Authentic Assessment in Software Engineering Education Based on PBL Principles
A Case Study in the Telecom Market

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Abstract—The continuous growth of the use of Information and Communication Technology in different sectors of the market calls out for software professionals with the qualifications needed to solve complex and diverse problems. Innovative teaching methodologies, such as the "Software Internship" model and PBL teaching approaches that are learner-centered and focus on bringing market reality to the learning environment, have been developed and implemented with a view to meeting this demand. However, the effectiveness of these methods cannot always be satisfactorily proved. Prompted by this, this paper proposes a model for assessing students based on real market practices while preserving the authenticity of the learning environment. To evaluate this model, a case study on skills training for software specialists for the Telecom market is discussed, and presents important results that show the applicability of the proposed model for teaching Software Engineering.

Index Terms—Assessment processes, Software Engineering Education, PBL principles.

I. INTRODUCTION

The growing and continuous presence of software in integrated products and services which are available and consumed daily by society call for the infrastructure of Information and Communications Technology (ICT) in the world to evolve continuously. In particular, in the Brazilian market, the outlook is one of likely growth given that it will hold major international events such as the World Cup in 2014 and the Olympics in 2016. Therefore, governmental plans that target expanding broadband in Brazil have created excellent opportunities for companies in the Telecom sector. Since they recognize that non-ICT companies wish to use software, they have been seeking to enhance the quality of their products and services so as to meet the demands from the non-ICT sector for improvements to in-country telecommunications networks. It is against this background that skills training for software professionals who have specialized in mastering applications that target the development of embedded software and network management with specific complexities related to communication platforms and protocols that are very rarely replicated in academic environments becomes a critical requirement if the telecommunications sector is to evolve.

As in any area that applies ICT to solve complex problems, what is needed in order to give software professionals expertise in the Telecom sector is an effective model for education that leads to technical and non-technical skills and competences being developed, grounded on practices of real projects which have complexities similar to those found in the labor market.

One such alternative form of education based on real practices for solving problems is Problem-Based Learning (PBL) [1] which has been applied in different market areas that range from the medical field, to which its origin is linked, to the areas of engineering and technology. Tynälä [2] stresses the main benefits of PBL when he defines it as an approach to teaching and student-centered learning, in which these are steeped in the practices of real projects, team-work is used to solve problems and also to foster the development of skills and attitudes, including group work, self-initiative and cooperation, and being co-responsible for one’s learning.

Despite the obvious benefits of PBL, it is important to emphasize that this approach is frequently confused with practical experiments in which students receive little support from teachers / tutors with professional experience in the area of knowledge in question and are supported by subjects which have a standard content and conventional processes for assessment based on tests and group work that is scored. However, an effective PBL methodology needs to preserve its principles by defining processes that ensure theory and practice will go hand-in-hand [3].

In [1], Savery & Duffy set out eight PBL principles and stress the need to anchor all teaching and learning process activities on a real, relevant and complex problem within a collaborative learning environment similar to the work environment. This is to enable students to develop the ability to analyze possible solutions and to reflect on the learning process. In practice, ensuring these principles are followed requires a high investment in planning for and monitoring PBL, which includes management time, effort, resources and processes and therefore they are not always strictly adhered to. For these reasons, many education programs choose to preserve some PBL principles so as to maximize positive
results based on drawing the academic world and the market closer to each other. It is important to emphasize that no matter how "pure" the application of PBL is, planning and monitoring processes are essential for evaluating its results and thus cannot be set aside even in an education program that adopts only some of its principles.

Prompted by this, this article puts forward a model for the authentic assessment of students for education programs based on PBL, which preserve, at the very least, the "real-world" characteristics of problems and of the learning environment. As a main reference, the strategy of authentic assessment set out by Herington & Herington is the basis for defining this model [4]. In authentic assessment, students are involved in learning environments in which activities are geared towards applying their knowledge, stimulating their thinking and critical insight towards solving real problems and deploying different ways of solving them. Therefore, this proposal shows itself to be totally aligned to PBL-based approaches.

