

Globalizing Software Development in the Local Classroom

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Abstract

Given the requirement for software engineering graduates to operate in Global Software Development (GSD) environments, educators need to develop teaching methods to enhance and instill GSD knowledge in their students. In this paper, we discuss two projects that provided students with a first-hand learning experience of working within GSD teams. One project was with Siemens Corporate Research, whose focus was to shadow the development of a real-life GSD project. The second project, whose focus was virtual team software testing, was carried out in collaboration with Ball State University. In parallel with these projects we undertook qualitative research during which we analyzed students' own written reflections and face-to-face interviews that focused on their learning experiences in these contexts. We identified three specific forms of learning which had taken place: pedagogical, pragmatic and the acquisition of specific globally distributed knowledge. Our findings confirm that mimicking real work settings has educational benefits for problem-based learning environments.

1. Global software development

The number of organizations employing GSD strategies continues to increase [1]. In some GSD teams, project tasks are divided and distributed as separate jobs. In others, virtual teams are created where team members are located in more than one geographically distributed location. Thus, managing GSD teams is not a straightforward endeavour. Distance introduces barriers and complexity which directly impacts the team's management and operation. However, other related factors also come into play. Coordination, visibility, communication, control and cooperation are all negatively impacted by distance and if their impact is not identified and correctly managed, they can produce further barriers and complexity within a project (see Figure 1).

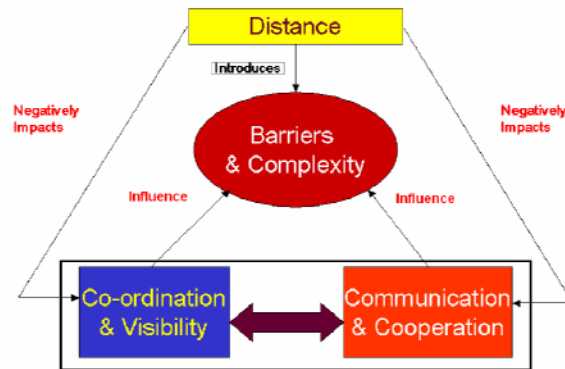


Figure 1. Factors in Virtual Development [5]

Some of the difficulties encountered include the problems of understanding requirements and the testing of systems [2]. These difficulties are compounded by cultural and language differences, lack of communication, distance from the customer, different process maturity levels, testing tools, standards, technical ability and experience. These issues are further exasperated by the lack of trust among teams. Trust is important for software development teams to work together successfully, and it is harder to establish trust within virtual teams than it is with local teams [3]. This arises from the fact that face-to-face and informal communication methods that can build trust are generally not present in distributed teams [4]. Moreover, established trust gained from co-located experiences can deteriorate over time in distributed settings [5]. To address these substantial issues with a view to implementing a successful GSD strategy, traditional co-located project management must change.

The consequence of the emergence of global team and organization structures within the software industry is that graduates from software engineering courses must become familiar with global software development approaches. Software engineering educators, through innovative pedagogical approaches, must provide software education that allows students to become the 'global' software engineers that are required by international industry.

2. Educating the graduate

Through research carried out by the authors [6], we have identified specific knowledge required by people working in GSD. Required knowledge and responsibilities change as individuals move from development to management positions.

2.1 Knowledge required by the Software Developer and Software Manager

When working in the global environment, language, communication protocols, knowledge of culture and process knowledge takes on a greater importance than when working in a local team. For example, languages such as English or German are often the required business language during GSD. However, many co-workers will not have these as their first language and misunderstandings can occur. Communication tools must be used correctly to benefit and not hinder projects, as their incorrect use can have a negative impact on the operation of the global team. Responses to communications need to be made in a timely manner. Otherwise, response delays can cause frustration and decreased motivation among team members [7]. Without the informal contact normally found in local teams, distributed software developers

need to develop cooperation within their team, and this can be a formidable task. Therefore, graduates must acquire the knowledge to use language and communication tools efficiently and effectively in the global development team. They must have knowledge about cultural diversity and appreciate that it can provide advantages to the GSD team.

GSD processes are typically different than local processes. GSD processes support global information flow, global reporting and the effective division of labor. Process tools are needed to manage processes such as configuration management, risk management and testing. Visibility of project activities is important, as culture can have an effect on whether overruns in project tasks are reported. To minimize difficulties, it is important that scheduled regular, timely and accurate reports submitted by all team members are made available to everyone.

