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Searching for Global Employability: Can Students Capitalize on Enabling Learning Environments?

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Literature on global employability signifies "enabling" learning environments where students encounter ill-formed and open-ended problems and are required to adapt and be creative. Varying forms of "projects," co-located and distributed, have populated computing curricula for decades and are generally deemed an answer to this call. We performed a qualitative study to describe how project course students are able to capitalize on the promise of enabling learning environments. This critical perspective was motivated by the circumstance of the present-day education systems being heavily regulated for the precipitated production of human capital. The students involved in our study described education system-imposed and group-imposed narratives of narrowed opportunities, as well as many self-related challenges. On the other hand, students welcomed autonomy as an enjoyable condition and linked it with motivation. Whole-group commitment and self-related attributes such as taking care of one's own learning appeared as important conditions. The results highlight targets for interventions that can counteract constraining study conditions and continue the march of projects as a means to foster complex learning for the benefit of students; and professionalism in global software engineering.

CCS Concepts: •**Social and professional topics** → **Computer science education;**

Additional Key Words and Phrases: Project-based learning, Employability, Global software engineering education

1. INTRODUCTION

Today's work environments call for a workforce which can demonstrate creativity or innovation ability,[1] and tackle open-ended and ill-formed problems in multi-cultural settings. Many scholars have accordingly noted that such attributes should be included in the repertoire of present-day and future graduates [Yunfei and Qin 2009; Yang and Cheng 2010; Fila et al. 2012]. Creative problem solving is strongly aligned with taking responsibility and willingness to learn, which again are attitudinal attributes emphasized by employers [Coll and Zegwaard 2006; Hernández-March et al. 2009]. Computing graduates face an increasing need to demonstrate these attributes in the complex domain of Global Software Engineering (GSE), which takes place over multiple sites and involves cultural dimensions and temporal differences.

On the other hand, today's higher education introduces another kind of force: instrumentalist conduct urged by marketisation; see, for instance, Giroux [2001], Clear and Clear [2014], and Sutton [2015]. Pressurized under this force, teachers may experience severe personal paradoxes [Sutton 2015] and students may narrowly hope to receive the "right skills" that, they believe, increase their employability [Ingleby 2015]. Sincere teaching and learning are at risk to occur only in the "interstices" of the education system [Sutton 2015].

The tension between the two premises above suggests a topical framework for and motivates more research on students' responses to enabling[2] learning environments. A bachelor level project-based course at the University of Jyväskylä (Finland) exemplifies such an environment. The course theme is the globally topical interest in how to

[1]We use creativity and innovation ability as synonyms; pedagogic literature often speaks of creativity while engineering and computing education literature also use the term innovation ability.
[2]We use the locution "enabling" to summatively refer to the conditions where students encounter open-endedness, ill-formedness, and the requirement of creativity.

benefit from open resources. Small groups ideate[3] and implement open-data themed applications. Very little "external pull" is provided to students who are instead required to take an active role and substantive responsibility of the projects. The groups decide on all aspects of their projects, including not only technical questions but also the project topic and means of management. GSE-Ed scholars have recently raised the need to increase student responsibility regarding the implementations of GSE-Ed courses [Beecham et al. 2017b]. This call was grounded in observations that much of the educational attention readily goes into technical performance instead of generic aspects concerning self-reliance, project management, and interpersonal skills. The co-located project course referred to above serves as an early preparation for global software engineering in this regard.

In reference to this project course, we conducted an inductive qualitative study on how students were able to capitalize on the promise of an enabling learning environment. Grounded in the two premises above, we were interested in identifying aspects that facilitated or constrained their study. This signified a rather critical research lens compared to a more typical one concentrating on course validation. "Critical" here indicates a profound interest in the underlying aspects that influence study processes in an enabling learning environment; the important student perspective that can inform education design. The "capitalize on" perspective in our title question accordingly indicates a wide interest in how students felt about the expectation of complex learning and elaborated on their studying under such expectations, leaving room for inductive description.

The main research instrument was interviews, by way of which the students' experiences were examined in the light of their previous experiences of studying and views on employability. Following a thematic network analysis approach [Attride-Stirling 2001], the themes interpreted in the data were arranged into graphical illustrations (networks). The contribution of this study is specifically argued to be in its perspective, yielding categories that, we argue, encourage scaffolding on overarching educational attributes that are important to GSE-Ed; such as self-reliance and self-identified ability to be creative.

2. EMPLOYABILITY, LEARNING ENVIRONMENT, INDIVIDUAL STUDENT

Employability is often discussed in terms of "core and generic" [Dunne et al. 2000] or "vocational and generic" [Hernández-March et al. 2009] skills, with the former constituent referring to a subject-specific domain, and the latter to a domain important across disciplines. Transferability, adaptability, and application are the characteristics of the generic domain typically advanced by employers as important graduate attributes (e.g. [Crebert et al. 2004; Hernández-March et al. 2009]). In the study by Hernández-March et al. [2009], willingness to work and ability to work with other people stood out as employer-valued generics in conjunction with disciplinary skills, while, put briefly, employers generally emphasize "ability to function in the workplace," and such ability comprises a lengthy list of skills [Harvey et al. 1997]. A constantly stated measure to foster the development of generic skills is the use of authentic learning environments such as projects and placements [Crebert et al. 2004; Hernández-March et al. 2009; Tymon and Batistic 2016].

Scholars have also addressed employability by looking at particular, single attributes. Tuner [2014] was concerned with the development of student self-belief. She argued that contributing to students' self-belief requires students' realization that ability can be developed and that they can plan and achieve their goals. Moreover,

[3]We favor the unusual term "ideate" over longer circumlocutions and the stronger term "innovate."

Tuner argued that students should believe that the contexts at hand permit goal attainment. Tuner's position emphasizes context-specific self-belief through the experiences of mastery and success. Computing curricula have emphasized project-based learning for decades [Tomayko 1998] and thereby seek to provide "experiences to develop agency within enabling structures" [Turner 2014, p. 597]. Students' experiences of improved self-belief are frequently found in both experience reports and research studies on project-based learning: Many authors have referred to increased student 'confidence' [Clark 2005; Newman et al. 2003]. In an empirical study, Helle et al. [2007] reported factors that students identified as motivating. One was "feelings and cognitions related to competence," which reflects the positive experience of increased mastery. An illustrative student reflection on a realistic project course, a quotation where a connection between increased self-belief and life after graduation is explicitly stated, reads as follows: "now I know I have a chance to make it in working life " [Isomöttönen 2011].

Tymon and Batistic [2016] studied "proactivity" as an attribute potentially contributing to both employability and academic success. The term refers to an ability to plan and preparedly take actions on one's career path. The authors considered it to be both a person's long-term disposition and situational behavior. They note that the former manifestation is difficult to intervene in, while the latter grants opportunities for improvement through education. Finally, Tymon and Batistic refer to integrative capstones as a means to foster proactivity, which seems plausible from the present CS education standpoint; successful performance in projects arguably requires proactivity—planning for future and taking actions according to plans under fixed timescales.

The review above highlights project-based learning as a useful means to foster employability. Below we raise the aspects that may nevertheless constrain individual students' studying in such environments. Knight and Yorke [2003] argued that improving employability necessitates complex learning. To achieve this, they stressed holistic curricular design in place of separate, piecemeal actions. They conceptualized that students' approaches to learning may include deep/sense-making, apathetic/just-getting-by, surface, and strategic, the last signifying selection amongst the first three on a situational basis. Although noting that students' cognitive strategies are difficult to infer, they regarded learning environment design as important, potentially having effect on the approaches that students adopt. Their chief argument nevertheless was that if students cannot discern a holistic learning culture of a program, surface approaches such as information reproduction may be employed. In our thinking, individual courses requiring complex learning through substantive effort are, then, likely to witness difficulties that relate to the whole education system, as was the case when a demand for self-regulation was heavily emphasized in a programming course [Isomöttönen and Tirronen 2017]. This condition is further explained by Atkins [1999] who articulated reasons for generic employability agenda not receiving attention in curricula. One reason is the academics' concern over needed reduction in subject-specific content, and the other is concern over cost-effectiveness.

Knight and Yorke [2003] also argued that self-efficacy challenges may cause students to approach complex tasks emphasizing sense-making as routine tasks. Yet another concern is that when sufficient support is not available, learning in authentic settings can engender discouraging experiences [Isomöttönen 2011]—an opposite to increased self-belief. Furthermore, regulation and steering in today's higher education may intensify instrumentalist learning behaviors instead of ones with linkage to complex learning. This concern was recently raised by Sutton [2015] from the perspective of academic identity conflict originating in increasing bureaucracy within the neoliberalist education system. In a paper by Ingleby [2015], employability was also studied in the light of the neoliberalist condition: the students' view of employability conformed

to such a condition, stressing "right" skills leading to employability. Specifically in the field of computing, Clear and Clear [2014] articulated a mismatch between regulation-imposed, ever-increasing, pass rate expectations and the typical pass rates of introductory programming reported in internationally-scoped studies. They warned that this mismatch is likely to bring about "perverse behaviors" amongst local stakeholders—consider here teachers, local administration, and students—as they attempt to comply with external, nationally imposed targets.

