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Guidelines for developing educational environments in the automotive industry

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Abstract. Automotive industry has become one of the leading markets which introduces cutting-edge technologies in order to meet the requirements of different clients. This paper presents an e-learning approach developed in the automotive industry in order to address the demands of teaching AUTOSAR standard. The focus of this paper is to illustrate the used methodology, results, but also faced issues and learned lessons. Developing this solution has offered insights into how to approach such a task. These results are valuable for the further expansion of the project, but also for future researchers who might encounter a challenge of developing e-learning solutions for this kind of companies. The offered guidelines are structured from the point of view of management, development and testing teams. In order to establish how suitable the proposed solution is for different categories of prospective employees, the Carl Jung's and Isabel Briggs Myers' typology test was being conducted with relevant results on how the e-learning solution is perceived by future users.

Keywords: Education; e-learning; Guidelines; Automotive industry

1 Introduction

In the past two decades, automotive industry has been the leading industry in using state-of-the-art technologies in order to offer a higher gratification for its customers. Complex projects have been developed and offered to a plethora of markets. Different automotive consortiums have been formed in order to come up with latest research being present in their products.

One of the success factors in such projects is the professional quality of the members. The high degree of technical complexity involved in automotive industry has coined the term of *corporation field expert*, namely an employee which is proficient in a certain narrow, extremely important area of a development process. Hubs of corporation field experts have been formed in different Research & Development (R&D) locations of a certain consortium. Their task is to develop and present accurate trainings for their fellow colleagues; they can come from different cultures and vary in number as was presented in [1]. Such trainings are generally

presented in more than one Research & Development locations. Dealing with global corporations, this reaches a global scale. A specialized training developed in a European hub, for example, by a corporation field expert, can later on be presented in Asia or America. During the past years, a plethora of technologies have emerged in the automotive industry. Such complex technologies require continual training of the corporation's personnel, therefore leading to an exponentially increase in the number of trainers and business trips.

One such technology is that of the AUTomotive Open System ARchitecture (AUTOSAR) standard which was developed as a partnership in order to offer an open industry standard for the automotive software architecture between suppliers and manufacturers [2]. In [3] it is defined the anatomy of this standard as being formed by a set of specifications which are describing the components of the software architecture, but also by the definition of the interfaces between them. One of the large companies that is using the AUTOSAR standard is Continental Automotive AG [4], providing solutions for the major automobile manufacturers of the world.

Faced with an increased number of trainings in the AUTOSAR projects, the management team has decided upon targeted e-learning trainings. This paper presents the case of an e-learning solution called Academy. First of all, by this strategy, the issues of time and cost can be surmounted, but also such solutions are available to different learners which are spread in different parts of the world. Alternatively, the content can be downloaded and consulted offline and also different assessment modules can be implemented in the e-learning training. Secondly, the management team hopes to create an educational environment for the employees, which is characterized by the fact that the e-learning material can be cognitively processed by every single individual in a desired time, while keeping itself engaged and devoted to the training's content.

2 Literature review

The literature review for the presented topic, first of all presents previous work regarding learning environments. Among that kind of research, our approach aims at identifying those solutions that are using e-learning environments, specifically to industrial environments (such as automotive industry). When talking about e-learning environments, a key ingredient into constructing such settings is the way in which students are understanding a certain theme. Therefore the last part of the literature review section is presenting previous work on this matter.

In order to create an educational environment, the crucial steps have been presented in [5]. The first one is the engagement of the learner, which can be affected by learner's preferred learning style and previous experiences. The conclusion of this study is that *"in adult learning theories, teaching is as much about setting the context or climate for learning as it is about imparting knowledge or sharing expertise."* In [6] is presented how such a learning context can be created by an e-learning environment. However, in order to further enhance the e-learning environment, a two-dimensional approach should be used. First of all, a social dimension should be added to the training, such as responding to different postings, engaging students in

discussion and not just simply posting materials. The second dimension is related to understanding which is the best way a student can understand the topic. In other words, the tutor should get to know the learning styles of the students. Other studies, such as [7] have presented how the built environment can influence the cognitive process of a trainee, such results being useful both for students and tutors.