This paper also sets out how to validate a model based on a real case study conducted on an education program which seeks to train professionals to develop embedded software and network management for the Telecom market.

This education program was implemented by means of a Software Internship [5], similar to a medical internship/residence, in which students learn by doing. Conducted in a partnership between an institute of technological innovation and a company that manufactures solutions and equipment for the telecommunications industry, the program was run after first of all creating a learning environment based on a Software Factory, supported by processes for developing software, designing real applications and multidirectional interactions between interns students, specialized software professionals in the role of teachers and tutors and the intensive participation of the client, represented by the company from the telecommunications industry.

II. AN AUTHENTIC ASSESSMENT MODEL

The concept of authentic assessment used as a reference for the assessment model proposed was defined by Herington & Herington in [4]. They draw attention to seven essential elements in an authentic assessment:

1. The context needs to be real, thus reflecting the conditions for assessing the students’ performance within this context;
2. Students need to participate effectively in solving problems, as doers, based on knowledge acquired while being trained;
3. Students need to devote time and effort to collaborating with others involved in solving problems;
4. The problem needs to be real, and of relevant complexity;
5. The assessment needs to be integrated with students’ activities;
6. The assessment should include multiple performance indicators;
7. The indicators need to have well-defined and reliable criteria.

These elements underscore the need for a real learning environment, focusing on problem solving based on collaborative work supported by well defined processes that cover different aspects. When these elements are taken to the software industry, it is easy to relate them to the processes that support software engineering, which are placed on top of delivery schedules and artifacts built iteratively.

Although these elements bring out the critical factors to be considered in authentic assessment, they do not indicate how this can be applied in a real learning environment, i.e. they do not describe how assessment strategies should be used.

In [6], the author discusses some important points when defining the evaluation process in PBL, highlighting the need to define who does the assessment, what the best assessment tools (oral or written) are, what the best approach (formative or summative) is and what type of indicators could be used. Based on an experiment in which teachers were trained in PBL, some conclusions emphasized the importance of all those involved in the assessment process taking part, and there being continuous feedback throughout the process, a characteristic of formative approach. In this context, the study presented in [7] reinforces the importance of formative assessments in the PBL approach, both in the assessments of groups of students, and in individual assessment. Another important aspect discussed in [8] stresses the need for alignment between the educational objectives and the evaluation process: "Assessment of PBL needs to focus on the objectives that PBL fosters in conjunction with the educational course objectives". These studies discuss relevant issues concerning the evaluation process in PBL, but none of them proposes a model that can facilitate its implementation.

In [9], the author defines assessment strategies in the context of PBL from three perspectives: Content, which is related to the knowledge acquired by the student; Process, which is related to the ability to apply the knowledge acquired to solving problems and; Output, which is related to the products generated as results. The combination of these perspectives allows an assessment process that identifies not only what the student understands with regard to the fundamentals and concepts needed to solve problems, from the perspective of content, but also provides an analysis of the process of solving the problem that includes procedures and analyzing alternatives, beyond the end solution proposed for this problem.

Additionally, for an authentic assessment, it is important to consider indicators compatible with each perspective within the learning environment built. For example, if the learning environment is represented by a software factory, on evaluating the perspective of Process, indicators related to the process of developing software used by the factory, with clear criteria related to the development methodology adopted, will certainly reflect the reality of the environment in which students are learning. From the perspective of Output, which may be associated with developing software engineering documents or software code, it is also necessary to establish indicators related to the quality of these products, such as organization and
clarity, in the case of a document, or meeting the architecture standards in the case of software code.