Yet another noteworthy force that may impede students' development is hesitation to engage with complex learning (here, reflection at a conceptual level) under practical, intensive coursework. Attempts to foster such learning has engendered student responses such as "time wasted on meta-thinking" [Isomöttönen 2014]. Such responses may be indicative of a "doing mode," in which mere completion of practical assignments is regarded as a sufficient learning outcome [Su 2010], a condition which in our thinking can readily prevail in the praxis-oriented computing discipline. Moreover, simply the fact that students are heavily occupied by intensive project assignments may hinder their focus on generic reflection [Parker et al. 1999].

The above observations motivate investigations on individual students' perceptions when they encounter enabling learning environments. While learning environments may link with students' approaches to studying, several critical forces may cause distortions regarding how individual students approach and are able to perform under the expectation of complex learning.

3. OPEN-ENDED, ILL-FORMED, CREATIVITY-PRESUMING

Due to our tendency to use the terms ill-formed, open-ended, and creativity to characterize our learning environments, we concisely review these attributes. Ill-formedness can by defined in relation to Conklin's [2003] characterization of "wicked problems." He put that understanding the (wicked) problem requires working on the problem and even coming up with solutions, and that typically the stakeholders involved possess different worldviews, which introduces differing communication domains to the solving process. Moreover, the constraints on the work may change over time, and the problem remains unresolved in a traditional sense.

The term open-ended is instead generally used to characterize problems that do not involve a single inevitable direction. Education discourse tends to contrast "open-ended" with "closed" and links these characterizations with "divergent thinking" and "convergent thinking" respectively [Kwon et al. 2006]. Kwon et al. argued that the use of open-ended problems, allowing for divergent thinking, enables individually-scoped studying and promotes creativity in terms of increased flexibility and originality. Their study provides evidence for the effectiveness of open-ended problems in the context of mathematics education.

Kazerounian and Foley [2007] provide a useful summary of the definitions of creativity; see references therein. Of the many, we quote the Plucker et al. [2004] definition: "Creativity is the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context." A short and informal characterization provided by Kazerounian and Foley [2007] is :"the ability to generate new ideas or new association between existing ideas." Sternberg [1996] argued that creative activities necessitate three abilities that can be developed: synthetic, analytic, and practical. The first is the same as the informal definition above. The second refers to critical thinking, to the ability to analyze and evaluate ideas, and the third denotes the ability to convert ideas into practical accomplishments.

As for educational settings, a chief argument is to enable exploration of space (e.g. [Resnick et al. 2005]), meaning that the learning environment and tasks therein are

not "inevitable." Apiola et al. [2012] named such a setting a "creativity-supporting learning environment (CSLE)," and grounded it in the self-determination theory developed by Ryan and Deci [2000]. This theory emphasizes the attributes of competence, autonomy, and relatedness as antecedents of internal motivation. In order to implement a CSLE, Apiola et al. [2012] also emphasized domain relevant skills (that is, good computing skills) and working styles such as brainstorming. Their empirical trials showed variation in students' responses to such an environment. Students who had difficulties dealing with an open environment developed negative feelings toward course arrangements, while for other students finding solutions to creative problems led to rewarding and flow-like experiences. According to Csikszentmihalyi [1996, pp. 107–112], a creative flow indicates intrinsically rewarding behavior with a sufficient balance between challenges and skills. It does not simply translate into a nice activity. Rather, when an individual performs in a flow, factors that push towards goals outweigh the difficulties causing anxiety. The individual must also be aware of how well one is doing not to drop out of the flow into anxiety.

4. GSE-ED AND THE PRESENT CONTEXT

Approaches to implement GSE-Ed include multi-site projects, participation in open source development, and simulation [Beecham et al. 2017a]. The first two approaches build on the argument that it is important to involve students in authentic GSE, while the simulation approach is based on the observation of restrictions in educational settings.

Challenges and recommendations of GSE-Ed achieved recent prominence in a systematic review [Clear et al. 2015]. The dimensions found were global distance, teamwork, people/soft issues, stakeholder role, infrastructure, curriculum/pedagogy, and development process. Examples relevant to the present study are many: Global distance challenges included skill balance, differences in communication style, work culture, and learners' readiness to ask questions. Teamwork challenges also referred to skill balance and relatedly to task allocation. Under soft issues, motivational issues included differences in work culture, lack of commitment, differing goals, and procrastination. An infrastructure challenge was the lack of shared version control systems to coordinate project collaboration.

The review also showed that the complexity of GSE had yielded recommendations that an instructor should focus on clear guidelines and course structures. GSE had relatedly been considered appropriate at an advanced level and noted to benefit from all students possessing sufficient skill level. At the same time, flexibility and being alert to emergent problems had been identified as important attributes in the instructor role. As for the student role, the review highlighted that students often encounter processes and management issues without pre-requisite courses, and then "in a very difficult global situation."

Conforming to the challenges reported in the review [Clear et al. 2015], potential gaps in GSE-Ed were noted by Beecham et al. [2017b]: One was the lack of attention to non-technical aspects such as project management, and interpersonal and leadership skills, and relatedly to student responsibility of projects and their operations. Another gap was the lack of student work in regulated application domains. An example given by Beecham et al. [2017b] is software engineering on medical instruments.

4.1. The target course

At University of Jyväskylä, a bachelor-level project-based course was added to the curriculum in 2013 to pave the way for a master-level industry-strength software project

Table I. Comparison to GSE-Ed

	Target course feature	**GSE-Ed feature**
1	Open resources	Global awareness
2	Student decisions; self-reliance	Student responsibility (gap)
3	SW process and management through self-reliance	Preparation for process and management skills
4	Pedagogic focus on group work; fairness	Skill balance & task allocation
5	Grouping strategy; ideation in groups	Diversity
6	IPR questions	Regulated domains (gap)

with real customers. During this 12-week, 5 ECTS[4]-credit project course, small groups ideate and implement software prototypes that utilize open-data sets and open APIs (Application Programming Interfaces), which are increasingly released in societal interfaces and cover a wide range of social domains. According to Domingo et al. [2013],

> open data is the concept that defines the publication of government or private company data without copyright restrictions. The data should be formatted so that citizens can reuse it at their discretion to create new, innovative services or applications.

This approach to project-based learning emphasizes creativity together with a highly open-ended starting point. The course seeks to increase students' understanding of software process, project management, and group work, and introduces them Intellectual Property Right (IPR) questions. The course has been an option for practical study required in the bachelor degree, and is taken yearly by 12–26 students (3–7 groups with preferably four students in each).

Groups are first made aware of the existence of various open resources on the web and asked to develop and iterate project ideas by considering matches between personal interests and intentions, available data and APIs, and potential target groups. The resultant project ideas are presented after 2–3 weeks in a session where the groups receive feedback from peers and supervisors. The beginning of the course also includes a lecture on group concepts (fairness, statuses, roles, norms, and typical patterns anchored to these concepts) and software process. Throughout the course, the main working mode is independent group work, which is scaffolded by short weekly meetings. That is, a teacher in charge and a senior student who provides technical guidance meet each group on a weekly basis to discuss and conceptualize emergent issues in group work and software process. During the course, an expert lecture on IPR is also provided. Groups present their products during a final presentation day in their project rooms, to which other students and staff members are invited. The visiting audience can test project products and discuss students' project experiences. Passing the course requires active participation with a minimum of 100 individual work hours reported, and a personal end-of-course learning report.

Table 1 provides a non-exclusive comparison to GSE-Ed, and is reviewed starting from the top: (1) The course theme is the globally topical interest in open resources, and students thereby become aware of a global, open innovation aspect in their professional area. The students' IPR decisions in groups have typically indicated the use of open software licenses, and hence the projects also associate with open source development projects initiated based on the students' creativity.

(2) A gap identified in GSE-Ed was the lack of student responsibility for course operations. Beecham et al. [2017b] stated that approaches need focus on

[4]European Credit Transfer System; one credit unit equals to 27 work hours.

> weaning students off reliance on their instructors and enabling them to take more active ownership of the course design and operation as an integral part of their learning.

In the present course, students "explore space:" There are no instructor or customer initiated project proposals, instead student groups ideate the projects. Groups also decide on all other aspects: they make requests for faculty PC support regarding operating systems to be installed in project rooms' PCs, they select the platforms, programming languages, and project management tools they wish to use. The same openness applies to software process, project management, and student roles. Students are introduced with alternatives and scaffolded through a list of questions. The questions are of the form: "do we assign a project leader?," "how do we manage project tasks?," "do we apply an agile, feature-based process or a phase-based process?," etc. The software process is rather addressed at a conceptual level by emphasizing principles such as commitment and situation awareness, and by discussing and conceptualizing emergent issues during projects. The use of a version control system is expected of all groups, and the student selection has without exception been Git. The course attributes reviewed in the previous sections (creativity and ill-formedness, and open-endedness), illustrated here in how students take responsibility for project features, emphasize self-reliance. Groups are provided with project rooms to support independent group work.

(3) The key incentive for the bachelor level project course was to gradually prepare students for complex learning, by paying attention to process, management, and group work early on. The GSE-Ed review revealed that students often encounter process and management challenges in highly complex GSE courses without preparation [Clear et al. 2015].

