students (who were non-native English speakers) to reflect on their experiences. The open ended questions enabled the participants to express their own ideas without researcher interference, while the follow-up questions enabled us to probe further depending on the original response.

Nineteen students responded (17 male and 2 female) to the initial call for participants. All students had previous academic background of studying CS in different universities in China and had spent 1 to 5 semesters studying at Uppsala University. We asked 20 questions concerning the students' opinion of the content of CS, of teaching and learning CS, their own studies in Uppsala University, and their personal development in Sweden. We followed up each reply with further questions about interesting or unexpected answers relevant to our study, as well as to further clarify the conceptions expressed by the student and to understand the student's experience. Two movie tickets were given to each participant as recognition of our appreciation for volunteering for the study.

V. FINDINGS FROM THE 2008 STUDY

On inspection, the data from the 2008 study revealed interesting insights into the experiences of the students and the capabilities they had developed. Using the phenomenographic perspective on learning (described in section 2), we analytically separated the *what*, *how*, *why*, and *where* aspects of learning from the descriptions given by the students. We illustrate these aspects with excerpts from the interviews. The excerpts are identified with fictitious (English) names to maintain the anonymity of the Chinese students. We use male names for all the students to protect the privacy of the two girls who participated in the study. The names of the institutions in which students studied previously are referred to as [Chinese University]. The excerpts from the interviews have not been edited for grammatical errors.

A. The WHAT aspect of learning

The differences in what the students learn in CS related to the topics and to the emphasis placed on different areas of the discipline. The course content was seen as varying in the two countries. The students identified new topics they studied at Uppsala University such as data mining, human interaction, distributed systems, artificial intelligence, and logic programming.

Below is an excerpt that focuses on the differences between the practical versus theoretical nature of the CS programs in the two countries.

Benjamin: *When selecting courses, (Chinese) students may tend to consider more the fact that if the course is practical, i.e., if they are going to use the technics taught in that course in their career. However, technics are changing very rapidly, new technics, programming languages emerge every now and then, it is even hard to make sure that the technics you learn today will still be in use when you start working. On the other hand, the basis of Computer Science didn't change too much since the very beginning. Therefore, choosing some more theoretical or research oriented courses, which Uppsala University is very good at, might help [Chinese] students as well.*

The research driven approach of the CS courses at Uppsala University is highlighted in the following extract.

Steven: A lot of courses in CS of Sweden are connecting teaching to research such as introducing the current on-going research projects related to the courses. Most courses here focus on students' own ability to solve real problems.

One of the students explained the benefits of the course program in Sweden being driven by the need to address gaps in theoretical knowledge rather than to cater to market trends.

Richard: Due to the fierce competition among markets, many IT colleges in China focused on how to qualify its students to meet the needs of the market. And in many cases, this is the only thing they care about. Usually students are driven by this thought, like how we are always taught, "you don't have your personal interests, the marketing needs are there to be your interests". But I see this is different in Uppsala University. It cares about what the students have learned, not what to learn. By giving students a good environment for them themselves to choose from. I'm not saying focusing mainly on practical needs is bad, it has its reasons in that circumstances. But I like it more when we got to choose what we want to learn.

Question: Do you feel that we teach more theory as a result of this? Is that useful? In what way?

Richard: Hmm, you focus more on how to let students acquire a good knowledge base, not only how to meet the markets…. what I think is that a good teaching system should provide students with both academic atmosphere and practical environments, and leave the options to students.

B. The HOW aspect of learning

The differences in how the students learn CS in Uppsala University related to the nature of the learning tasks (e.g. problem solving, questioning) and to the type of class activities (e.g. collaborative group learning and discussion). One of the students explains how he solves problems.

David: I used to only focus on finding the solution to the problem. But now I will think more about the problem, not only its solution, but also how many solutions I can find out, which solution is most efficient and the new problems brought up because of this problem.

For a student not used to collaborative group work, the experience was novel and stimulating:

Larry: When we do assignments together, sometimes, when I met problems that I cannot figure out, I tried to find information from internet to understand the problems. Sometimes I cannot get

the correct answers or I still do not understand, but after discussing with my group members, we discussed together and find the problems together, at last, we learn more than just finishing the assignments. And I also learn the students from other countries, sometimes, there are more than one way to consider one problem, and I have experienced how they think about a problem. Furthermore, I also learnt a lot that I did not know before from them.

Another student appreciated the opportunity to demonstrate understanding and reasoning:

Frederick: At school (Uppsala University), teachers and students are quite serious about what they are learning. In the course named database design, my assignments were always rejected and returned for modification two or three times before they get passed….. you are expected to do more reasoning and give more explanations in an exam to show that you really understand the knowledge.

In the extract below, a student tries to explain his understanding of why Uppsala University students are more motivated to learn:

Michael: People around me, they are all very serious about studying and learning. No matter teachers or students, they respect knowledge and advocate science. Their attitude about life teaches me a lot.