From the automotive industry perspective, in [8] it is emphasized the importance of education time, with a special accent on the time needed to learn (called trainee or learner time). They propose a comprehensive model that satisfies four requirements: the one for the client-side courseware, the courseware developing environment, the Resource Management System (RMS) for monitoring the students as well as an educational document store. In [9] it is also stressed the relevance of education time in the industry, e-learning being presented as the most suitable solution. The system architecture proposed in [9] is unique due to the balance of customized e-learning and the knowledge gathering aspect from both trainer and trainee with the final-goal of obtaining an extensive knowledge management system. The authors of [10] focus their study on both education and industrial experience, by presenting a peculiar difference between the industrial and educational-specific approaches, namely the time factor. It also provides several guidelines to merging the teaching and industrial processes.

Based on a cognitive and behavioral point of view, in [11] it is stated that *"anxiety and facilitating conditions are found to be the antecedents of perceived ease of use, and social influence is found to be the antecedent of perceived usefulness"*. Nevertheless, with all these said, in [12] it is acknowledged only the personal learning networks as important for the conclusion to use a web-learning system. A counter-argument can be formulated, that in [11], the authors took into account only blue collar workers, but this brings the multi-modal, multi-user teaching methods into focus. In [1] it is offered a spectrum of presentation methods that needs to be employed to satisfy the different learning needs of the participants.

In [13] it is also underlined a modular approach, but the meaning is shifted to a collaborative on-the-spot Agile automotive learning system; this also serves as a knowledge repository. The e-learning architecture is faultlessly integrated with the Agile process, due to a modular method. Nevertheless, no real learning management system is implemented in this solution. The literature of this field contains a large range of papers, but most can be categorized at different ends: either offering an engineering/pedagogical approach or an industrial one. For example, in [14] it is presented a practical engineering pedagogical approach, by using virtual tests to allow users the discovery and fixation of theoretical concepts. In [15] an engineering approach is presented, which is using an e-learning solution in order to present an extensive 3D virtual reality system orientated towards active learning. Even if no learning or knowledge management system are implemented, in [16] is discussed the possibility of interlacing various parts of the "digital ecosystem". In the same time, this research is stressing the multimodal, interactive flexible selection approach. On the other hand, the active learning part, is exquisitely executed and tracked.

3 Material and method

In order to come up with a solution to building an alternative system for the existing method of transmitting automotive technologies, which is mainly based on a classical training, presented in different parts of the world, the present research is based on the following plan.

Step 1. Requirements.
The management's requests were formulated in terms of coming up with an optimal alternative in terms of time and costs to the existing way of distributing AUTOSAR trainings, in a suitable educational environment.

Giving the fact that such complex technical AUTOSAR (or we might generalize as automotive) trainings were developed in a certain hub around the world, the need to impart the knowledge and experiences of those trainers was done at the cost of long business trips, telephone conferences, e-mail discussions and so on. In time, giving the large amount of involved employees, this process has become very complicated. Even forming local experts was not enough anymore because these local experts were supposed to also be active in their respective jobs as software developers or software testers. The need for an alternative was more necessary than ever. The new solution was supposed to be creating an educational environment with the main characteristics of transmitting the necessary know-how, but also to facilitate a proper cognitive process for each trainee.

A suitable educational environment was agreed with the management team to be defined in terms of state-of-the-art literature [5], [6], [7] as having different characteristics:

- engagement of the learner (this is affected by their motivation and perception of relevance),
- cognitively processing of presented knowledge,
- social dimension to be present (by receiving answers to issues),
- training offered in the preferred learning style.