(4) Learning about group work is a key goal. A specific intervention is carried out in each group in order to enable the groups to become aware of their situation, in particular concerning emergent roles and fairness. The course is graded with 'pass' based on active participation, which, in place of numeric and competitive grades, seeks to facilitate analytic discussions during the intervention sessions. The constantly emerging topic, which the student groups resolve in these discussions is the skill balance; a separate study under construction indicates that students increase their awareness of, and continue to pay more attention to, task allocation as a result of this intervention.

(5) Project ideation based on group members' various interests indicates that students need to negotiate diversity. This is further intensified by a group formation strategy where students in a group have not previously worked together, creating a realistic, "starting a project with new people" challenge. The situation conforms to GSE where distributed teams introduce diversity.

(6) Working with the data releases of different degree of openness, and agreeing on how to release end products as a group, require students to become acquainted with the topic of IPR (see [Isomöttönen and Kärkkäinen 2016]). Due to IPR issues, groups have had to modify their intended project idea and even change the whole project idea during the project. Data providers have been contacted for clarification and university legal counsel consulted to support decision making. Such work may be seen as useful preparation for software engineering work in which different kinds of regulations are readily encountered.

Taken together, the characteristics of an enabling learning environment, as well as the pedagogic focus on conceptual understandings about software process and group work, and the topic of IPR, seek to prepare students for complexities that are increasingly encountered in GSE.

5. THE STUDY

The main research question was: are students able to capitalize on enabling learning environments? More specifically, we were interested in aspects that played a role in students' performance, as described by the students when they elaborated on their experience of being in such a course. Our lens was the general one illustrated by our review in Sections 2 and 3. This means that we concentrated on aspects that emerged as important when students reflected holistically on their experiences in the continuum of their education.

Hsieh and Shannon [2005] described three approaches to qualitative content analysis: conventional, directed, and summative. The first is an inductive, data-driven approach. The second refers to a theory-directed approach in which data is used to verify theory-driven hypotheses. The last indicates a goal to provide summative frequency information on the concepts in the data. We followed a conventional content analysis approach; literature motivated and informed the research question, while no particular theoretical constructs were used in operationalizing the data collection.

More specifically, we followed an inductive thematic network analysis [Attride-Stirling 2001], which exemplifies qualitative content analysis, but specifically proposes the use of graphical illustrations ("networks") as an analytical tool. As its underlying theoretical foundation, Attride-Stirling [2001, p. 387] alludes to Toulmin's argumentation theory [1958], which addresses negotiation processes by examining "connections between the explicit statements and the implicit meanings in people's discourse." Similarly, Attride-Stirling explains, networks provide a formalism that facilitates linking low-level themes with more abstract principles, a process proceeding from the recognition of "basic themes" to "organizing themes", and finally to abstract principles, "global themes." The point of departure is to explore "understanding of an issue" [Attride-Stirling 2001, p. 387], which here denoted the exploration of students' understandings of their being in an enabling learning environment within the continuum of their education. The networks hence comprise emergent aspects resulting from an inductive analysis approach.

5.1. Data collection and subjects

The research context was the open data-themed project course described in Section 4.1. The primary data were elicited through a series of interviews performed in late January 2017. The interview plan consisted of three themes. The first was the students' experiences of previous learning environments: what kinds of environments they had participated in and what were their preferences and dislikes therein. The students were prompted to think of their schooling background before the university studies, and the university studies before the project course. The second theme was their experience of the project. The students were probed to think of open-endedness, the need to ideate a project topic in a group (creativity), and the related ill-formedness. Probing occurred without academic terms such as ill-formedness, generally making a point of working with no customers nor inevitable teacher-set direction or degree of product readiness, and of the continuous possibility to advance ideation. The students were probed to consider if it was easy or difficult to adapt to the project environment, and which of the two approaches better characterized their being in the course: working merely for credits or working for learning. Comparison between school and university studies was not our goal per se. Rather, discussion that started from the time of schoolgoing aimed to bring to the foreground students' accumulated perceptions of formal education, and thereby to facilitate reflection on their ability to cope with the project. The third theme was the students' view of employability in terms of how they saw the purpose of higher education and what they thought they will eventually gain

from it. The interview method was informal, at most a semi-structured approach; the interviewees were granted space to focus on the matters that they began to elaborate in the interview situation; categorical responses were not enforced.

Thirteen students (P1–P13) participated in voluntary research interviews. Of these, eight took the course during autumn 2016 and the remaining five during autumn 2015. The participants were rewarded with a movie ticket. Due to our sensitive research lens, asking students to describe their personal approaches to studying and constraining items therein, we do not provide detailed descriptions of the participants. This is motivated by the principle of "relational ethics," which means that the identities of important others need to be protected (see [Ellis et al. 2010]). [5] Generally, the minimum prerequisite courses are CS1 and CS2. Some of the participants had also taken basics of web programming and an introduction to software engineering where project management topics were introduced. The course cohorts consist of CS majors complemented with a few (1–3) non-majors (e.g., physics, mathematics, statistics) yearly. The interviewees were roughly third-year students "in their late bachelor studies." With the exception of one student, the participants were CS majors.

Personal learning reports that are prepared at the end of projects were used as a minor complement to particular aspects in the interviews. This data resource was looked at through the analytical scheme that emerged from the interview data, and was selectively employed to support the interpretations of the interview data and to complement the descriptions of a few themes therein. For instance, the interviews included brief mentions of the influence of the ability to obey a software process, and this indication could be confirmed and illustrated by the learning reports. A few quotations originate in the learning reports, and are indicated by "Student-LR." The present study overall represents an interview study.

5.2. Procedure

The analysis began from the audio-recorded interview data. Parts of the recordings were fully transcribed while other parts were transcribed by writing out the points made by the interviewees using the analyst's language. This was because of the first author's preference to code key points in the recorded data by listening; such initial codes were marked within the text being produced. This yielded a textual presentation of the data having the same purpose as the first step suggested by Attride-Stirling [2001], that is, data is coded (in a sense, selected) according to the theoretical lenses used. Indicative "basic themes" were then extracted and refined from the initially coded data. Here, the textual presentation was iteratively examined and audio recordings were re-listened to at several occasions. By considering similarities and differences, the basic themes were then organized under more abstract grouping principles, organizing themes; see, for instance, "System-imposed" in Figure 2. Finally, holistic principles in the data, global themes, were contemplated and deduced, as indicated by thinking over the organizing themes and their basic themes; see "Opportunity narrowed" and "Transformations and success" in the resultant networks. The networks were then reviewed and discussed among the authors. During this process, accompanying examples were identified in the learning report data. Final revisions of textual descriptions of the themes followed. A single participant could contribute reasoning to several of the themes. Moreover, one data segment could indicate explicitly a particular theme, whereas other segments showed a similar aspect indirectly, whether from the same or other students. The themes are narrative-like regularities over the whole

[5] This principle is a feature of auto- and self-ethnographic studies that report sensitive personal accounts that unavoidably relate to important others in the research context.

data. In support of our stance on relational ethics, we present the results by mixing the use of the singular and the plural.

5.3. Validity considerations

It is useful to describe the researchers' thinking and activities related to the research focus. The first author had recently performed counseling-related teaching activities, reaching an authentic picture of study difficulties in local higher education. Moreover, during the past 10-year period in the university, "performativity" [Ball 1998] discourse was increasingly observed, and discussed amongst the authors, contributing to a broader and critical interest in education research. This position motivated the present research, and contributed to the formulation of the research perspective. However, this position was reflectively acknowledged, and the study did not draw on any theory favored or formulated by authors. A bias such as a tendency to uncritically validate a particular theory by the analysis was hence avoided. The study demonstrates an explorative interest in students' "understandings of an issue," and it is argued that the analyst's (first author) personal scope described, rather than complicating the analysis, helped retaining a constructive view on the student-described challenges conveyed by the thematic networks. The data analytical themes do not indicate any negative connotations toward student cohorts. The research setting is that students' viewpoints valuably inform education design.

A potential bias arising from students talking to a course teacher was counteracted by conducting the interviews *after* all course activities were completed, and by explaining the research perspective—the interest in study conditions in reference to the project course features instead of a course evaluation—to the interviewees. It is noteworthy that the resultant themes include both constraining and personal issues that had affected the students' course participation, which, we intrepret, signals no notable bias arising from teacher-student relationships or voluntary participation. Moreover, the nature of the interviews were largely about professional dialog, observations about studying in the present education system, which, we believe, contributed to having trustful interview situations (see Appendix A). The above-reviewed potential biases relate to the "credibility" dimension [Lincoln and Guba 1985], a concept corresponding to internal validity.

Furthermore, we included a lot of quotations to illustrate the connections between the research question, the themes extracted from the data, and the data. This enables the reader to observe the trails of our interpretations, echoing the aspect of "dependability" in our process [Lincoln and Guba 1985], which corresponds to reliability in quantitative research. In our view, the use of thematic networks contributes to this aim.