Question: Do you find that people are more serious here than at [Chinese University]?

Michael: There's no doubt teachers both at Uppsala University and [Chinese University], they care about students and be willing to educate them. But the percentage of students who are serious about studying at Uppsala University is larger than at [Chinese University]. I don't mean they are not serious but don't have much fun with what they are learning for now…. And I think it's not all their fault, because in China, students don't have much choice to learn what they are interested in and many even don't know what they are interested in. That's the contradiction between student's willing and government's policy. But in Sweden, normally people can do what they want to. They don't have so much pressure in society like in China. Fortunately, I like what I'm learning.

C. The WHY aspect of learning

We asked the Chinese students why they wanted to study in Uppsala University and what they thought they will learn. The students' aims and motives were related to wanting to study abroad, the reputation of the university in CS

education, and their interest in improving their prospects for a future job. A typical answer was:

> *Richard: "...has better education quality and reputation. Personally, I also preferred the way that computer science is taught in..... As a result, I can have much more solid knowledge base. So that in the long run, I am able to work on an area that I am really interested in.*

We found references to the country and culture that showed that students also considered these factors when deciding where to study abroad. Some comments were: "*Studying in another country is amazing experience. And also, ... is a famous college in the world. I think I can learn a lot at ....*"; "*I have always been very interested in the ..... culture. I have many ..... friends, and they made me want to know more and more about ..... culture. .... is a very lovely country*".

D. The WHERE aspect of learning

We questioned the Chinese students about their personal development when living in Sweden. These questions related to what effects they thought that their time in Sweden will have on them and their future life. Apart from developing systematic thinking about solving problems in CS, the students reported the improvement in their ability to communicate with people from different cultures and countries, to work in a team, and to learn from others. Referring to other effects of their time in Sweden, students mentioned opportunities to learn Swedish and English and learning about Swedish society. One of the students explained the process of adapting to working in multicultural groups:

> *Steven: During university projects and master thesis work, I have experienced teamwork with [Countries suppressed], etc. I also have experiences working with other Chinese, either Chinese nationalities or ethnical Chinese from other countries......The biggest difference of working with people from the Occident and Chinese is that the latter involves much more personal relationships....For example, in a Chinese group, if one member doesn't agree with another one on some technical issue, he should always avoid saying it out in front of other people. Even if he tries to tell his opposition to the other one privately, it's still better not to do it straight, but rather imply about it. As a result, in the beginning a Chinese might misinterpret the fact that another Westerner opposes him on technical issue in front of other group members as an opposition personally. There are way many other detailed differences that require people to gradually get adapted. ... In a word, this is a perfect chance offered by Uppsala University - now or never for me to learn the spirits of teamwork in an international environment.*

We also asked the Chinese students about how they had changed by being a student at Uppsala University and what in this change had been the hardest for them. Many of the students mentioned that they had learned to live independently in a foreign country and to adapt to western culture and life. An increase in confidence and self-reliance was noted. The changes also related to a much better tolerance of multi-culturalism and value perspectives of others. A student explains this widening of his worldview:

> *Charles: This is the first time I've been living in a different culture, dealing with people from different cultures every day. By communicating and learning from every little thing, I learn how to think in a different way. I enjoy this very much....By communicating with people from different culture change my views on many things varies from those daily stuff to some world big issues. Which is good because when you live in your hometown, you just get used to the way how people live and think there. But different culture brings up a brand new world. Like you have never seen this part of a certain thing before, it widens your horizon. And I believe that this could change my life.*

An increasing understanding of fundamental rights can be found in the following extract.

> *Question: What other effects do you think that your time in Sweden will have on you and your future life?*

> *Bradley: Wider comprehension of fundamentals including freedom of speech, equity and social justice; much better tolerance out of multi-culturalism.*

> *Question: This is an interesting answer. If you do not mind, it would be interesting to hear if, and in that case how, this has affected you?*

> *Bradley: Sweden, as its difference from other Western countries, is arguably a perfect combination of the free market and social justice. I've learned very much from it. However, I still cannot agree with few of the values. For example, people here have the ultimate belief of freedom of expression, which I absolutely agree and I respect a lot. But sometimes this belief becomes too extreme that its lack of very important pre-conditions ... They don't have to defend their freedom of speech by doing something that is considered as inhibitions or taboo in another culture. There are better ways to defend, because basic respects for the other cultures are also of great importances. I know this issue is quite controversial; anyway, it's only my personal opinions.*

The changes caused by learning and living in Sweden also proved hard for the students. In particular, leaving their own home country and parents meant coping with loneliness and helplessness. Learning to arrange the details of the daily life and study schedule took time. Group work also proved problematic as the following extract from a student shows:

> **Thomas:** *When we work with foreign students we talk use English. I have to say sometimes the language is a barrier of team working, different understanding of the same sentence can lead to misunderstanding in the discussion, and then we need to use more time to explain. But when we use our own home language, we don't have this problem. Second I want to say is that, sometimes Chinese students are worry about asking questions and don't like to tell others their own opinions. Because in China, the teaching system is teacher teach and students listen. We don't have much chance to do discussing. So Chinese students are always very shy and don't like to ask questions in public.*

VI. DISCUSSION OF OUR INSIGHTS

The phenomenographic framework offers a possibility to analytically separate the different aspects of the students' experience of learning CS in Sweden. As our current study is a pilot, our aim is to find out if the students' reports can be taken as an indication that the students' understanding of computer science *per se* is contextually and culturally situated, and if we judge that this is the case, how this relationship between the experience of computer science in an intercultural context leads to the development of intercultural competences.