2.2 Knowledge required by the Software Manager

The software manager requires specific knowledge to ensure that his/her team can work effectively. Managers are responsible for ensuring the visibility of tasks, team members, project structure and reporting structures across the global team. They are likely to be co-located with some team members, and may never meet face-to-face with all their global team. Lack of co-location requires more efficient management and clear communications. Furthermore, moving initially from a collocated team structure to a global team environment requires technology transfer and knowledge management. The GSD manager must have the knowledge be able to delegate the roles and responsibilities within the project team so that the team can work successfully together. They must recognize the variety of individual competencies and manage these competencies for the project's benefit.

Companies are not always aware of the true cost of GSD, and indeed there is no 'silver-bullet' providing them that information. Negative influences within a global team can cause decreases in productivity. Within countries, such as Ireland, which are no longer considered to have a low-cost economy, people who work on project teams can perceive the implementation of GSD as a step in the transfer of their jobs to low-cost economies in Eastern Europe and the Far East. This can, in turn, lead to an element of fear and mistrust among the project team members. The role of the GSD project manager requires them to have an understanding and knowledge of these fears and address them where possible. Maintaining a level of motivation will, in turn, facilitate the development of 'teamness' within the group. Additional risks involved in managing a global software development team are significant and need to be specifically acknowledged and addressed.

2.3 Providing GSD knowledge to the graduate

The graduate of the 21st century will be required to demonstrate knowledge which allows them to operate effectively in the global environment. As educators, we considered how our teaching methods could be developed and enhanced to instil required knowledge in our graduates. We introduced experiential learning through extending education across international boundaries, cooperating globally between educational institutions and industry. This gave the graduate an educational experience that could not be provided in locally.

The GSD team structure and process created a 'problem based learning' environment for students, the benefits of which are well documented [8] [9]. Joy [10] has recently shown the benefits of group working experiences in the context of a computer science curriculum by highlighting outcomes such as the application of knowledge, motivation, advanced cognitive competencies (or deep learning) and self direction. Furthermore, when learning from direct

and relevant experience, students' own sense about the plausibility of their learning environment becomes stronger [11] [12].

3. Global software development in the classroom

The University of Limerick (UL) delivers a Master of Science in Software Engineering degree course. Participants have previously completed a related undergraduate degree course and some have prior work experience. To maximise students' learning, we implemented two situational GSD projects. One of these projects (the Global Studio Project) was carried out in conjunction with Siemens Corporate Research (SCR), U.S.A. and ran for two years [13]. In each year, there has been one team of five people collaborating with development teams from other universities. This was managed centrally by SCR. Of these UL students, nine had no prior industrial experience. The other project was run with Ball State University (BSU), U.S.A. during one module [14]. Twelve full-time students, ten of whom had no prior industrial experience, participated. Four of these students also participated in the SCR project.

4. Research Methodology

At the University of Limerick, we collected and analysed data throughout the lifetimes of each project. Each member of the two UL/SCR project teams participated in semi-structured interviews which focused on expectations and experiences. At the time of the interview, five students had completed their dissertations and the remaining five had completed 3 months' involvement in the project. During the UL/BSU collaboration, UL students were required to maintain a log book describing their participation. They were also required, in small teams, to write a reflective analysis on the experience of being involved in a GSD testing team.

The researchers adopted a semi-structured, grounded approach to facilitate students in identifying learning-related issues in their own words. Students were guided in the provision of responses and insights by requesting particular information. These included answering questions such as: Why did you participate in the project? Were your expectations fulfilled? What did you learn? What was done well? What was done badly? What should be changed? Would you participate again? These questions were designed to assist students in summarizing their experiences and allowing the researchers to use those insights to understand the learning which had taken place. The questions also facilitated the capture and dissemination of issues important to teachers and academics planning similar interventions.

The interview notes, log books and the reflective analysis was analysed by the researchers using qualitative content analysis to identify overarching themes associated with the students' experiences of this learning intervention. Based on the review of the available data, students' insights of the educational experience emerged. While we recognize that the implementation of specific global development practices, e.g., collaboration tools such as wikis, central project management and architectural reviews, are important to global development projects, our focus within this research paper is on student learning and not on the artefacts and processes used. The processes used for the Global Studio Project can be found in [13].