In qualitative research, external validity is typically addressed in terms of "transferability," which poses the question of how the research findings apply to other contexts [Lincoln and Guba 1985, pp. 124–125]. The present analysis associates with the critical realist position [Bhaskar 2008], in which the possibility of transferable and modifiable (not universal) objectifications are assumed. Thus, within a similar educational context, it is likely that the same or similar analytical themes emerge. A regional aspect, in particular prevailing education system characteristics, provide a useful example of a "context," as our interviews incorporated discussions on the education system and perceptions of it. If the context changes, it is to be expected that new or different categories emerge, which is explained by the differing context. With respect to our results, for instance the "system-imposed" and the "self-related" themes could emerge differently in another regional context, depending on the amount of regulation perceived by the students and their prior experiences of education, which seem to shape the students' approaches to study and self-theorizations. Transferability can be enhanced

by describing a research context and process in a sufficient detail [Lincoln and Guba 1985], which we attempted to do. We also included a brief reflection on transferability from the present authors who teach in a distributed GSE-Ed setting (Section 6.4).

With respect to our rather small study population, this study does not make a claim to be exclusive in the present context. We respond to this concern by referring to the utility of our results; the study brings to the foreground an analytic thematization that elucidates a tacit and assumed educational position, that students axiomatically gain useful learning outcomes from project-based learning. The resultant thematization informs interventions that attempt to improve students' learning possibilities, which was our argument for contribution in Section Introduction. We are referring to "validity-as-relevance," which emphasizes "the utility and empowerment of research" to advantage those studied [Altheide and Johnson 2011]. Moreover, it is worth noting that improved control over a local situation is an important attribute of rigor for an action researcher [Melrose 2001].

Qualitative data readily comprise rich accounts regardless of the low number of participants; as is exemplified by many studies (see, e.g., Redpath et al. [2013]). Autoethnographers, for instance, may develop valuable narratives from single person's accounts using memory as data. Given that our aim was content analysis in place of theory development, where theoretical sampling would have been needed to advance an emergent core category toward a saturated theory, we see our data as sufficient. A potential concern from the low number of participants is also responded to by the aspect of utility; the data collected yielded useful results.

We also note that this study principally stands as an interview study, although an additional data source was utilized. Group phenomena that are addressed in learning reports do contribute to and hinder students' being on an enabling course. These are nevertheless related to emergent group configurations and thereby merit separate studies. Attride-Stirling [2001] accordingly notes that the analysis does not necessarily cover all aspects of the data but may be limited by the research focus.

Owing to the research design, claims on the relative importance of the themes reported cannot be made and would be misleading. This is because the interviews sought to reveal aspects that students raise, and did not require equal attention to each interview probe from all participants. Moreover, the basic themes illustrated by the thematic networks emerged by the analysis, and hence were not available as questions during the interviews. We are able to use the themes for operationalization and investigate their relative importance in our future work. This study resembles approaches such as phenomenography because we describe understandings over the whole study population; interest is in qualitatively different aspects over the whole data instead of mapping categories to individuals.

6. RESULTS

We first present a thematic network that describes students' experiences of being in the education system: "Search for meaningfulness in 'foundation' education." Thereafter, we present a network that describes students' experiences of constrained opportunities for learning, which is titled "Opportunity narrowed," and a network that describes aspects that underlie positive "Transformations and success." These two networks are for many parts similar while opposites to each other. That is, a single attribute can underlie both a lost opportunity and success.

6.1. Search for meaningfulness within foundation education

We were able to characterize the students' view of being in the education system as a search for meaningfulness within a foundation education; see Figure 1. This general characterization emerged from the tension between students' unexceptional prefer-

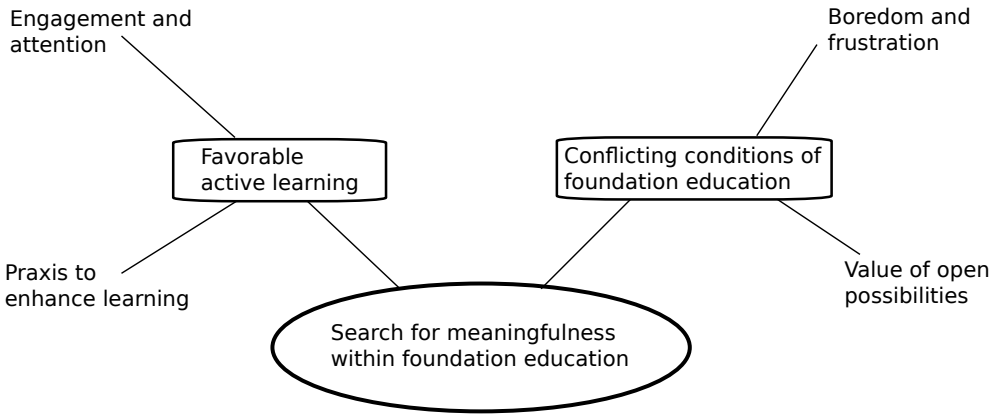

Fig. 1. Thematic network of "Searching for meaningfulness within foundation education"

ence for active learning and their conflicting feelings on a wide and general education, which they observed to exist in both the high school (schooling background) and the university. The students themselves used the term "foundation."

6.1.1. The conflicting conditions of foundation education.

Boredom and frustration. Students describe their being in high school in ways that indicate boredom with studying:

> Student-P13: *The biggest thing making being* [in the high school] *enjoyable was that you saw your friends and spent your days hanging around with them. And then maybe some interesting courses like some mathematics were interesting and made it quite enjoyable.*

The wide and general curriculum had indicated time spent ("*sitting*") on subjects that were not personally appealing, and this had caused frustrations:

> Student-P12: *I hated that studying [refers to high school] as you had so little chance to influence what you were studying.*

In connection to boredom and frustration, it is important to note that students describe how they progressed without much struggle during their schooling background:

> Student-P3: *The preliminary schools was so equalizing, I do not mean that I would be somehow super-talented, then they gave you nothing* [to study further]. [In the high school,] *you could progress with ease without applying yourself to the content.*

Concerns are also attributed to university study norms, students explaining that during lectured courses one loses attention, and that it does not even make sense to be present:

> Student-P8: *If courses are such that they can be studied independently, I would sit totally in vain there* [refers to lectures].

The students had paid attention to a general property of their university studies as well, the below quotation illustrating a negative connotation therein (cf. boredom and frustration):

> Student-P3: *It feels that everything is covered cursorily. (emphasis ours)*

Relatedly, one student saw it as acceptable that the university emphasizes theory, with the consequence that praxis is expected to occur in a self-directed manner outside formal studying. This student explicitly referred to university studies as another intermediate phase in the schooling pipeline before working life. In a sense, the student had abandoned the idea of the school as a place for meaningful praxis.

The interviewed CS students thus saw their university studies as general education over the range of topics, which seems similar to the students' view of a high school as general education over the range of subjects.

Value of open possibilities. On the other hand, students appreciate the general nature of high school education because it grants them a range of subsequent opportunities. One student seemed to pull back the experiences of frustration when reflecting on a past event of returning to high school after trying another option during the high school time. Nor does the students' use of the term "foundation" as the outcome of the university studies indicate negative connotations when the students refer to a needed element that *enables* them to perform in the field:

> Student-P12: [you develop] *a kind of a foundation, that you can then absorb things quite quickly. In my experience, learning the next thing is easier when you have come to know of some earlier things.* [refers to previously studied courses and their topics] *I have heard from my friend that during the first two weeks* [in a workplace] *you study the specific framework provided by the employer.*

6.1.2. The favorable active learning. All students interviewed articulated a preference for active learning. This preference generally shows in students' experiences of old-fashioned teaching methods in the preliminary school and the high school, and in the favorable comparisons made to more diverse teaching methods (work with assignments) at the university. Pure lecturing was deemed suitable in particular subject-specific situations, as short introductions, or when the teacher had developed an appealing/interesting mode in the classroom.

Attention and engagement. The students' wordings particularly signify attention and engagement in learning situations. They bring this up by contrasting such a condition with lectured courses where they, as reported above, lose attention and do not learn.

Praxis to enhance learning. Another significant aspect is the opportunities afforded by active learning, as illustrated below:

> Student-P11: *An exam-based course, where you go to sit and then take the exam, is really not suitable for me, the content does not impress itself on my mind during such a course. If I really want to learn something, I need to do something concrete on a course instead of mere reading and listening.*
> Student-P13: *The ones where you do the actual thing* [are useful], *where you receive that "hands-on."*

We have now reviewed a cross-cutting feature in the students' accounts. The thematic network in Figure 1 alludes to both possibilities and inherent tensions in the education system, as perceived by the students. This condition serves as context for the themes reviewed next.

6.2. Opportunity narrowed

Figure 2 displays the thematic network that indicate complicated studying on an enabling learning environment.