Step 2. Classical vs. e-learning solution.
In choosing a schema to train automotive industry employees there are a couple of options available. Management needs to take into account both the trainer and trainee from a time and cost perspective. There are two main currents: the traditional (classroom) method which can be seen as a centralized option and the e-learning method which is a distributed option.

The traditional (classroom style) methods implies the presence of a corporation field expert (the trainer) who is very well versed in the subject and also has pedagogical skills that allow him/her to develop a suitable training. This training is distributed to selected R&D locations, in which other senior-level individuals learn it and then pass it on to junior-level personnel. The training session can last a day or more of concentrated learning. In the particular case presented here, this also might imply that the location trainer might be "borrowed" in other locations that do not have personnel with enough expertise, therefore creating, from a management point of

view, a loss of time spent developing senior level-activities and / or training local employees as well as business trip-related costs [17].

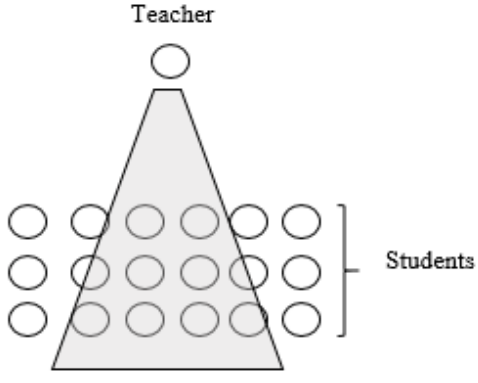

Fig. 1. "Triangle of influence" [5] – traditional classroom can leave different students excluded.

Table 1. Time and cost constraints in traditional classrooms and e-learning environments.

		Traditional classroom		e-learning environment	
	Point of view	Trainer	Trainee	Trainer	Trainee
Activities		develop training OR learn and present training OR development/tester tasks	spend 8 hours every 3 months to learn + can leave students excluded ("triangle of influence" [5])	study previous trainings + develop training + present training + collaboratively evaluate + maintenance + interface between levels + make aware the management	spend as much time as needed until lessons are learned
Time	Education	16 hours or more; multiple-sites around the world; recurring	8 hours; recurring	250 hours or more; one location; one-time; some business trips might be involved	varies;
	Industry	less development time (senior-level) less business trip time	less development time (junior-level)	can be externalized	varies (expected to be lower)
Cost	Education	medium; recurring	medium; recurring	high; one-time; maintenance can be involved	very low; recurring
	Industry	high: senior-level tasks delayed + some business trips might be involved	medium: low-level tasks delayed 1 day every 3 months	medium to high; one-time, some business trips might be involved	very low; recurring

The e-learning methods imply a lot of work on the trainer side, who has to have significant knowledge in both the training field and the pedagogical area. Moreover, a

strong research and comparison of previous trainings is necessary, which coupled with the strong inter-personal skills needed to mediate between the management's many requirements and trainees' capabilities, create a very specific and specialized skill portrait for the trainer. However, once the trainer completes the preparation, only minor maintenance is then needed, thus making the whole process a one-time occurrence. From the trainee side the e-learning is definitely a better experience, as it allows self-pacing, informal interfacing with others at the same-level and even, occasionally, mentorship chances that boost one's moral and drive in learning the subject.

One interesting point to be encountered in the traditional classroom is what [5] identifies as "triangle of influence" (an example is presented in Fig.1), namely trainer's attention being focalized just on some students, while others get to be ignored. This particular aspect can be overcome in the e-learning variant.

The available options are summarized in Table 1, where the e-learning option comes out as an economic and time-conscious solution. The next steps to be presented are based on adopting an e-learning system in order to train future trainees into AUTOSAR standard. The management team agreed on this part, so the following steps started to take shape.

Table 2. Characteristics of the tools.