5. Student insights

Our analysis of the data reveals seven categories of student insight into the learning experiences associated with the GSD project process. Each category, supported by respondent statements (presented in italics), is discussed in further detail below.

5.1 Importance and subtleties of communication and timing of contact

Insights into communication focused mainly on its inherent value, subtleties and timing. The importance of having regular and positive virtual team communication was highlighted, while students also revealed perceptions that this was difficult to achieve. We observed that the pragmatic issue of timing of communication, particularly ‘waiting’ for responses gave rise to frustrations and anxieties which affected the group and its work: *If the [local] team finds an error at 8am then it won't be until the next day that team B will tackle the error, leading to delays.* Communication conflicts and misinterpretations were also invoked by the students. Several respondents noted the importance of face-to-face contact and seemed to suggest that tone and patience are more important when communicating with remote team members: *With the teams so dispersed there was no face-to-face warming of the teams. This led to a slow start in stimulation of the participants.*

5.2 Interpersonal awareness and team dynamics

Commonly, students’ reflective statements about their project experiences highlighted the issue of interpersonal awareness and team dynamics. Students referred to issues about ‘getting to know’ the remote team members or themselves more accurately. These reflections focused on team dynamics and interpersonal awareness issues: *I started to understand the importance of group work. I have more of an understanding of different personalities – what we had to deal with – laid back or not.*

In particular, one of the respondents indicated a need to ‘get the measure’ of people in the remote locations and refers directly to ‘making up’ personalities. *[With this project] you never get a sense of what the other guys are like. We have made up a personality for [him].* This suggests the conscious ‘construction’ of individual images along with their own mistrust in their theories about other people. Theories about team functioning also emerged. Several comments from respondents suggested that they generated overall hypotheses about how teams should work, based directly on the project experiences: *Teams should be more inquisitive; when there are 5 people there are always problems of someone not there.*

5.3 The movement from incompetence and uncertainty to confidence and command over ambiguous dynamics

A developing sense of competence and confidence started to emerge as part of the GSD experience, as demonstrated by following statements: *We did not know what they meant. As we went through the course more we got to know what they meant.* This development to competence included encountering an experience of ambiguity and confusion: *Hard to pin down how code was going to work in a new system.* Insights about improving confidence also emerged, particularly when we encouraged them to think specifically about what they learned from the process. Familiarity, comfort and confidence seems to have replaced the sense of the task having been ‘daunting’. Students recognized the importance of experience and the role that it played in reinforcing and developing their learning.

5.4 Issues associated with energy and emotion: stress, isolation, commitment, morale, satisfaction and motivation

Students also suggested that they were readily able to identify ‘emotionally relevant’ aspects of the experience of working on a GSD team. The ability to signal the relevance of

difficult feelings associated with stress and isolation as well as the more positive emotions associated with commitment, morale and motivation demonstrate another dimension of self-awareness that may have developed and became enhanced over the course of the experience.

Some of the stress was linked to the time deadlines associated with the learning experience, while one respondent also highlighted that the emotional engagement with the task could be experienced as simultaneously positive and negative. In addition, responding students also seemed to demonstrate an awareness of the commitment required in order to complete the task successfully and on time: *Are you going to be in at 9 a.m. during the 3 week break? It is worth it in the end if you can do it.*

5.5 Awareness of and concern with how students present themselves as individuals and teams, and how they represent their institution

Respondents were clearly concerned with how the local student team presented itself and appeared to the remote members of the GSD teams. A concern for how they came across to their corresponding team members in the other locations emerged as something that was important to students: *We didn't want to look like a bunch of muppets and you were our supervisor. We didn't want to be seen as a failure.* Due to this attitude, they were reluctant to clarify, question, and learn in the early stages of the projects. This was only because of an internal pressure which they put on themselves and a concern regarding how they might be viewed by other stakeholders in the process. Once they had met face-to-face with a representative of the remote team, this reluctance and concern diminished significantly: *This year's team hasn't got that problem at all because the links are stronger.*

5.6 Career development advantages and practical 'real-life' experience

Students mentioned the pragmatic benefits associated with participating in the process. Many of them specifically stated that participation in the project would be helpful for their career opportunities, indicating particularly that it provided them *the edge* in an interview setting. In addition, the benefits of having been involved in an activity that reflected the real-life pressures and structures of GSD were viewed as something that was positive and beneficial.