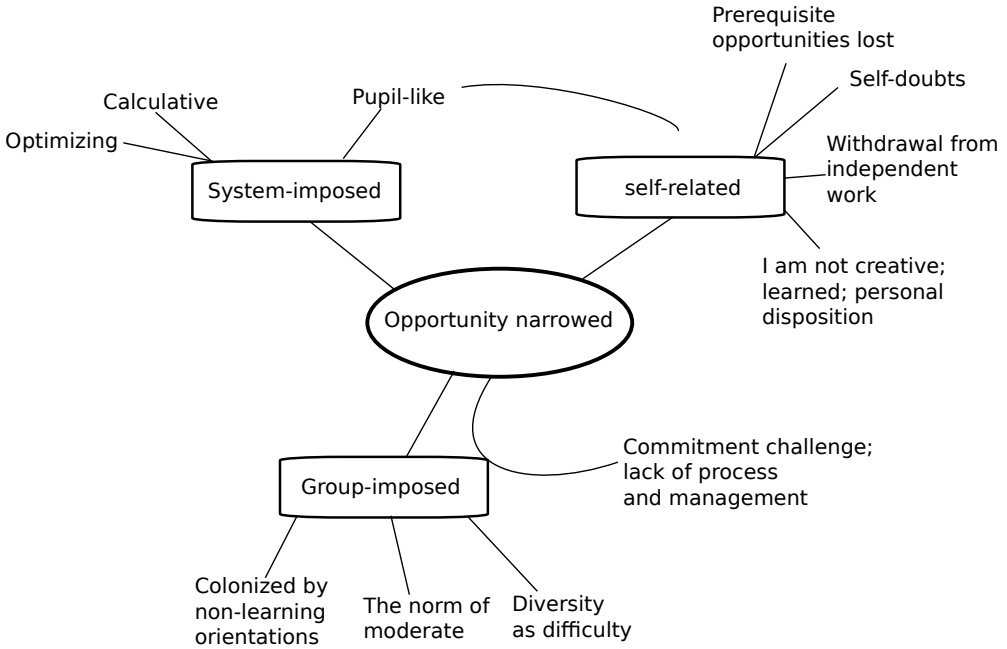

Fig. 2. Thematic network of "Opportunity narrowed"

6.2.1. System-imposed.

Calculative. National regulations on yearly credits and study allowance, and relatedly the goal of progressing on time toward graduation, give rise to a strategic study approach, which we termed (system-imposed) calculative. Then, work with a group assignment starts by observing the degree of commitment by other group members. All of the effort is targeted at receiving credits instead of learning. Such narratives also describe an aim of avoiding being "punished" for personal initiatives and investments in doing:

> Student-P4: *It is not that you are only learning, you need to get that 45 credits completed, you need to use your wits* [refers to all courses] *[...] It* [the project course] *was purely about completing the course* [instead of doing something personally meaningful] *[...] in the end, if you start pushing toward something fine, you probably, usually, suffer from that, [...] as learned from the previous courses, you are likely in trouble compared to following a happy medium. In this course, for instance, I had an idea that I have some groundwork from the previous courses* [refers to assignments] *that I can utilize and just bring something new to it. Then this course nicely flows to a completion.*

This approach to study can sympathize with lecture-based studying if presence in lectures compensates for more onerous activity. Perseverance is described as a key attribute for employability, while it becomes harnessed for navigating through the education system.

Optimizing. Behaviors resembling calculation emerge accidentally and without a feel of cynicism. We refer to such narratives with the term optimizing. An illustration is found in the narrative on the consequences of noticing early and concrete progress in the project:

> Student-P10: *The effect materialized that, in the beginning we had nothing, and then we quite quickly produced something visible [...] You are like everything is easy now, this is ready now, we have 10 weeks to go, there is not much to do, and that this was an easy course. [...] I recall the thought that other courses functioned so differently, with exact weekly deadlines, and they were running in the background at the same time [...] it is not a conscious thought that you reduce your efforts on the project, but you notice that now you have time for these others and start focusing on them.*

The student further refers to time constraints and the observation that one cannot invest unbounded time into something, crystallizing in a comment "*studying hinders learning.*"

"Pupil-like"; sustained habit. A student can possess a fixed self-theorization of oneself as a learner who willingly reproduces content and problem-solving techniques, but is troubled by the need to break out of such a comfort zone. The student can be very dutiful and seek after a position that allows for a contribution to the shared undertaking, although this contribution remains close to the comfort zone. Finding the ways to contribute causes experiences of stress and hopelessness. We call these narratives "pupil-like," as they are rooted in the descriptions of passive (reproducing) role during schooling and continued adherence to this role. On the one hand, students admit an inner desire to learn, but on the other hand, the sustained habit prevents this desire from being realized:

> Student-P6: *The beginning of the course was frustrating as I felt I cannot do anything [...] I said to the group directly that I'll appropriate* [this; anonymized] *area of the project* [close to comfort zone] *[...] This was like a lottery winning to me! [...] I'd like to know more, but I am through all the courses related to these* [technical skills], *I should then study them again...*

This quotation "I should then study them again" also refers to the challenge with prerequisite opportunities, which is illustrated by quotations from learning reports in Section 6.2.4. Moreover, the self-related themes in Section 6.2.4 were interpreted to resemble "pupil-like" described here, which explains the connection between these entities in Figure 2.

6.2.2. Group-imposed.

Colonized by non-learning orientations. Potential for constructive participation may become colonized by non-learning orientations, as illustrated with a following conceptualization: A student is initially willing to perform a project with excitement, perceiving the requirement of creativity and ill-formedness therein positively, and looking forward to learning in a new way. At the commencement of the project, the student observes that the majority of the group he or she was assigned to nevertheless shows a non-learning-oriented approach to completing the project. The student has reduced opportunities to enact her or his pre-project aspirations, and the initially constructive approach by necessity turns to that of mere survival.

> Student-P7: *I was myself in the beginning with the view of that very good course in the head, you get the chance to learn in the environment with no clear instructions on what to do. The chance to get to study in a new way. Then, the division of students into groups is accidental, and then not all have the same thinking, and you observe a lot of that thing, that we just take the credits from here. And if you are the only one in the group, it then follows that, well, this appears to be the way of being then.*

The conflict in these narratives is also obvious in what attributes students value with respect to employability: "*advances in thinking, professional skills, and willingness to learn new things.*" One student described annoyance at the views of employability in which learning ends with a formal education.

The norm of moderate. Qualitatively thinking, a much less constraining condition is the "moderate" norm where all collaboration concerns the project only and the completion of a "decent" project. In other words, a group takes care of performing decently, while its members as a whole are not hurling themselves into a lively project. An individual student may recognize that his or her opportunity for transformation is not fully exploited and be longing for a more lively group norm. In short, the lack of lively interactions is experienced as narrowing the opportunities for learning emerging from such interactions:

> Student-P2: *We did not really chatter on anything else than the project [...] We were doing the project, and the schedule and deadline came first. I made lots of questions as I learn so much by it and enjoy it. Well, I actually did not employ humor in my group that much, but did it elsewhere...* [refers to an outside-group setting; social media]

Other related examples indicate that eagerness of one student may be experienced as problematic by others willing to comply with the norm of moderate.

Diversity as difficulty. Students described that starting the project with new people who have a range of personal interests complicates the process of finding a single project topic:

> Student-P9: *Searching the topic with new people is difficult, as it is not clear that interests are shared.* [...] *It was basically good that you were given carte blanche to do things [...] becoming a group caused the biggest difficulties. There were new people, and everyone had their own visions.*

The most radical wording in the data is "*everyone is hindering each other*," originating from the case where the challenge with the ideation persisted for long. With respect to such conditions, students describe that selected project topic may simply be one deemed doable based on accidental reviews of data sets but not interesting for anyone in the group. This unfortunate process has consequences for approaches to studying:

> Student-P12: *Coming up with an idea was damn difficult. We got the idea basically by coming across with the data that enabled doing something. Our only shared thing seemed to be studying at the same department. The result* [of this difficulty] *was that everyone was only interested in getting the project completed.*

We note that the diversity challenge described here stands in contrast with the notion of industrial creativity that signifies diversity through as many interactions as possible between individuals [Bach et al. 2008]. Students' work with a customer problem (cf. a given domain to begin with) is likely to more readily lead to the appreciation of diversity; see Heikkinen and Isomöttönen [2015].

Furthermore, a related viewpoint is found in the students' commentary that a more limited starting point might have worked better—the course theme was generally the ideation and implementation of an application by utilizing open data. The reason for this call was that the more open the starting point, the more easily diverging interests cause difficulties. In this light, the students state that the highly open-ended starting point regarding the project topics slows down the project.

6.2.3. Commitment challenge; Lack of process and management. In connection to the experiences of troubled projects, students' narratives disclose how following a software process and performing project management activities did not materialize:

> Student-P9: *You cannot kind of picture the problem* [refers to the project topic ideated in the group] *because you hadn't divided that into proper tickets [...] It followed that everyone did what they did* [the tone of the voice is "whatever"].

This appears as a great practical challenge, as indicated by frequent "we should have" comments in the learning reports. Students realize the need for and the value of the software process but the issues that culminate as the lack of commitment in the group (see the various challenges in the present section) complicate their ability to put theory into practice as a group:

> Student-LR: *Now our project progressed in a way that, every time we met and worked at the school, we could work a day or two, eight hours in a row, but then longer breaks emerged, during which we did or did not do things. The work hours should have been divided more equally* [cf. commitment to project management] *so that everyone could have pictured what others had found out and where the project stands.*

This commitment challenge concerning process and management did not thematically fit well in the category of group-imposed, while it clearly links with commitment in group work; the theme is presented alone but in connection with the organizing theme of group-imposed in Figure 2.

