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The Learner Experience of Student-Led International Group Project Work in Software Engineering

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Abstract—Software development has become increasingly globalized because of technological innovation, the evolution of work and business processes, as well as prevailing educational systems and national policies [1]. This paper addresses the challenges faced when creating realistic opportunities for students to participate in team working on a globally distributed software engineering project. We examine the experience of one set of students who undertook a single semester software development project, the technical objective of which was to create a product using online collaboration tools [2]. The students involved were studying at two widely-separated universities: Robert Gordon University (RGU), UK, and the International Institute for Information Technology, Bangalore (IIIT-B), India.

A classroom-based action research approach has been used to evolve and reflect on the project [3]. Detailed student feedback was canvassed using an open-ended questionnaire. The students report favourably on acquisition of employability, collaboration and professional skills. A number of challenges remain in areas of project management, the use of collaborative technology and of scaling the project to larger classes, while retaining a manageable supervision overhead.

Keywords—*international group project; global software engineering; collaborative technology; employability; student experience*

I. INTRODUCTION

Globalization has profoundly affected economies around the world [4]. Increases in information flows and international travel [5] have resulted in major shifts in employment patterns. Current trends in the accessibility of communications technology, and the ease with which people can participate in virtual teams, means that these developments are likely to continue.

One area where these changes have been most evident is the software engineering industry [6, 7]. The trend towards globalized software production has been pioneered by software intensive high-technology businesses [1] and global software development (GSD) that involves outsourcing, offshoring and use of different distributed development models, has become the norm. This is motivated by the need to compete in a global software market, sustain productivity and respond to changing software procurement processes.

The growing impact of globalization on graduate employment patterns is not simply restricted to the field of software engineering. The widespread accessibility of information technology will also have profound effects on the way in which universities prepare students for many different professions [8]. Educating students to be able to deal with these changes in employment practices will be a major challenge for tertiary level institutions. However, while technical skill will always be an important component in graduate employability, professional bodies such as the ACM argue that universities should also promote acquisition of professional skills, and that students should be able to demonstrate these as they enter the workforce [9]. The inclusion of such competences in the learning objectives of university programmes, particularly in disciplines such as computer science, is driven by a desire to enhance student employability and one of the roles of university curricula is to reflect this by providing appropriate learning environments in which students can develop these skills.

This situation presents two main challenges for those teaching Computer Science at higher education level. Firstly, given the importance of geographically distributed software development projects within the sector, how can universities provide opportunities for students to gain first-hand experience of this type of task? Secondly, how can such project experiences be harnessed to improve employability skills in the commercial and global software engineering sector?

A full resolution of these two issues will, no doubt, require extensive investigation and analysis, given the large range of academic, social, economic and technological factors that impinge upon them. However, in this paper, we investigate two elements of the problem and present an exploration of these issues using student perception of this kind of activity to frame the discussion.

With regard to the question of how universities can provide students with opportunities for such activity, we focus on the issue of communication technology to facilitate interaction between geographically separated groups – specifically, on student perceptions of the utility of tools used to allow group work – while on the second issue of enhancing employability, we investigate student views about who perceives the activity to be beneficial.

The general setting for the investigation of these issues, is an international collaboration between the International Institute of Information Technology, Bangalore (IIIT-B), and Robert Gordon University (RGU) that allows students to participate in a globally distributed group project in which they undertake a one-semester module the aim of which is to project-manage the collaborative development of a piece of software.

The paper is structured as follows. The following section considers the background theory of the activity in the context of problem-based and project learning. We also situate the practice of the project within an agile software development process. We then discuss the broad pedagogical issues that give rise to the research questions that we wish to answer. As this is an initial study, these questions focus primarily on the "value perceptions" that students have of this type of project. We identify two key areas for subsequent investigation: a) how students perceive their interaction with the collaborative technology, and b) what they themselves believe to be valuable about this kind of collaborative project and whether they think that other stakeholder have a similar opinion.

Section IV describes the methodology used, in this case a classroom-based action research approach, as well as the instrument used to gather information. The following section then gives details of the results of this questionnaire. Wherever possible, we have attempted to take an approach that lets the student responses speak for themselves. Section VI then gives some preliminary analysis of the responses and we conclude the paper with some brief remarks about the current project and issues for further investigation in future action research iterations.