5.7 Empowerment, locus of control and decision making

Students highlighted the struggles and issues that they encountered in the development of a more 'internal locus of control' for the work that they were doing. They highlighted key questions and problems indicating a gradual emerging of empowerment occurring over the course of the project. The worries associated with task responsibilities were indicated in the following types of statement: *I'd feel a good bit responsible; I didn't think we should go to Ita.* An emerging conviction was that the decision making related to the task ultimately lay within their own team: *We had to learn to figure things out for ourselves.* They also noted the issue of responsibility and locus of control as something that needed to be defined and clarified.

Another intangible but important aspect of learning and work performance is relevant to this issue of locus of control. Understanding levels of responsibility and empowerment influences individual and group decision making in very significant ways. In grappling with the issue of locus of control and decision making in GSD contexts, students gained a deeper level of insight about their own engagement with the tasks and processes.

6. Conclusions and observations

Through the qualitative analysis conducted, we demonstrated students' own perceptions of the learning concerns, experiences, benefits and outcomes associated with being part of a virtual GSD team.

As we have highlighted, graduates are increasingly expected to obtain knowledge for Global Software Development. Through involvement in the projects discussed, students gained the knowledge required by the global software developer. The real-life exposure to the complexities of GSD provided several benefits for participants. By providing or mimicking real-world GSD environments, students became familiar with the complexities of teamwork, different cultural or local norms, time zone issues, the co-ordination of work tasks and the divergent use of communication tools. Within this context, they learned about issues of cooperation, not vicariously, but experientially. Furthermore, it was clear from analysing student feedback, that such lessons were also incorporated into their accounts of their own learning. In addition to these generic skills associated with internationally distributed teamwork, the experiences focused also on more specific skills and competencies necessary for GSD. Participants in these projects were exposed to processes such as requirements and configuration management and were expected to continue development even with changing requirements. Global tools were implemented and used by the students. In addition, time and task management knowledge was gained through participants making regular reports to both their internal university supervisor and to the teams with whom they were working.

The experiences described in this paper provide examples of environments that foster deep learning among students of GSD. While it may have been possible to acquire the identified knowledge and insights using more conventional teaching and learning methods, we argue that the first-hand experience of real teams working together created an active, engaged learning context. Furthermore, students' own reflections on their learning confirmed that they had learned complexities and subtleties of working in a GSD team that will be likely to benefit them in many different working contexts.

In summarising the impact of the experiences, we argue that together, the seven categories of outcomes we have identified can be further categorized into three forms of learning impact: pedagogical, pragmatic and acquisition of specific GSD knowledge. The pedagogical impact is reflected in the way in which the students regularly refer to the development of competence or when they referred to the sense that they had moved from *feeling like a novice*, to *feeling like an expert*. The pragmatic impact seemed also to be a strong and motivating aspect of the learning, with practical drivers associated with regular references in the data focusing on curriculum vitae, career and perceptual impact of having participated in either of the projects. Finally, the specific GSD competency development is demonstrated through the students' accounts of their sense of accomplishment and the identification of detailed GSD related skills. Furthermore, these self reports have been confirmed through the assessment process, the achievement of related employment and through feedback from current employers. We observed a marked rise in students' levels of engagement and their orientation towards future learning and skills development.

In summary, we argue that real-life, or 'real-lifelike' learning experiences can be of particular benefit to students of GSD, and may create higher levels of self-awareness, cultural fluency and specific GSD related skill development than might otherwise be possible in more conventional learning settings. We recommend the use of such innovations and techniques

among educators and recommend that as GSD educational curricula continue to develop, such experiential opportunities are considered as a central element of effective, complex and high level learning.

7. Acknowledgements

This research was funded by Science Foundation Ireland through the Principal Investigator, B4Step project (Grant no. SFI 02/IN.I/108) and Cluster project GSD for SMEs (Grant no 03/IN3/1408C) within the University of Limerick, Ireland; by the National Science Foundation (U.S.A.) within the Software Engineering Research Center, Ball State University, Muncie, Indiana, U.S.A. (Grant no: EEC-0423930); and by Siemens Corporate Research, Princeton, New Jersey, U.S.A.

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