6.2.4. Self-related.

Prerequisite opportunities lost & self-doubts. Students describe that, in prerequisite programming courses, they relied heavily on support from TAs, and these narratives link with the difficulties experienced in the project with independent work. Related to such narratives, students express strong self-doubts about their skills:

> Student-LR: *Transition from receiving full support during [previous; anonymized] courses to almost fully independent work* [the project] *was perhaps too much for me [...] I am still very unsure of my skills [...]*

Withdrawal from independent work for learning. There are also narratives that describe withdrawal from independent work. These resemble the previous theme and the "pupil-like" above, but the approach to study here additionally reflects attitudinal barriers:

> Student-LR: *In those courses, you did not need to come out of insurmountable tasks* [a favorable comparison made to highly structured and instructed courses]
> Student-LR : *I thought that the project topic should please those who I know would do the most of it.*

Here, we do not find it justifiable to refer to a "bad" attitude. We rather interpret these illustrations to be indicative of a self-efficacy challenge that has developed into a kind of an attitudinal barrier that complicates personal participation and learning when a challenge, such as ill-formed, creative assignment, is encountered. This thinking is supported by Knight and Yorke [2003] who noted that self-efficacy challenges may influence approaches to study. How the present learning environment supports self-belief [Turner 2014] merits attention.

"I am not creative". Narratives on creativity as a challenge vary greatly. Creativity is described as a challenge, the origins of which are unclear, while it is also attributed to the lack of experience with the references being made to prevailing study conditions in the schools and the university:

> Student-P5: *I lack creativity. [...] it is very difficult for me to come up with ideas by myself, when you do not have that given task. I don't know why.* [probing on the previous study conditions:] *it was so regulated, your received instructions on everything. You did not envision yourself.*
> Student-P6: *Somehow I have learned that my creativity equals to zero.*
> Student-P7: *I have that concern that do I come up with anything. The mainstream is that you receive instructions on what to do and creativity does not develop therein. It should be a bigger theme in the curriculum.*

In some of these narratives, the challenge is accepted and looked forward to, which seems to occur in connection to the narratives on attitude (Section 6.3.4). Other narratives rather indicate a huge relief due to someone else coming up with a project idea in the group:

> Student-P5: *It was nice* [the project course] *because one of the group members had an idea prepared. It helped a lot. [...] It would have been a worse situation, if I had had to make decisions. It was a relief that the idea came from someone else.*

Such narratives also indicate willing withdrawals from creative action and in our interpretations link with "pupil-like" (Section 6.2.1) and the pre-learning experiences that had not developed agency (Section 6.2.4). At times they also show the attitudinal challenges reported above.

6.3. Transformations & success

A thematic network titled "Transformations and success" is displayed in Figure 3. The organizing and basic themes are reviewed below.

6.3.1. Autonomy and motivation.

Self-paced. Students describe the autonomy of the project course by contrasting it to other courses where "*you have to submit the first working solution.*" The continuous submissions and the risk of falling behind by a couple of loose days are described as a cause of stress.[6] They are referring to the more self-paced study offered by the project course, and in this connection to internal motivation.

Self-selected. The other ways in which autonomy (or self-direction) plays a role in students' experiences concerns self-ideated projects and the possibility to self-select technologies and techniques. Students link these aspects with realistic work, which make them favor the course. Such realism contributes to having a learning orientation (cf. motivation), and so regardless of the personal difficulties with self-regulation.

> Student-P11: *I liked the fact that you were not given everything. Only a fraction of our courses are like that. You were granted the opportunity to form your ways of doing and select languages [...] it was one of the best courses.*
> Student-P2: *I tend to prefer courses with clear small deadlines. Here, it helped that the whole thing started from ourselves. It was easier to keep this work on the top of the list* [refers to personal todo items].

[6] Here we interpreted a potential reason for why the calculative approaches emerge (Section 6.2.1).

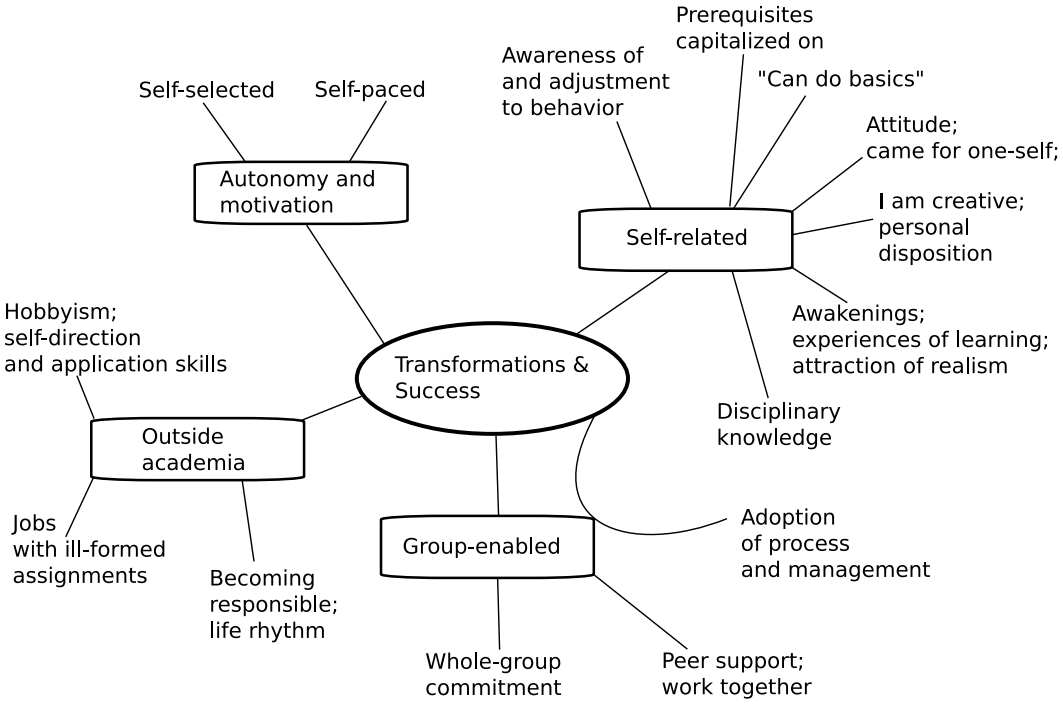

Fig. 3. Thematic network of "Transformations and success"

These narratives on autonomy and motivation link with the theme "Awakenings" (Section 6.3.4); Students' seem to awake to the meaningfulness of the disciplinary, realistic (cf. autonomous) work.

6.3.2. Outside academia.

Becoming responsible. An illustration of this theme below relates to increased regularity in daily life due to a responsible position:

> Student-P1: *It was quite funny that, I now have a dog, before that it* [refers to discussion on working according to schedules] *was more difficult, now I have received schedules for mornings and evenings, and I notice that I spend time outside more [...] I have better managed the school things.*

Hobbyism. This theme is illustrated by the case where a student had a CS guru as a friend in their youth, which developed self-direction to resolve computer-related questions. The student recalls being a computer support for relatives.

Jobs. Previous job experiences with ill-formed situations and the expectation of independent work therein are also mentioned as factors that contributed to work on the project.

Importance of skills developed outside academia is evident in how students possessing them (skill of application) express over the lack of application skill on the part of others:

> Student-P3: *How can you ideate new things and start from scratch when you cannot even apply the skills already studied during the previous courses*

Such critical remarks, we argue, deserve attention in light of Section 6.1.

6.3.3. Group-enabled.

Whole-group commitment. Narratives referring to successful projects and favoring the project course experience comprise mentions of whole-group commitment.

> Student-P11: *Regardless of how difficult problem you encounter, if you have a good group, everyone thinking that they are in the same trouble, you will find the ways out.*

Furthermore, the whole-group commitment is characterized by the students' use of locutions such as "*busy atmosphere* [in a positive tone]" and *"feeling of joyful work"*.

Peer support. Peer support engenders positive narratives, as it has helped individuals make progress from initially challenging situations as to their view of their own skills:

> Student-LR: *My role was influenced by my low skill level. I am very happy about the fact that others in the group actively and patiently taught me and involved me in the project. In the end of the project, I already dared to express my opinions.*

Adoption of process and management. Students discussing how the open-ended assignment of the course could be managed state that they were able to obey a software process and manage tasks and their division. These comments particularly emerge in conjunction with the narratives of the "whole-group commitment." We thereby state this theme under "Group enabled" although the point is also the ability to apply disciplinary skills (understandings about software process).

6.3.4. Self-related.

Awareness of and adjustment to behavior. These narratives originate in the students' transitions to the university. Along with this transition, they had observed differences and difficulties in studying, and the requirement of independent study in the university. They describe this awareness and adjustments to behavior. Although this narrative reflects attitude, we emphasize students' awareness of learning behaviors here (cf. meta-cognition or self-regulation):

> Student-P10: *There is the challenge that you keep staying at home* [when entering the university that allows for a lot of freedom], *this* [being in the university] *is a lot about learning to learn.*
> Student-P9: *The courses were that easy* [in the high school] *that you did not need to do much. My first* [university] *year was that I did 30 credits. During the second, I received 110 credits. The first year was spent on familiarization with studying here.*

Prerequisites capitalized on; "can do basics". These narratives indicate that students who had taken care of their own learning so far are able to, instead of being stuck in self-doubts, articulate about and build on their knowledge and skills and self-direction:

> Student-P1: *I know I have a of lot things to learn, although I know that I can do basics and am able to do Googling. If I hadn't this basic level, it might be a pretty nasty idea to start from scratch* [refers to the open starting point encountered in the project].