II. BACKGROUND

A. Pedagogical Approach

Problem-based learning (PBL) creates learning situations that are open-ended, self-directed and that are founded on enquiry and discovery [10]. The intention in PBL is to design an area-specific study scheme in a group setting for learners, around problems closely related to a real life scenario [11]. Such an approach helps model the ways people learn to solve problems by applying their knowledge and skills. We view project work as a form of problem-based learning. Prior to joining a professional group, project work provides an opportunity to rehearse activities without the immediate pressure of assessment. Such activities enable the learner to develop skills and construct newer understanding in a safe environment. Due to direct learner involvement, the project work attracts advantages of PBL along with opportunities for learners to follow their particular interests within the project. Further, student learners are expected to demonstrate planning skills, creativity and imagination to complete the project assignment. Motivation is achieved through the fact that learners control the direction, project scope and its solution. However, such an approach demands sensitive supervision of learners, as well as sufficient learner initiative along with analysis and evaluation of candidate solutions.

B. Agile Software Development

It is to be noted that agile development is not a methodology in itself. It is an umbrella term that describes several agile methodologies. These methodologies include Scrum, XP, Crystal, feature-driven development, and dynamic systems development methods. Moreover, lean practices have also emerged as a valuable agile methodology and have been included under the agile development umbrella.

In the project under consideration, which is outlined in next section, the scrum methodology has been adopted as a part of the student activity. Such development methods use short delivery cycles, increasing flexibility in the face of changing customer needs [12]. Scrum focuses on orchestration and management of agile development processes [13]. In addition, the scrum method advocates short, focused periods of development called 'sprints' that typically last between two and four weeks. The functional requirements for software under development are recorded, analyzed and then prioritized in the form of user stories. The user stories are brief textual, non-technical descriptions that are prioritized before the start of each sprint by a customer representative. Project team members communicate with each other during the eponymous daily scrum meeting and are responsible for the demonstration of working, tested software to the client at end of each sprint. These customer demonstrations are used to gather feedback from the client.

III. PEDAGOGICAL ISSUES SURROUNDING INTERNATIONAL GROUP PROJECTS

Since the international group project is a recent educational development, it was unlikely that the majority of students who took part in such exercises had prior experience of this type of activity. While there is obviously some degree of continuity between a conventional group project and the distributed version, there are, nevertheless significant extra challenges that may present themselves to the participants.

Problems associated with time and resource management are more acute due to the distributed nature of the team and the fact that different members work in different time zones [14]. Ways of working that appear to be settled and firmly embedded within the professional practice of one part of the group may seem less so from the perspective of others. There may be significant communications problems due to language differences. Cultural assumptions that seem innocuous to some members may be problematic to other members of the team. In general, the problems associated with social and professional interaction among group members can be exacerbated by distance and unfamiliarity.

As mentioned above, we focus on elements of two important issues when considering learner perspectives on this type of project:

A. Issues concerning Technology

Collaborative communication technologies (CT) are an indispensable element of the infrastructure needed for successful participation in any kind of geographically distributed group work. The fact that students on this module

were engaged in a software development process increased the need for appropriate collaborative tools but also meant that they were given access to a wide variety of technological solutions that have been adopted by professional software engineers faced with the same type of problems. While this situation clearly increases the range of options open to the students, it does mean that they need to decide which particular technologies are appropriate for the context in which they are working. This, in turn, requires them to understand the benefits afforded by the different collaborative technologies and to have some management system in place that allows them to make a decision on the adoption of a particular tool.

B. Employability Issues

One of the main drivers for this work is to give students an opportunity to engage in the type of activity undertaken by professional software developers since it can be reasonably argued that successful participation in a globally distributed development team should enhance the employability of the students involved. Part of this enhanced skill set comes from the experience of being familiar with the operation of the software tools used to facilitate that type of interaction in a professional environment. However, a potentially more important input is the project management aspect of the work. Being able to function effectively in the constrained working environment of a development team, being able to present information clearly and succinctly, being able to manage time and other resources efficiently, are all skills that contribute significantly to the professionalism of graduates and increase their value to potential employers. Moreover, these professional skills are refined by the need to carry out the task in a global context. As a consequence, the ability to collaborate closely and effectively with people living and working in geographically separated teams requires the student to apply previously-learned professional competences in a more sophisticated way as well as to deepen their understanding and development of new skills such as those associated with intercultural competence.