Although the three perspectives of Content, Process and Output assess much of the teaching and learning process in PBL, they do not take account of interpersonal characteristics developed by this approach, such as self-initiative, teamwork and leadership in guidance towards solutions. Moreover, when these assessment strategies are compared with assessment solutions adopted by the software industry, what cannot be left out is evaluation from the perspective of customer satisfaction, which is normally related to characteristics such as productivity, quality of the service and transparent communication, which once more lie outside the perspectives defined in [9]. In this context, the model for authentic assessment put forward in this paper adds two more perspectives to the assessment strategies: Performance, a subjective analysis of the students’ interpersonal characteristics; Client satisfaction, an assessment based on criteria for client satisfaction.

Once again it is important to emphasize the need to use indicators (and methods) that the market has already adopted. Various models for assessing performance have been adopted by Human Resources departments in software companies that can also be used in the context of the learning environment [10]. As to evaluating satisfaction, it is essential that indicators be defined with the effective participation of the client.

Finally, given the importance of this article setting out some guidance as to the application of assessment strategies, it is important to relate this to the main types of evaluation defined in [11]: formative and summative ones. The purpose of formative assessment is to evaluate the student’s performance throughout the problem solving process, by encouraging continuous feedback, whereas summative assessment evaluates results at the end of the stages of learning [12]. In other words, as the Handbook says [11]: “When the cook tastes the soup, that’s formative; When the guest tastes the soup, that’s summative.”

Based on these definitions, Table I shows a relationship between the perspectives of assessment and the possible type of assessment to be adopted. This relationship shows that perspectives of assessment related to Processes and Performance, resulting from continuous monitoring and feedback, are characterized as assessments of the formative type, while prospects such as output are inherently summative.

<table>
<thead>
<tr>
<th>Assessment Perspectives</th>
<th>Formative</th>
<th>Summative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Process</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Output</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Client</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

It is worth noting that the combination of types of assessment in a process of authentic assessment is a solution that reflects the assessment procedures of the labor market, which very often err as to formative assessments, due to resource constraints and the timing of projects.

However, despite the limitations inherent in real scenarios of software development, it is believed that the application of this evaluation model is suitable for any software development environment aimed at solving problems based on groups of people collaborating and cooperating with clear goals for serving and meeting the demands of real clients.

III. CASE STUDY: SOFTWARE INTERNSHIP FOR THE TELECOM MARKET

The concept of a “Software Internship", just as in Medical Internship, at bottom includes: (1) the formal teaching of relevant knowledge by a teaching entity and; (2) going deeper into practices within an area of specific knowledge, acquired directly into an environment of developing real software, in an analogous way to the hospital during Medical Internship [5].

To apply this concept, Internship in Embedded Software and for Network Management was created with the goal of training software professionals in the skills needed for jobs in companies from the Telecom industry that make infrastructure products, and covered the period from November 2011 to April 2012.

This was conducted under a partnership between C.E.S.A.R (www.cesar.org.br), a technological innovation institution, and Datacom Brazil (www.datacom.com.br), the leading Brazilian manufacturer of equipment and solutions for the telecommunications industry. Given the growth of opportunities in this market and the need to hire professionals with the skills needed for new projects, the design of this program was aimed at training specialized professionals in a short period of time whom Datacom could suitably hire. For simplicity, this program will henceforward be deemed as the "Datacom Internship”.

In order to have a better understanding of the program, this section describes the structure of training, with reference to the model proposed by Santos [13], which highlights five key elements in the PBL approach to teaching: Learning Environment, Content, Problems, Human Capital involved and Control Processes.

A. Learning Environment

The Datacom Internship used the model of a Software Factory as a practical learning environment; Datacom employees as real clients; and C.E.S.A.R as a teaching institution. It is worth pointing out that the Software Factory concept adopted is related to structured and integrated units of development, with clear roles and responsibilities, supported by well defined tools and processes, as described in [14]. Figure 1 illustrates the structure of the learning environment.

The Datacom Internship consisted of a group of 18 interns, organized into 2 groups of 9 interns: (1) Group A, whose focus was on developing embedded software for Datacom products; (2) Group B, whose focus was on developing software for managing networks in the language of Java. The interns had a technical profile, being students who had graduated from information technology courses, but who had no experience of
Datacom products and platforms, and in almost all cases, little experience in Java.