Attitude. Experiences of lack of skills and initial self-doubts do not necessarily lead to backing up from independent participation. As we interpreted, attitude toward learning can lead to constructive behaviors:

> Student-LR: *My skill level was remarkably lower compared to others in the group, which obliged and inspired me to study and find out about things I did not know about.*

Students also describe long-standing attitudes towards learning:

> Student-P2: *I hoped that I entered the university to be a life-long learner*
> Student-P3: *I came for myself* [to this course] *[...] and wanted to make good use of the opportunity.*

The narratives of this kind link with other narratives such as enjoying autonomy and overcoming dependences on instruction and externally set structures.

"I am creative". The present section (Transformations and success) indicates aspects that facilitate encounters with creativity. There are also explicit statements about creativity, and these refer to a personal disposition rather than a learned or habitual practice.

> Student-P10: *I have that facility to come up with ideas of how things could be improved or why certain things do not exist yet.* (emphasis ours)

The student described that the project course provided a forum to bring this facility to the foreground and exercise it.

Awakenings. By this theme, we emphasize transformations arising from the encounters with an enabling learning environment. For instance, students might be heavily constrained due to a paucity of experiences of ideating (cf. creativity), while wording about personally important transformations ("awakenings") in this regard:

> Student-P9: *The only thing addressed during the course, in which I did not really develop myself, was ideating. Our group had severe difficulties with ideating, which can be seen in the outcome. [...] Many courses do not at all require student ideation, which is a bit negative thing. We have learned to work on predefined topics or problems, which is likely to cause passivity and makes ideating painful. You do not learn to ideate just like that but, encouraged by this course, I started to think over this matter more closely and will work on the matter somehow in the future.*

Disciplinary knowledge. This theme conveys that students' understanding of software development (that is, disciplinary knowledge) can contribute to how they are able to cope with ill-formedness. To illustrate, when discussing the absence of a teacher- or customer-set targets in the course, and difficulties that this arrangement might cause, one student responded that "*it* [the software product] *is not ready today.*" The student was signaling that (s)he did not experience stress from ill-formedness in this sense, making a point that the life cycles of software products continue over development periods such as the 12-week course that was referred to (cf. refactoring and maintenance).

6.4. Reflections on transferability

The present authors (Uppsala) teach in a multi-site GSE-Ed setting in which student teams from two global regions collaborate [Laxer et al. 2009]. In light of the transferability of the results, their reflections on the resulting themes read as follows: It is especially the two latter thematic networks that are relevant to reflect on (Figures 2 and 3). The GSE-Ed setting in Uppsala shares many of the learning objectives described for the present target course, such as preparing students for working on open-ended

problems and developing an attitude suitable for becoming a professional with a holistic mindset (cf. self- reliance). Fuller descriptions of the Uppsala course setting can be obtained in the study by Daniels et al. [2010].

The "Opportunity narrowed" thematic network can in many ways be seen as the reason behind the most of the pedagogical interventions that have been added to the Uppsala course setting over the years. Perhaps the most prominent one being the inclusion of learning agreements based on a set of professional competencies [Clear et al. 2016]. One of the nine competencies students are prompted to choose to focus on is "Thinking skill," which is closely related to the ideating concept (cf. creativity) in the present study, and students have expressed similar concerns regarding this as those in Figure 2. One student said that it was impossible to change his disposition as being non-creative, but after some discussions actually chose this skill to be among the three to focus on. Another pedagogical approach is the use of reflections, which was introduced to shed light on some of the obstacles mentioned. It is perhaps especially the commitment challenge that is in focus for the early reflections where students are asked to identify potential threats to their collaboration in a project, and explicitly state what they themselves can do to reduce the risk. Final individual reflections and accompanying meetings often show that opportunities were still narrowed due to the components depicted in Figure 2.

This Uppsala's project course is given at the master level, and it is clear that the student cohorts, which include students from a wide set of previous educational institutions, are ill-prepared to deal with autonomy (cf. self-related challenges in the present analysis). An example of this is a student explaining why (s)he has not done a certain thing by not having been explicitly prompted to do so in the learning management system. More encouraging is to note that many observations and comments about the course are related to the items in the "Transformations and success" thematic network. Students with a broader background and/or having encountered aspects of openness in earlier courses are those that tend to be describing their learning experience in terms that fit with the items in Figure 3. A typical expression is the appreciation of the authenticity of the educational setting, where reflections similar to those captured as awakenings and a sense of responsibility are common.

7. DISCUSSION

Computing educators would arguably like to prepare students for the complex environment of global software engineering through the promise of the flagship teaching method that is constantly utilized to fill the gap between university and working life—project-based learning. Using inductive thematic network analysis, the present study reported on the students' position on studying in an "enabling" learning environment. The context is a particular project-based course that emphasizes creativity, open-endedness, and ill-formedness as its starting point. The answer to our title question (namely 'can students capitalize on enabling learning environments?') are the inductively derived result themes, a student perspective that can inform interventions and curriculum design with the goal of improving conditions for complex learning. In what follows, the reader is advised to refer back to the explanations in the results section.

We begin from the network titled "Searching for meaningfulness within foundation education," and notice that the students' "foundation" characterization of their education outcome differs from "adaptation" in the literature on employability: the students did not principally portray that they are developing adaptation but that they are receiving a foundation that facilitates their subsequent work in more specific contexts. Although this characterization is not problematic per se, it may be indicative of a piecemeal CS curriculum and of why students tend to consider holistic project work

to be more realistic than their previous courses regardless that many courses incorporate praxis; for instance P11 who valued the chance to work with a problem that was not ready-made (Section 6.3.1) further explained that "[...] I took this course because I wanted to push myself toward working life, as I knew here you were allowed to apply your skills (which is rare in our courses)." The student similary valued that they were assigned to teacher-selected (newly-formed) groups and noted the experienced correspondence between such arrangement and working life. In our thinking, the experiences of a wide and general education are likely to induce the foundation terminology in place of some other. Using the explicit locutions "adaptation," "application," and "attitude," which are emphasized in the employability literature (see Section 2), might help improve project course students' recognition of the competences they are developing. This is the first intervention we propose.

The thematic network titled "Opportunity narrowed" comprises aspects that complicate employer expectations regarding employability. Hernández-March et al. [2009] foregrounded "willingness to learn" as such an expectation. We are rather able to interpret that the opportunities for complex learning were confounded by the system-imposed themes "Calculative" and "Pupil-like," and by all self-related themes, which were "Prerequisite opportunities lost", "Self-doubts", "Withdrawal from independent work," and "I am not creative." We are cautious to assign attitudinal concerns to these categories because the students' characterizations of their prior educational experiences and reference to the regulation by the education system suggest that the education system itself complicates the educational outcomes demonstrated in the employability literature. Here, the categories Prerequisite opportunities lost and Self-doubts stand in direct opposition to self-belief, which Turner [2014] stressed as an important employability attribute to be fostered during education. The condition titled "Optimizing," where students are compelled to alternate their attention between several parallel courses, was experienced as a hindrance to persevering work with the project; hence, complex learning in an enabling learning environment. Knight and Yorke [2003] stated that employability requires complex learning, while Atkins [1999] noted that considerations on cost-effectiveness constrain the incorporation of complex learning into curricula.

"Norm of moderate" (Section 6.2.2) instead refers to a rather accidental learning condition that could be addressed by an intervention explaining that an emergent group norm has consequences on group performance [Brown 1988], encouraging self-regulation in groups in this respect. This condition could thereby be refocused as a useful learning item concerning interpersonal skills. Although named as a considerable obstacle by students, "Diversity as difficulty" is similarly a useful learning challenge, and a relevant aspect of global software engineering in which cultural diversity needs to be coped with [Conchúir et al. 2009]. The grouping strategy where students begin their group work with new people, together with the assignment that necessitates creativity, seems to usefully create a diversity-related learning opportunity. In short, students must compromise between differing personal interests and intentions when deciding on a project topic. Scaffolding focusing on the students' ability to be creative in newly formed groups is needed to turn Diversity as difficulty to an opportunity; this stance aligns well with the results of an empirical study in which GSE professionals viewed cultural diversity as an issue that can be turned into a strength [Deshpande et al. 2010]. Students should be explicitly told that creativity is an attribute that can be exercised and developed, as is proposed by research; see Kazerounian and Foley [2007] and the references therein. At the same time, students are prepared for global software development where creativity may be an important part of internationalization competences [Holtkamp et al. 2015].

We now turn to the network titled "Transformations and success." The theme "Outside academia" confirms the view of learning for employability reviewed by Knight and Yorke [2003]. They referred to activity systems [Trowler and Knight 2000] and communities of practice [Wenger 1998] in noting that learning occurs not only through instruction but also in day-to-day surroundings. The "Self-related" themes in this network indicate a position to one's own learning that is not fixed in a constraining sense ("I am like this") but underlines care for one's own growth. The categorization of self-theorizations by Knight and Yorke [2003] defines this position as one allowing for a plausible claim for employability. The theme "Autonomy and motivation',' together with "Awakenings," speak for the possibility to promote a deep approach to study through an enabling learning environment.