While we believe that a strong case can be made that this type of activity is advantageous to the student, this, in itself, does not mean that students automatically appreciate the range of benefits that participation brings. Nor does it mean that they understand which educational stakeholders (employers, academics, fellow students...) might also recognize these benefits. This is an important point as it has a direct impact on motivation, both for undertaking the module in the first place and for maintaining high levels of engagement throughout the project. An important task, therefore, is to determine what students think about such collaboration and ascertain whether they believe it is valued by potential employers, their student colleagues and the wider computing profession in general

IV. METHODOLOGY

A. Research Methodology

This work has adopted a classroom-based action research approach. Action research is an iterative methodology for understanding and reflecting upon practice [15, 3] that can be

used to overcome some perceived challenge or effect positive change in that practice.

The project itself has completed two main action research cycles. The first was an initial pilot, in which a small number of students from RGU undertook a software development task in collaboration with a similar number from IIIT-B as an extra-curricular, non-credit-bearing, voluntary activity associated with a software engineering module. The second iteration, on which we report here, involved six student volunteers from each institution and the task that they were asked to complete did contribute to their overall course grade. Assessment of the module involved examination of both the technical capabilities of the participants as well as their project management skills. The latter were assessed using a reflective journal which included entries made at critical points throughout the projects [16]. These journal entries were then reviewed, coded and analyzed [17]. In addition to this formal assessment activity, students were asked to complete an open-ended survey questionnaire was used to elicit feedback from participants on both the technical and project management challenges that they had faced. Ten out of the twelve student participants returned the questionnaire.

Our action research cycle comprised four phases: (1) problem identification, (2) planning, (3) action and (4) evaluation [3]. A third action research cycle commenced February 2014, and saw a broadening out of the project participation to all members of the classes undertaking the module in both institutions.

B. The Participants

For this study, two groups of six students, comprising three students from each participating institution, were used. The groups were responsible for establishing a project manager role, which was rotated through different group members during the project. Each of the groups had online meetings. Further, the decisions taken in such meetings were documented through meeting minutes. Each group was asked to produce the requirements and design documents, implemented software, testing results, and a project report. Participants forming these two groups were selected from a set of volunteers. The participant selection was made on the basis of previous experience, academic performance, individual class attendance records and communication skills (as assessed by an oral interview). Each of the participants of the groups was given an opportunity to undertake training in the agile software development process.

Interactions during group meetings were scheduled in timetabled class time as this simplified the process of arranging real-time conversations between group members. Groups were also encouraged to arrange additional meetings outside class.

An intensive two-day workshop on agile software development methods was provided to group members. This was based on a commercial short course available from RGU and so was comparable with professional instruction on this type of development methodology. The supervisory team acted as product owners using the scrum agile method. The role of the product owner is to represent the interests of the client towards the project. The product owners provided a prioritized

list of software's functional requirements. However, they did not project manage the team, as such.

Each of the teams was required to build a software application comprising an online survey environment involving mobile phone client software for asking questions collated into a server for storing survey results in a database. The quality of the final software deliverable was assessed and, together with an assessment of project management aspects of the activity, contributed to the final module grade.

C. The Questionnaire

The questionnaire used to elicit information from the participating students was made up of nine questions, the majority of which used a textbox format to request information. In addition, some initial questions used a Likert-like scale to assess familiarity with the process of group work or with aspects of collaborative technology. The questions themselves were used to investigate a number of specific issues. These consisted of the prior experience that the students had of working in groups and using collaborative technology (Q1 – Q2), the process by which the group went about setting up the collaborative project (Q3 - Q4), student perceptions of how well they used the different technologies in the project and how it contributed to the collaboration (Q5 – Q7). The penultimate question (Q8) enquired about benefits that the students thought they had gained while the final question (Q9) investigated what, in the student's opinion, would be the views of other stakeholders on the project. As this last question was considered important by the authors in order to assess possible motivational issues, it was explicitly flagged as such to the students, and fairly detailed direction was given within the statement of the question itself.

The questions asked were as follows:

- Q1. On a scale of 1 to 5, please rate the degree to which you considered yourself to have been prepared for the group work aspects of this particular module.