Interns were selected through a selection process that included evidence of technical skills, interviews and group dynamics.

B. Content

The program lasted for 5 months: the first month focused only on subjects taught; two months of combining practices supported by subject teaching and; the last two months focused exclusively on the practices of real projects.

The training included a set of taught subjects common to the two groups and one group of subjects specific to each group. Thus, the entire class attended the courses on Agile Project Management, Computer Networks, Datacom Products, Linux and Managing Configurations and Change. The specific subjects in Group A focused on C, C ++ and Advanced Linux, while Group B attended courses on Java and Software Testing.

It is worth pointing out that the way in which the content of the program was delivered, since it contained subjects taught which were not necessarily directly associated with solving a real problem, had a direct impact on one of the main principles of PBL, which holds that all tasks of the learning program need to be anchored on a problem. The decision taken to have this format was justified by the client's need for a "leveling" of knowledge among all the student interns in some subjects, given the specificity of the sector, within the time limits and resources of the program. Thus, the teaching approach adopted cannot be considered purely PBL, but only "based" on some of its principles.

C. Real Problems

The real problems were driven by Datacom’s wants. Each group received specific demands for software development: initially Group A received four demands for embedded software, while Group B received two demands, related to developing and testing software in Java.

The initial demands were of low complexity, and to the extent that the subjects were tutor-led, the demands gained a higher degree of difficulty as the course progressed.

D. Human Capital

To create real applications to be offered to the market on this platform, it was necessary to structure the Software Factory including a team of professionals whose skills were compatible with the goals of the training and who would interact continuously with the teams formed by the interns. Figure 2 gives the organogram of the program.

Thus, each team of interns received continuous support from a technical tutor whose skills and experience were specific to their respective group, and together they interacted continuously with two representatives from Datacom, the client, one for each group, A and B. Interns also received skills training from a group of teachers, and experts in the respective subjects of training.

To ensure the effectiveness of the teaching methodology, an Educational consultant (the first author of this article) took part in the program, by defining the teaching methodology in order to preserve its principles, within the constraints on resources, and to implement and monitor the model for authentic assessment proposed. Finally, a management team comprising an academic coordinator, who was responsible for monitoring the academic and educational program, and a project manager (the second author of this article), responsible for planning and monitoring projects and the delivery of applications, formed the Datacom Internship team.

E. Control Processes

For planning and monitoring the development of each demand, Scrum [15] agile management techniques for projects were used, thus enabling the tutors and managers involved to monitor the interns continuously.

Scrum is an empirical approach focused on people, developed for environments where requirements emerge and change quickly. The implementation of Scrum is based on defining tasks and setting priorities (Product Backlog), made with the client’s support, and grouped in development units of short duration (maximum of 4 weeks), called Sprints. The process is governed by an actor called the Scrum Master who aggregates monitoring and feedback activities. These activities are generally conducted during short daily meetings, attended by the entire team, to pinpoint and correct any shortcomings in and/or impediments to the development process [15].

The Scrum method also uses a visual board, usually divided into three columns: Backlog, Doing and Done. Each column represents the actual status of the activity. When a task is
begun, this is indicated by transferring it from the “Backlog” to the “Doing” column, and its conclusion is evidenced by moving it to the “Done” column.

One Scrum visual board was created for every demand of each team.

The use of Scrum during the Datacom Internship provided some important contributions. The presence of a product owner (the respective client), who was responsible for the application conception and its validation, saw to it that the requirements of the demands were made clearer. The Scrum Master’s role was shared between the technical tutors and the project manager, who prioritized activities, chaired the daily meetings to monitor how the demands were developing and to assess impediments. The Scrum visual board, which showed the “Backlog”, “Doing” and “Done” tasks, provided greater visibility and transparency to the flow of tasks in each demand, and identified general issues that many of them shared.