Tools	TT Knowledge Force	Adobe Presenter
Costs	Already purchased	Price depending on version
License	Not limited	Different purchasable licenses
Main functions	- Team-trainer Knowledge Force (TTKF) for authors is a tool to create web-based, e-learning trainings in TTKF Training Portal - creating and maintaining both the documentation and interactive e-learning media - structuring content in the Topic and Course views - modelling business processes in Process view - localizing knowledge objects to match other languages or different audiences - the publication of such knowledge objects as Web-Based Training (WBT) and a manual, or as a single document - the supply and distribution of knowledge models via portal technology	- conversion of PowerPoint presentations into interactive eLearning content which can be delivered to desktops, and tablets using HTML5 publishing - passive content turned into video presentations, product demonstrations, training videos - generate tests and feedback forms for participants of online training - quizzes, actors, themes and drag-and-drop modules can be added - videos can be published to portals, desktops, and mobile devices - analysis of learning progress of participants

Step 3. Establishing a development tool.

Once the decision on obtaining an e-learning solution for the technical software engineering trainings has been officially released and since the requirements were previously set up, the next step was to identify a proper tool where to develop the project. In this regard a market survey has been done and in the end there were two

tools that emerged as possible future development tools. The tools were TT Knowledge Force [18] and Adobe Presenter [19]. The characteristics that were of particular interest for the team are summarized in Table 2.

The final decision was in favor of TT Knowledge Force, one of the key factors that contributed to this decision is that this tool was already used in different departments (mainly in mechanics, accounting and logistics) throughout the company.

Step 4. Implementation process.

In order to construct the e-learning solution, an implementation process was first defined. This process is presented in Fig. 2.

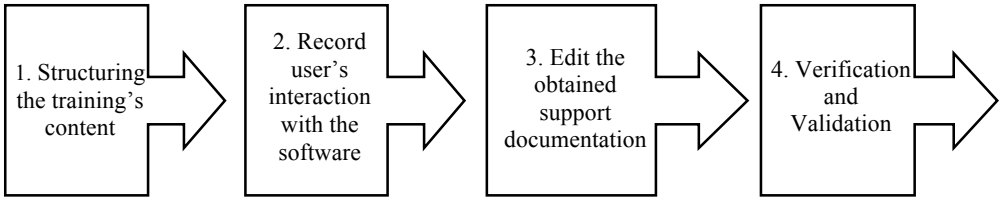

Fig. 2. Phases of implementation process.

The first phase of the implementation process consists of structuring the training's content. Together with the field experts that have already offered the training in the traditional approach, the content was defined and structured. The approach to this phase was on two layers. First of all, meetings were organized with local R&D trainers that were offering the trainings; they were trained by the expert fields and also had the huge advantage of daily working with the practical parts of the technology. The local trainers offered valuable insights into the material, but also precious ideas on how to improve the actual content with additional information and explanation to the ones already existing in the training. One of the advantage of this first layer was that the local R&D trainers had a close interaction with the trainees and could also provide specific feedback from the trainees. During this layer, first observations on how to change and improve the content were gathered. The next layer consisted of reviewing the input from the local R&D trainers with the field experts, but also gathering new thoughts and suggestions from them. The output of this first phase was a complete definition of the content, but also a material structuring in chapters and lessons. The structure was then implemented in TT Knowledge Force.

The second phase of the implementation process consists of recording the interaction with the software tool functioning. This is a most valuable step which comes very straightforward to be accomplished in TT Knowledge Force because the future user is supposed to interact with a software tool. By such an interaction recording, the trainee gets to know different options (such as developing and testing configurations) of the software environment that the future AUTOSAR specialist will use.

The third phase consists of editing the documentation that TT Knowledge Force is automatically generating, this facility saving a lot of time during the implementation process. This documentation is a very useful tool for the trainee because different practical steps can be found out in a structured approach.