Please describe in a short paragraph any previous experience of group work.

- Q2. On a scale of 1 to 5, please rate your degree of familiarity with Collaborative Technology (CT), i.e. any hardware or software technology that enables you to work together across a distance.

Please describe in a short paragraph your previous experience with CT.

- Q3. What were the initial challenges you found in working in this collaboration?

- Q4. Which collaborative technology (or set of technologies) did you use in the project? How did the group make the decision about which technology to use?

- Q5. How good was the match between the requirements of your task and the capabilities of the technology you chose to support it?

- Q6. How did the technology affect the way you interacted with other members of the group? Please give examples.

- Q7. How did the technology affect the way you interacted with other members of the group?

- Q8. What benefits do you think you have gained from this exercise?

- Q9. What do you think were the aims of this module? What were your personal objectives in taking it? Has the module been successful from your own point of view? What do you think the aims of staff were when they set up the collaboration? Do think that they feel it has been successful? How do you think employers would view this kind of activity? Is there anything that could be done to improve it?

In addition to these questions, there was also some space available for general commentary.

As well as the queries themselves, some questions also carried explanatory details that notified students of possible factors they might consider when answering. For example, Q3 ("What were the initial challenges you found in working in this collaboration?") carried the subtext "*These challenges may have been operational (e.g. different time-zones...), academic (e.g. different sets of prior knowledge...), social (e.g. different cultural approaches to social interaction...) or something else.*" The clarifications were considered important because they direct the student's attention to specific aspects of the question. While this may serve to constrain possible responses, it was anticipated that this disadvantage would be mitigated by the conceptual focus that this kind of direction would give the comments. Question 4 ("Which collaborative technology (or set of technologies) did you use in the project? How did the group make the decision about which technology to use?") was clarified by the text "*What were the main factors that led to its adoption? Were there any negative aspects associated with the decision? Did you use any structured method to analyse or prioritise the various factors? Was the decision made by consensus, by majority...*". For question 5 ("How good was the match between the requirements of your task and the capabilities of the technology you chose to support it?"), students were directed to the concept of "Technology Fit" [18, 19] and suggestions on the areas of commentary were given: "*[H]ow well did it provide communication support; how did it support the structuring of the project management processes; and how did it support the development (design, coding,...) of the software objects that form the basis of the project deliverable?*".

V. RESULTS AND ANALYSIS

A. Comments about General Difficulties

The general results from the questionnaire dealt with how well the students felt they had been prepared for this module by participation in previous academic work and their use of collaborative technology. In addition to this, information was sought on the initial challenges faced when beginning the project.

Even among the small number of participants, the range of experience claimed by members of the groups varied widely with one RGU student claiming no prior experience while two IIT-B students claiming extensive experience of group work. Since the data was self-reported, the information characterised student self-perceptions rather than describing levels of experience on some objective scale. However, in general, the IIT-B students identified themselves as more experienced group workers than their RGU counterparts. The reported self-perception of familiarity with collaborative technology was similar between the two cohorts, although there was again a wide range of values within each group.

Looking specifically at problems setting up the collaboration, almost all students reported that connectivity and the difference in time zones caused considerable problems:

"Due to the fact that there was a considerable time difference between our two locations we had to take this into consideration, both when setting up meeting times and messaging one another. Furthermore, we had to aim to be on time when it came to meeting timelines due to the fact later meetings left the Bangalore students would be up later at night to attend these meetings."

and

"Time Zones: Different time zones leads to greater time requirement for the completion of the project."

While the students appeared to realise that the problem associated with the different time zones was significant, there were a number of responses that suggested that some students did not prioritize finding a suitable resolution to this problem. Adverse effects on the smooth running of the development groups were seen as a consequence of the time zone difference but some students did not appear to have an underlying appreciation that such difficulties could be mitigated by greater attention to standard project management tasks:

"The time zone difference was a real issue and we found ourselves missing out on planned meetings quite a number of times."

In addition to the problem with time zones, the wide range of prior software development experience of the participants was also identified as a cause of some difficulties:

"The challenges were different time-zones, different academic schedules, different technical backgrounds of the group members."

B. Student Perceptions of Technology Use

Most students identified Google groups and Google drive, and Skype as the dominant collaborative technologies used in the project. This was somewhat surprising as neither of these technologies were specifically designed for this type of project work.