Despite the various benefits of Scrum, it worth pointing out that one of the groups of interns had some trouble keeping the Scrum framework updated and, at times, pondered using another technique for monitoring. These considerations are discussed in more detail in the section that describes how the Authentic Assessment model was applied (Section IV).

Even in the context of control processes, this internship was applied the full model proposed in Section II, and consisted of the following perspectives:

1. **Content**, based on conceptual, practical and contextual assessments used in the disciplines;
2. **Process**, based on assessments conducted in project status meetings and meetings required by the Scrum methodology;
3. **Output**, based on assessing the demands from Datacom;
4. **Performance**, based on assessing the individual performance of each interns;
5. **Client satisfaction**, based on assessing criteria defined by the clients, Datacom.

In the Content perspective, the teacher conducted the assessment, based on the content and practices discussed in his/her discipline, in the iterations with interns and in monitoring that demands were being met. This assessment used a 5-point scale of values: "excellent" (5); "very good" (4); "good" (3); "satisfactory" (2); "insufficient" (1).

From the perspective of process, this was evaluated by the technical tutors and project manager monitoring how applications were developed. This monitoring was conducted by means of meetings recommended by the Scrum methodology, in general, on a daily and weekly basis. Bearing in mind that the Scrum agile method is already rather prescriptive, the criteria for making evaluations from this perspective were defined as follows: (1) compliance with the frequency of the meetings recommended by Scrum; (2) assiduity and documenting in managing the configuration and change; (3) undertaking unit testing. Each indicator could assume a value from a simple 3-point scale of values: "Considered" (100%), "Partly considered" (50%) and "not considered" (0).

As to the perspective of Output, this focused on analyzing artifacts of the applications produced by the interns. These analyzes were conducted throughout the development process under the following criteria: adherence of the code to the architecture defined; a code within the Datacom standard for coding; a code written in accordance with good programming practices (clarity, documentation, reuse, etc.); quality of the documents (form and content); approval of the sprint (iteration of the Scrum) by the client. On tackling how documents were to be drawn up, rather than software code, the respective criterion received the value of "not applicable". Once again the same simple 3-point scale of values was used. The technical tutor of each team conducted these assessments.

From the perspective of performance, seven competencies were assessed: initiative; ease of understanding/learning, teamwork, communication, flexibility, self-development, and being results-oriented. Due to the subjectivity of this analysis, a 5-point scale of values was used in this perspective: (1) "needs to develop a lot", (2) "needs to develop", (3) "meets the need of the function", (4) "has a superior performance", (5) "is an example for the others". This assessment was conducted by the tutors and project manager and applied in the form of self-assessment, assessment of the technical leader and peer assessment.

Finally, assessing customer satisfaction was based on criteria normally used when evaluating software factories: meeting deadlines and goals; team productivity, communication and transparency; technical quality and quality of the final product. This assessment used a 5-point scale with values similar to those used for Content, "excellent" (5); "good" (4); "satisfactory" (3); "unsatisfactory" (2); "very poor" (1). It was conducted by the C.E.S.A.R’s Project Management Officer together with the clients’ representatives.

**IV. APPLYING THE AUTHENTIC ASSESSMENT MODEL**

Based on the five perspectives of authentic assessment, it was possible to evaluate the interns’ performance in different aspects. Content Assessments enabled the subjects which were of greatest difficulty for the students to be identified, whether this was due to how their content was approached, their degree of complexity or the assessment method being inappropriate. The perspectives of Process, Results and Client enabled an analysis to be made of the teams, which thus identified the groups which most matured in the development process and the applications with the greatest technical quality of their components. Finally, the evaluation of performance enabled an individual look at interpersonal skills that are, in general, developed based on PBL-based learning approaches. The following sections present some of these results.

**A. Assessment of Content**

Table II shows the overall assessment of the interns from the point of view of Content for groups A and B. The result of these evaluations was announced at the end of each course, so followed the summative approach shown in Table I.
On looking at Table II, note that the interns of both teams performed less well in the subject of Linux. Since points of improvement were identified at the start of the course and discussed with the interns, remedial and reinforcement measures were taken to minimize them. The results of these measures were proved, given the success of performance of the subject of Advanced Linux for which Group A were trained. A similar situation occurred with the subjects of more technical and complex programming languages, which also needed measures to adopt content for the interns.