The forth phase is the verification and validation phase. The goal of this phase is to check if the system correctly implements the requirements. For this, a three layer approach has been devised. First of all, the content (including the educational environment requirement implementation) was sent to be reviewed by local R&D trainers and field experts. The suggested modifications were discussed, agreed upon and some of them were implemented. The final decision was taken by the management team. A faced issue on this layer was that of differentiating between working with TT Knowledge Force on a test server and on a production server. The official content is supposed to appear on a production server, hence the obligation to develop it here and not on the testing one. The second layer of this phase consisted of locally sending the e-learning solution to all developers and testers teams from the department so that they could evaluate and come-up with improvement ideas and findings. As an outcome of this layer suggestions were formulated to add a separate module on how the e-learning training is being used, but also adding quizzes and assessments to different modules. One of the issues that appeared on this layer was the fact that TT Knowledge Force is not a Learning Management System, therefore no tracking of participants could be realized. In order to surmount this inconvenient, the tool provider suggested to use other existing options which were already available in the company.

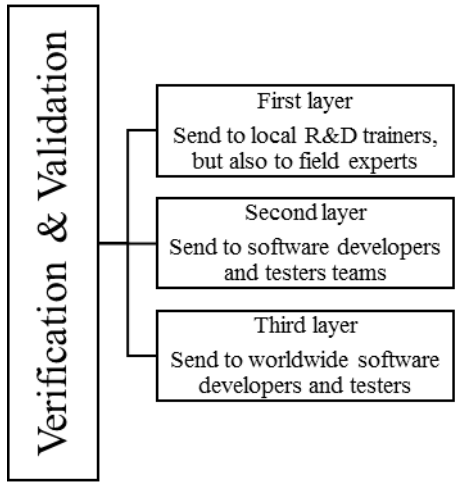

Fig. 3. Layers of verification and validation phase.

The third verification and validation layer consisted in sending the e-learning training to different worldwide software developers and testers to use it and send feedback about it. A summary of the verification and validation phases are presented in Fig.3.

4 Obtained results

4.1 Architecture of the e-learning solution

The obtained e-learning system architecture comprises of seven modules. This structure is offering to each trainee the proper educational environment which offers the know-how on AUTOSAR technology.

The approach is a gradual one, taking the trainee from an introductory level where general concepts and the overall framework is explained (Architecture Overview module), moving forward to a practical part where both the software developer and software tester roles are underlined (Introduction to CESSAR-CT module) and later on presenting advanced knowledge and practical usage of the AUTOSAR technology (from Run Time Environment module until Diagnostic Stack module).

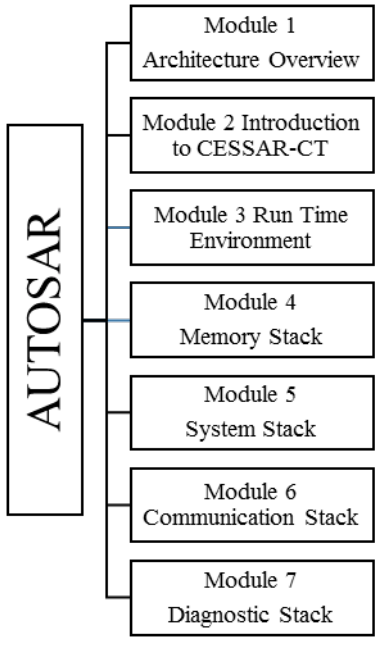

Fig. 4. Architecture of the e-learning solution.

Due to the e-learning nature of this solution, issues such as time and cost were overcome. Different participants from a spectrum of locations around the world can take part into the training while the trainer is no longer needed to move long distances in order to present the material in a certain R&D center. From the trainee point of view, a communication option in the training is offered for unclear practical or theoretical parts where he / she can ask questions to the trainers and get answers. Each

trainee can study the material until lessons are learned, but also a plethora of quizzes and assessments are available throughout the modules.