In general, students stated that the decision-making process around technology adoption was one of seeking consensus:

"All technologies were chosen by consensus as we felt as a group that each of them represent the best way of fulfilling the needs of the team without having to pay for any services."

Nevertheless, some students reported that the views of perceived experts were given extra weight within the consensus-seeking procedure. No student indicated how conflict resolution was achieved if this process broke down irretrievably.

"These technologies were chosen by a mixture of group consent and individual expertise. For example, those of us in RGU had limited experience with PHP, but when PHP files were sent over from Bangalore, we quickly saw the value in this technology and adopted it eagerly."

Some students noticed an interesting duality between the technology preferences of the RGU and IIT-B.

"There was certain pattern on the choices made by the students on either side regarding the various technology aspect of project."

1) *Students at IIT-Bangalore were interested to explore new technologies for mobile development, while students at RGU were more interested to stick to mobile app development using android SDK, which is traditional way of doing mobile development and is also known as native mobile application development.*

2) *When it came to development of web portal and web service (backend) for the application, the scenario was just opposite to mentioned above. IITB students wanted to use traditional Java based web services but RGU students explored wide range of technologies like Java, Ruby and C# etc. to do the same.*

I think above mentioned choice of technologies can be attributed to prevailing IT trends in both the countries."

Most students included comments about technology that was initially adopted but then discarded due to difficulties with installation or lack of available time to engage with it on a professional level. A prime example of this was the web-based hosting service, GitHub. Although several students acknowledged this to be a potentially useful tool, it was found to be too problematic to set up and was discarded, first in favour of Subversion, and then, when this also proved too difficult, in favour of a low-tech solution based on Google Groups.

It is also worth noting that the students themselves noted that decisions about the lack of adoption of software were sometimes a source of problems at a later stage. In particular, one student commented that the decision not to use the backlog management software, Asana, meant that the group...

"...didn't get the chance to estimate the difficulty of new user stories, [and] didn't answer properly the 3 questions during the stand up meetings, and couldn't track our progress, our direction and our velocity."

I believe this had a very important role in this exercise and we missed it completely"

C. Student Views about Employability

In this part of the paper, we focus on two issues with regard to employability issues of the project: what skills the students think they gained by participation in this kind of activity and

what views they think other stakeholders have of such a project.

As far as the first of these questions is concerned, the majority of responses show that both the UK and Indian cohorts of students tended to recognise the software engineering achievement of the project and to view the experience of developing the software deliverable as the primary learning objective.

For example, this is a typical statement (from an RGU student):

"The objectives for this module were to finish a project following the agile methodologies. My personal objectives in taking this module were to learn more about agile methodologies."

Similarly, this is a representative response from a IIIT-B student:

"According to me there were 3 aims

- 1) Introduce Agile Methods for project execution*
- 2) Develop a survey app for android phone*
- 3) Provide glimpse of GSD*

My personal objective of taking it was to learn Android and also to get a first-hand experience of working in a project where the entire team is not physically located together."

However, in a minority of cases, some students did acknowledge that experience of the project management aspects of the module were also worthwhile. For example, one RGU student wrote:

"My personal objectives when taking this module was mainly to develop my project management skills more so than my development skills, I aimed to expose myself to the development process from start to finish, something which I feel was achieved. Furthermore, I wanted to see what it would be like to work with a team of individuals to complete a much larger project in preparation for my honours project next year."

A similar point is made by a IIIT-B student:

"Most certainly [the] aims of this module were to develop team-working skills based on Agile principles. As it was not only a local project in the class but it required to communicate with another country in different time zone the objective of this module must also have been to develop skills in a multi-cultural collaboration and working on a remote project."

With regard to views about other stakeholders, the students focussed exclusively on employers but the views expressed were positive. There was a general appreciation that experience of working in such distributed teams and of using a range of collaborative technology would make the student more attractive to potential employers and would contribute positively to their CV. This latter point is surprising since much of the industry-specific collaborative and software development technology which the students initially adopted was later dispensed with in favour of more ad-hoc solutions to the problem of collaborative software engineering.