With respect to the two above-reviewed networks that are in many ways counterpoints to each other, a critical but potentially useful intervention at the beginning of university studies could be implemented by asking student cohorts to review analytic categories that illustrate study situations, such as the ones reported here. This might, at least, increase students' awareness of the positions to studying, meaning that the positions taken are informed. Such discussions should be overseen by capable teachers to take into account differences in actual and perceived skill and self-regulation levels, and issues such as school-related stress tolerances. The intervention should encourage students to explore their educational experiences and approaches to study instead of scaring them at the point of their transition to the university, which is known to represent a vulnerable phase in early adulthood [Dyson and Renk 2006; Leese 2010]. The constraining positions (calculative, pupil-like, and self-related) were decribed as rather established positions, indicating that interventions should also occur at the beginning of individual courses. To warrant positive transformations from "enabling" learning environments, curriculum design needs to holistically employ lenses such as the development of student autonomy. In our data, students themselves pronounced this call: *"this* [ideation; cf. students' autonomous position] *should be a bigger theme in the curriculum."*

Again echoing Atkins [1999], we note that academics may nevertheless think that increasing counseling-tinged actions narrows opportunities to address core disciplinary content, and hence risks, subject-specific learning. We argue that this difficulty is particularly relevant with respect to the CS curriculum, which is continuously "filled." To develop an example, we have our recent and justifiable necessities such as computer security and Internet of things that are likely to colonize curriculum debates "before" or "in place of" autonomy, self-belief, adaptation, and creativity (etc.). Granting opportunities for complex learning and understanding that less may be more seem nevertheless important based on our analysis—in our data, the student conceptualization that "*studying hinders learning*" underlines this viewpoint.

Next, we discuss group work and software process in reference to both "Opportunity narrowed" and "Transformations and success." Group work remains a controversial construct in our data. We can confirm that at best it makes learning flourish through "Whole-group commitment," while it can also account for narrowed opportunities; see "Colonized by non-learning orientations." Our results encourage an intervention where students are prompted to discuss group-imposed narrowed opportunities at the time of project commencement. Conversely, sufficient commitment needed from all group members should be highlighted as a conditioning factor that allows for and amplifies experiences of professional development. The present study did not specifically investigate group work, while it is a plausible claim that all basic themes under "Opportunity narrowed" are challenging regarding the development of interpersonal skills emphasized in the literature on employability [Hernández-March et al. 2009] and global software engineering education [Beecham et al. 2017b]. Of these, Norm of moderate,

Diversity as difficulty, and Commitment related to software process are rather natural learning challenges. The remaining appear more deep-rooted, and call for the self-exploration interventions suggested above.

Students' references to software process and project management suggest that ability to *apply* these project skills facilitates their progress when confronted with an ill-formed situation. For instance, the challenge highlighted in global software engineering, "reduced informal contact can lead to lack of critical task awareness" [Conchúir et al. 2009], is frequently encountered and continuously resolved in the target course. Frequent mentions in the learning reports data, which was only little utilized in the present research, nevertheless indicate that the cruciality of these skills is often understood only after experiencing lack of them and the ensuing difficulties. On the one hand, this indicates useful experiential learning and preparation for GSE settings. On the other hand, to scaffold, incessant support for application is needed; Previous research suggests that coaching students in this sense may be a crucial determinant of a successful project [Isomöttönen 2011].

To inform future research, we mention two theories that seem explanatory. The first is the self-determination theory [Ryan and Deci 2000], according to which experiences of autonomy, competence, and relatedness contribute to internal motivation. Noll et al. [2017] studied autonomy in GSE teams who had started to use Scrum, and concluded that increased autonomy alone may not result in higher motivation. They also proposed a research hypothesis that autonomy can be de-motivating without sufficient competence. Such conclusions may be reflected in the network of "Opportunity narrowed." On the other hand, rather clear wordings on autonomy and motivation, attributed to self-selected and -paced studying, surfaced in the interviews; see the interview illustration in Appendix A. Students compared autonomous coursework with other settings where studying was governed (structured courses), and recognized motivating effects of autonomy. It is noteworthy that some students expressed that governed learning causes stress, as one has to constantly adjust to prescribed schedules and deadlines. These differing aspects should be studied in detail in the future because the present study was not operationalized for studying motivation; an interesting question is if the opposite effects of autonomy exist side by side in studying. The second theory, a kind of a backfire here, is transformative learning: scholars have raised previous experiences as a trap preventing transformation [Boud et al. 1993, pp. 79, 127]. This seems obvious in the light of "Self-doubts," "Withdrawal from independent work," and how students described themselves with respect to creativity (see Section 6.2.4). Reflecting these two theoretical positions, future research should operationalize the present themes (in Figures 2 and 3) into a survey and study their relative importance. Moreover, the basic themes in the networks should be traced for deeper insights; it would be interesting to know what kinds of specific events in the learners' past bring about either troubling or fruitful approaches to study.

The reported student perspective and discussion above identifies the need for early while gradual introduction of attributes that prepare students for complexities of GSE. Beecham et al. [2017b] accordingly suggested that "sequencing student capability development" is needed. The present study further defines that this gradual development is likely to require study advice and holistic curriculum design. This is supported by reflections from a GSE-Ed context in Section 6.4, where teachers implementing GSE-Ed noted that challenges depicted in the present analysis tend to remain regardless of scaffolding during an individual course. In this connection, it should be noted that the unfortunate patterns reported do not imply that project-based learning here or elsewhere is now empty of growth stories and accolades from students. This study rather speaks for enabling projects. Its analyses hint that normative academic study conditions may not develop important employability attributes and can constrain students'

opportunities to benefit from such environments, by habituating them to a passive learner role. Our study, then, reflects our final argument that patterned constraints observed on enabling learning environments must be indefatigably revealed to identify crucial targets for interventions and scaffolding therein—to continue the important march of project-based courses for the benefit of students.

APPENDIX

A. INTERVIEW ILLUSTRATION

The interview themes and planned probes. Discussion was allowed to evolve into viewpoints relevant to the interviewee.

- *Learner background*
  - What kind of learning environments have you participated in?
  - Describe your schooling background?
  - How did you experience them? Preferences? Dislikes?
- *The project learning environment*
  - How did you experience the project course, in particular its open-ended/ill-formed/creativity assignment, and the active role and responsibility required?
  - Was it easy/difficult to adjust to it? Describe you feelings during the project?
  - Learning or performing for credits?
  - (conversation on open-endedness was additionally facilitated by questions on guidance: was there enough guidance?, how did you receive it?)
- *Purpose of HE*
  - What is the purpose of higher education (for you personally)?
  - What do you expect to gain from higher education?

A shortened illustration of how conversation evolved is given below, showing how self-selected and -paced coursework (cf. autonomy) was linked with motivation.

`[...Introduction of the interview purpose...]`
`Interviewer:` *Well this course you attended was rather open-ended in nature. But I am first interested in hearing what kinds of courses you might have preferred during your earlier studies. How do you see them, also thinking back the time in school, was your path through the preliminary school and the high school by the way?* [...]
`Respondent:` *Hmm, well, I think I have a preference for rather structured courses* [...elaboration on structured courses..]
`Interviewer, probing for explanation:` *So why.., you are raising the structured format, why do you think you like it, does it help somehow or how would you explain this?*
`Respondent:` *It is so that the way I study is against deadlines* [...description of this study style in the university...]
`Interviewer, probing for analysis of study style during the high school:` *If you compare this to your high school time, did you study in this way already then?* [...]
`Respondent:` *It was like, concerning the topics I was interested, I might for instance read about them in school books just out of my personal interest, but concerning the other stuff*, [names couple of examples], *if there was homework for tomorrow, I worked during the night before in the way I could...*
`Interviewer:` *Quite interesting*
`[...more probing on university studies, if the same thinking applies to the university...]`
`Respondent:` *Well, now that I think the courses in the beginning* [of the university], *I might nevertheless say that I liked the courses which you could study whenever you*

wanted to [names couple of examples]
The respondent so far explained a kind of a concurrent preference for structured courses and enjoyment out of autonomy where the student had a say on what and how to study.
Interviewer: *Is there some kind of conflict going on here, can you specify this, that you now refer to freedom* [in studying]
Respondent: *Maybe it is so that you don't get that stress [refers to scheduled, structured courses], it is that you have that incentive that now I work on this, you work on it to the extent you prefer, and exactly according to your own pace* [...]
[...discussion on project start and the intial feelings...]
Interviewer, probing regarding openness in the project in the light of the conversation so far: *If you now think of this project course as a whole, was is difficult or easy, I mean the active role required, with hardly any instructed targets set by the course?*
Respondent: *It helped a lot that the thing* [the project] *was initiated by ourselves* [by the group], *and it was in that sense interesting, it was not that fully dictated* [manner] *from the above*, [such as] *you need to do this and this* [...]
Interviewer: *hmm, would motivation be a wrong word to capture what you are referring to?*
Respondent: *No, it would be the right word. It was notably motivating, we found that* [project] *topic through collaboration in the group*
[...respondent continues insightful analysis of group collaboration, i.e., that the experience of self-selected project and the resulting motivation concerned the respondent because the project topic was developed through collaboration...]

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