4.2 Proposed guidelines

Based on the acquired practical experience developing the present solution and also taking into account the state-of-the-art literature review, a set of guidelines for developing educational environments for automotive industry is proposed. This set of guidelines is formulated in terms of guidelines from the management point of view, development and, finally, testing point of view.

Guidelines from the management point of view.

1. The management should have a clear view on the concept of the desired e-learning project, regarding the goal and final usage of such a project.
2. Clear requirements of the project should be offered to the development team. A lack of such requirements will lead to unnecessary modules implementation or even facing some unsolvable issues.
3. After taking the decision that a certain training or task could be transferred in an e-learning content, specific requirements should be formulated regarding the e-learning content. Examples of such mandatory requirements are: should the solution track the participants, is it necessary to use a Learning Management System, should the assignments be implemented for all students etc.
4. The management team should aim for implementing an educational environment. This means that in the beginning a clear understanding of trainees' way of perception should take place. In this way, the content of the e-learning ca be adopted accordingly.
    a. Only after a rigorous study of trainee's ways of assimilating the information, the content can be created.
    b. The management team should allocate time and budget for such a testing.
5. Iterations with clear feedback should be established for the development team.

Guidelines from the development point of view.

1. Try to profoundly understand management's requirements.
    a. Organize meetings with the management so that you can plainly discuss those requirements which are not straightforward.
    b. Clearly present alternatives to the management.
    c. For your proposed alternatives, always present which would be the gain for the project.
2. The development team should develop different use-cases for the offered requirements.
3. Conduct a professional study on which are the available options for implementing the e-learning project.

   a. Together with the management team, clearly establish if a Learning Management System is necessary or not. Such a system can easily track the participants and their progress. In some cases it is not required to use such a facility.
   b. Communicate with the management on what can the particular tool offer; clearly state the limitations. Even if there is a tool already available in the company, it is not necessary to use it for a certain task where is not completely applicable.
   c. If, from different reasons, you have to develop an e-Learning project with a solution that does not offer the tracking of participants, then search for alternatives for this particular task.
4. For the development part, follow a development process, like the one described in this paper.
5. Organize a training for the tool you finally chose.
   a. From this training, clarify which is the official way of deploying the training. Usually the content can be developed on a training and production servers. If the development is on a test server, then find out when the content should be moved to the production server where will be the official version of the e-Learning project.
   b. If the plan is to embed different media files in the chosen tool, understand the details of this operation (software limitations, bandwidth, etc.).
   c. Find out if you can obtain a local build of the project. This build can be further uploaded on a certain location for testing purposes.
   d. Understand if the tool is offering an automatically generated documentation and how this documentation can be edited.
6. Understand the differences between quizzes and assessments. Quizzes might be applied without a clear mark, just to understand some important topics, while the assessments usually take place at the end of a module.
   a. Consult with the management on the possibility of taking out the assessments for certain employees coming from different regions of the world.
   b. Decide if the attendance certification should be offered automatically at the end of the training or based on an examination.
7. Define a time when to implement in the e-learning solution the provided feedback. Usually this takes place in a future iteration based on the existent process.

Guidelines from the testing point of view.

1. Try to clearly understand management's requirements.
2. If educational environment elements are presented in the requirements, then these should be verified.
3. Build a list of found issues and send it to the development team.
   a. Assure that you have a clear vision on the solved tickets.
4. The improvement ideas should be tracked by the testing team, based on an official approval of the management.

4.3 A discussion on the educational environment

Building an educational environment is not a straightforward task because it implies different subjective factors, as we have seen in section 3, some of which being motivation and perception of relevance. The educational environment requirement is to be verified during the first layer of the verification and validation phase.

Remark 1. The present e-learning project is implementing the educational environment concept by a communication line with the local R&D trainers. After completing the training, in the case that a trainee cannot understand a certain topic or practical aspect, a communication line has been opened with a local R&D trainer. In this way, the personal communication factor is established (a key ingredient to building educational environments).