Some examples of these types of comments were:

"Employers would definitely view this module in a positive light due to the fact that it is modelled on industry standards, if they have the opportunity to employ a graduate who has experienced working like they do in the development industry then it would most likely improve his chance of employment. In addition, this also shows that the student is able to work as part of a successful team using collaborative technologies that are common in software development."

and:

"From my point of view this module has been one of the most interesting modules I have experienced so far, I am completely happy about its outcomes and would definitely encourage anybody to take part in such a project. I am also positive any potential employee would be interested in details of this work and it definitely will be a good selling point in anybody's CV."

D. Analysis and Determination of Further Issues

Almost all students mentioned logistical difficulties when discussing problematic factors associated with the distributed nature of the group project. The main cause for concern was the difference in time zones that placed significant constraints on the way in which students were able to communicate. It is interesting to note that no student mentioned different cultural attitudes as a source of difficulty. This may have been due to the small sample size but it is worth noting that a significant proportion of the RGU students were themselves from non-UK backgrounds and so the situation encountered by the students in this was multicultural rather than strictly bi-cultural.

It was initially anticipated that the problem associated with effective communication between the separated groups would be mitigated by careful choice of technology. However, it appears that the groups decided to use a "lowest common denominator" approach. There is some evidence that this was because they thought that more advanced technologies either took too long to learn, or else were tried and found to be unreliable within the constraints of the academic environment. While there was some IT support available for those undertaking the project, this was not comparable with the levels of support that would be given to software engineers in a commercial or industrial setting. However, the reluctance to engage with some tools and to persevere with others may also be an artefact of the decision-making procedure adopted by each group. The responses clearly indicated that group decisions were made by consensus. Given the range of prior software development experience of some students within each group, it may be the case that some members were unwilling to commit themselves to using unfamiliar tools that would have a detrimental impact on individual performance within the group.

There is clear evidence from the questionnaire responses that the students saw distributed group work as beneficial to their studies and something that would enhance their own employability. Their views concerning other stakeholders concentrated on employers but were again very positive. The responses tend to indicate an focus on the fact that employers would see improved technical skills, but students did generally acknowledge that their enhancement of professional skills was

also something that would give them greater flexibility and choice when seeking employment. Besides these considerations, the students did not specifically address the issue of globalization in the responses they made to the questionnaires and there were no responses which made reference to wider, more contentious professional or ethical issues such as out-sourcing or offshoring.

Although not addressed in the context of the questionnaires, one challenge that should be considered is the issue of scaling. It is readily admitted that the class size for the project described in this paper, while sufficient to start to obtain qualitative information on is, nevertheless, quite small. Even so, it was found that the groups needed high levels of academic and IT support and this suggests that enlarging the group size may be problematic. The class at RGU typically comprises 30-40 students while the IIT-B class is around 120 students. This clearly means that it will be difficult to maintain parity of RGU and IIT-B numbers within the software development teams and this may have implications for the cohesiveness of the groups.

VI. CONCLUSIONS

The development of software products has become an increasingly globalized activity. We have found that students are enthusiastic about the benefits that a carefully structured international group project would bring to their studies. As a result, we believe there is an increasing need to incorporate this type of activity into the computing syllabus in a more systematic way. Such an exercise provides students with a valuable learning opportunity to engage with current software engineering practices as well as acquire and improve their professional skills.

This study is still in its early stages but we have identified a number of immediate issues that require further investigation. One of these is to find ways to support students to look for appropriate group decision-making processes that go beyond the straightforward seeking of naïve consensus and can more fully take into account the various levels of technical competence and prior experience with regard to technology adoption. If, as conjectured, the reason for this behaviour can be traced to individual students' reluctance to use unfamiliar tools within the group setting, this issue needs to be addressed before. Other issues surrounding technology adoption also require examination.

The project raises a number of interesting educational issues, the main one being what kind of pedagogy is most effective for this type of activity? A number of lines of enquiry are being explored in this area: Computer Supported Cooperative Working (CSCW) [20] and Computer Supported Collaborative Learning (CSCL) [21] are pedagogical approaches that have a reasonably mature research history and provide a background theory of instructional design in this area. In addition, work done on Open-Ended Groups Project framework may also be useful in this context [22, 23].

For future work, ways of scaling this type of international project to a full class is being investigated. Plans to extend the scope of the project so that it could be made available to the large number of students which take the project module at

RGU and IIT-B while maintaining an affordable supervision overhead are being considered.

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