Although outside the scope of this analysis, which focuses on evaluating students, it is important to point out that interns carried out evaluations on teachers (on aspects such as knowledge, experience, security and ethics) and the approach of each subject (on aspects such as the clarity of objectives, content, relevance, good references), which resulted in an average of more than 4 (Very Good). This assessment level remained high even in the subjects in which the interns performed less well.

In general, despite occasional difficulties in some disciplines, the interns' performance remained above level 3 (good), with an overall average of around 4 (Very Good), as can be seen in Table II.

### B. Assessment of Process

Figures 3 and 4 show the evolution of the assessments from the perspective of process for Groups A and B, respectively, and do so in a formative way. The frequency of these assessments was guided by the development methodology used, in the case of Scrum and, therefore, each group received an assessment for planning under this perspective at the end of each Sprint. The percentage equivalent with respect to Process was calculated by summing the values assigned to each criterion (Section III.E), divided by the number of criteria evaluated in that Sprint. Thus, if all three criteria of this aspect received a value of 100% (fully satisfied), this would result in 300% divided by three, totaling 100%. The assessments were conducted by the project manager in conjunction with the technical tutors from each team.

On analyzing the behavior of group A, described in Figure 3, some impacts on the process are seen. This group had communication problems in Sprint 1, which adversely affected its performance. An attempt to use another tool to monitor on the Web instead of using the physical Scrum framework also ended up adversely affecting the performance of this perspective in Sprint 4. The absence of Sprint Review meetings in Sprints 5 and 6, due to the team focusing on producing results, maintained this result.

As for Group B, represented by Figure 4, the team’s main difficulty was to incorporate the culture of monitoring the Scrum framework. This problem was not overcome in the first three Sprints, but did so gradually in the sprints that followed until the end of the project.

### C. Assessment of Output

The graph in Figure 5 shows the outputs improved throughout Group A’s project. Similar to the calculation in respect of Procedure, the percentage equivalent to the Result aspect was calculated by summing the values assigned to each

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**TABLE II. SUBJECTS AND TEAM AVERAGES**

<table>
<thead>
<tr>
<th>Disciplines</th>
<th>Team A Average</th>
<th>Team B Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Agile Project Management</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Datacom products</td>
<td>4.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Linux</td>
<td>3.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Configuration Management</td>
<td>3.9</td>
<td>3.9</td>
</tr>
<tr>
<td>C</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Linux (advanced)</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>OOP and C++</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>OOP and JAVA</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>JAVA (advanced)</td>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td>Software Testing</td>
<td></td>
<td>3.9</td>
</tr>
</tbody>
</table>

criterion (Section III.E), divided by the number of criteria evaluated in that Sprint. While the sprints were being carried out, it was observed that the complexity of Sprint 3 made planning difficult, which had an impact on the final result, even though its processes were correctly followed. On the other hand, in the final sprints, this approach obtained a 100% performance and even had an impact on the compliance of processes (the absence of Sprint Review meetings).

As to Group B, the perspective of Output remained highly satisfactory, the only variations being in Sprint 3 (due to the complexity of the task, as mentioned above), and thus even showed a good alignment between Processes and Output.

The results of the assessments from the perspective of Processes showed a curious aspect as to evaluating software professionals in real working environments. A problem of compliance with processes does not always represent a negative impact on the outcomes of projects and client satisfaction. After all, the processes are there to achieve good results and high satisfaction, and if at some point they impede what is taking place, this is because they need to be reevaluated and modified. This observation is evident when evaluating the two perspectives, Process and Output, together.

D. Assessment of Performance

Due to restrictions of time and effort, the assessment from the perspective of Performance was performed only once in this program, in mid-March, at which point the teams were already producing at a stable rate.