Remark 2. The present e-learning project is implementing the educational environment concept by offering the chance to every trainee to access the material as many times is necessary. Giving the e-learning nature of the solution, each participant can access the training whenever finds it suitable in order to find an answer or learn a topic.

One of the key ingredients that make-up for an educational environment is offering the training in the preferred learning style of the trainee. As it was previously presented, this step is to be realized at the beginning of the process. In order to establish how many of the possible future trainees can suit their way of learning to our e-learning solution, a survey has been offered to 86 possible future trainees. The outcome of this survey was to obtain their 4-letter type formula according to Carl Jung's and Isabel Briggs Myers' typology [20].

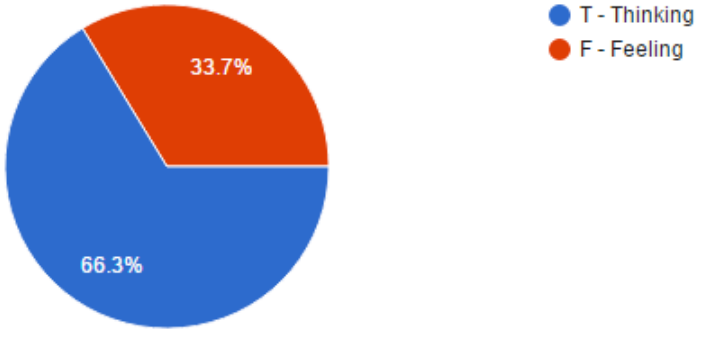

Fig. 5. Third letter of the Carl Jung's and Isabel Briggs Myers' typology.

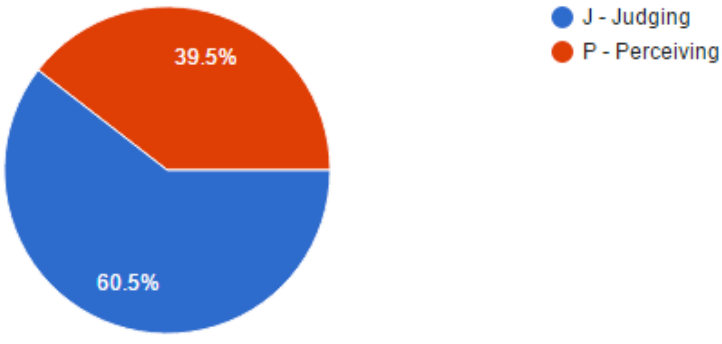

Fig. 6. Fourth letter of the Carl Jung's and Isabel Briggs Myers' typology.

The results that are of most importance for the present project are the third and fourth letter from the above mentioned test. The third letter is basically revealing how a person processes information, either thinking (the information is processed by logic) or feeling (the decisions are based on emotions). From the point of view of the Academy project, it is relevant that percentage that is indicating the information perceiving thorough logic: 66.3% of the prospective trainees are suitable to take part in such an educational environment due to their ability of logically processing the information (Fig. 5). The fourth letter of the test is showing how someone is implementing the processed information, either judging (by sticking to a rational plan) or perceiving (by improvising). From the study it can be seen that 60.5% of the possible future trainees are suitable to take such an e-learning course due to their capacity of following a structured presentation (Fig. 6).

5 Conclusions

This paper presents an educational environment implementation based on an e-learning architecture that is developed in an industrial company. Based on the acquired experience and previous work, a set of guidelines has been proposed on how to build such a project. A study has been also made on how many prospective trainees are suitable to take part in the e-learning solution which is a key ingredient in obtaining educational environments.

The difficulties of this implementation were to be faced in harmonizing the expectations of different managers towards the outcome of the project. Since this is an ongoing project, new iterations are expected to take place in the future where different other features will be added. One of the main future directions is to research specific methods to make this solution approachable by the "Feeling" and "Perceiving" categories of the Carl Jung's and Isabel Briggs Myers' typology test.

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