In the data collected from the pilot study of 2008, we found differences in the subject content areas and in the ways of learning computer science at Uppsala University and at Chinese universities. The students perceived the core of computer science at Uppsala University to be research-based with theoretical and practical orientation. They identified the CS taught at their home universities as practice orientated with a focus on the job market. The differences in learning and teaching between Uppsala University and the students' previous universities related to learning outcomes, assignments, teaching activities, learning tasks, and resources.

The students not only reported the changes in the knowledge and skills that they had acquired, but also changes in their beliefs, feelings, and values from learning and living in Sweden. The outcomes of living in Sweden were seen as improvement in communicative and English language skills, being able to work collaboratively in teams, and an appreciation of different cultures and customs including the Sweden way of life, work attitude, and way of thinking. The students also mentioned developing the capability to live independently and of being able to make their own decisions in life.

Our results clearly indicate that it is possible to analytically separate different aspects of the experience of learning CS in a specific environment. By inspecting the data we gained insights that what was learned in CS and how it was learned depended on the focus of the program, the teaching and learning tasks and styles, and the learning outcomes and expectations of the outcomes. Regarding their personal development, the students perceived that by interacting in the intercultural classroom they improved their communicative and collaborative learning skills and developed new capabilities (appreciation of different cultures, attitudes, and new customs) and new habits, attitudes, and ways of thinking.

The data has thus revealed two interesting aspects worthy of further investigation. The first aspect related to the noticeable difference between the CS disciplinary cultures relating to *what* was taught and *how* the students learned CS at the different universities. The second aspect emerged from the students' reflections about their own studies and life in Sweden and the perceived impact of their studies and stay for their future life. It appeared that the socio-cultural effect of studying and living in Sweden led to the distinct development of cultural sensitivies. From the data we collected we have evidence that the students developed intercultural competence [26] signified by a change in knowledge (cognition), attitudes (emotions), and skills (behaviour). We have also seen the growing awareness, valuing, and understanding of cultural differences through experiencing other cultures and a deeper self-awareness of one's own culture [28].

From our findings we can infer that the students' development through living in Sweden reflected on their relation to CS, their studies, and their cultural sensitivity and competencies. What students mean by computer science, what they find important in CS, and how they understand CS seems to vary over cultures. It appears that students imbibe values, practices, and ways of thinking in new contexts and make it theirs.

For the Chinese CS students in Sweden, what is learnt, how the learning takes place and the development of cultural competencies seem impossible to separate. It is in this relationship that we have noticed learning outcomes (theoretical knowledge and practice skills in computer science) and capabilities (intercultural competences) that the learners gained.

VII. FUTURE WORK

In as much as our pilot study clearly indicated that our initial assumptions were worthy of further research, it also gave us, through the underlying data, the empirical underpinnings for developing an analytic framework [32, 33] for use in our follow-up study. The main features of this framework are.

- Analysis: Using the phenomenographic perspective on learning we analytically separate the *what* and *how* aspects of learning.
- Interpretation: We again use the interview data, as well as findings from the analysis. By applying intercultural competency models, we identify the

intercultural competences the students gained from the interactions in CS classrooms.

- Explanation: In the last stage, we explain our understanding of the complex relationship of the situation and phenomenon of learning set within the contextual and interactional aspects of learning CS. We further explain how the analytical, interpretive, and explanation stages of our framework relate to relational, contextual, and disciplinary outcomes expected from applying the framework.

VIII. CONCLUSIONS

We have reported an exploratory study on the complex relationship between the students' experienced computer science context and the intercultural learning situation in which students developed skills and competences.

The findings from our research contribute to insights on:
- students' understanding of CS,
- learning of CS,
- acts of learning CS,
- learning of CS in a particular context and
- the relationship between these aspects.

Our long-term aims are to enhance teaching and learning of CS in environments where cultures meet and to encourage universities to create learning environments where cultural differences support learning of CS.

With this pilot study as a background, we are encouraged to believe that this is a theme of research that deserves further studies. Thus we have made a second data collection, built on the experiences from the study presented here, have defined a framework for analysing this complex data and are currently using this framework to understand the new data.

In our continued work, we hope to make recommendations for CS educators on environments that encourage development of disciplinary knowledge and intercultural competencies. Our future work will focus on methodological development for analysing data from such complex studies and on questions of transferability outside our setting.

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