On analysing Table III, which shows the average of the teams for each aspect assessed, it is seen that the interns demonstrated a good performance in all aspects, as they reach a point in the scale higher than 3, indicating, at the least, that the competence developed met the requirements of its function. This evaluation also pointed up the strengths of each group, with respect to more subjective criteria. Group A was outstanding in the competence of "self-development" and "being easy to understand", while Group B showed themselves to be more "flexible" with greater competence in "teamwork" and "self-initiative".

### TABLE III. TYPES OF PERFORMANCE AND TEAM AVERAGES

<table>
<thead>
<tr>
<th>Performance</th>
<th>Average Time A</th>
<th>Average Time B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiative</td>
<td>3.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Easy to understand</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Team work</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Communication</td>
<td>3.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Flexibility</td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Self-development</td>
<td>4.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Results-oriented</td>
<td>3.2</td>
<td>3.5</td>
</tr>
</tbody>
</table>


Note that these features are well aligned to the demands of each group. Group A, charged with developing embedded software, needed to be more investigative and geared to discovering solutions, while Group B, charged with developing Java software and testing, needed to be more collaborative and adaptable.

It is important to point out that this evaluation has an individual character, which is not recorded in Table III for reasons of confidentiality, feedback being carried out personally with each intern. In this context, two interns, one from each team, showed that they had developed greatly with regard to aspects of performance. One of them obtained performance 5 ("is an example to others") in all aspects. Therefore, this type of evaluation still tends to emphasize the character of student leadership within group activities.

E. Assessment of Client Satisfaction

From the perspective of client satisfaction, two rounds of summative assessment of character were held, one at the beginning of the practical activities, and the other at the end of the Program. Table IV summarizes the results achieved by the two groups, A and B.

### TABLE IV. CLIENT SATISFACTION AND ASSESSMENTS OF THE GROUPS

<table>
<thead>
<tr>
<th>Client Satisfaction</th>
<th>1st Assessment</th>
<th>2nd Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Group B</td>
<td>4.0</td>
<td>4.3</td>
</tr>
</tbody>
</table>

5 – Excellent | 4 – Good | 3 – Satisfactory | 2 – Unsatisfactory | 1 – Very poor
The results from the evaluations show a high rate of client satisfaction, even at the beginning of the activities, when the teams faced challenges related to adopting processes. One of the reasons identified for this outcome, based on making assessments from other points of view, was that the teams constantly targeted the results of the projects, which characterizes concerns related to most of the aspects of client satisfaction described in Section III. This feature is also reflected in the assessments conducted on performance.

It is important to emphasize the assessment of customer satisfaction in this program had a connotation that was only slightly academic, considering the goal was for Datacom to hire qualified professionals with the skills it needs. This is a common feature in the context of Software Residency programs, which are almost always focused on specific outcomes for the clients involved. This learning environment, which is more realistic than other education programs, preserves principles such as solving real problems within real development environments. Given the difficulty and costs associated with creating such an environment, the "Software Internship" applied in this case study is a good alternative for making such programs viable since it respects the essential elements of teaching approaches based on PBL principles.

If the various aspects of "Authentic Assessment" are explored, the different points of view for assessment may be matched and analyzed, and will offer important information both to those who lead the process of teaching and learning and manage training, and to clients who require professionals with the expertise who meet their wants and needs. In particular, the application of the model based on continuous monitoring, prompted by feedback meetings throughout the program, not only enabled points of improvement to be identified, but strategies to be defined that might enable the weaknesses found to be overcome and strengths to be maximized. Furthermore, this model makes it possible both to assess the student from the perspective of group work and individually, thus contributing to developing improvements specific to each individual, within the criteria evaluated in the labor market. Finally, the case study presented successfully achieved its objectives: of the 18 interns trained, 94% were approved for hire by a client, with only one refusing the invitation at his own initiative. Currently, the ex-interns form teams which fully develop new software projects for the Telecom market, and involve the partner companies of this program.

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