Teaching Computer Programming in a Platform as a Service Environment

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Abstract—**In this paper we recall a previous research on the future development of the current model of higher education, which highlighted that the labor market is looking for people with competences and skills reflecting a T-shape model. As a consequence, universities should include a wider mix of disciplines in the curricula of their courses. Hence, to overcome existing criticisms and to provide some suggestions on how to enhance universities' performances, we thought of education as a process with inputs, outputs, and relevant dependencies. We based our research on a smart-city-like model due to the fact that next generation networks and relevant services are going to be more and more integrated with existing infrastructure and information management systems. Thus, it is mandatory that smart solutions are the most prominent assets of modern university environments, to improve the effectiveness of higher education. We called such a university a "smarter university" in which knowledge is a common heritage of teachers and students. In this paper, we report experimental results from a specific case study of collaboration between industry and university, which could be used as a reference for the definition of patterns to be applied in the redesign of the current education systems, even tough it is referred to a technological application scenario.**

Keywords-cloud computing; smart applications; collaborative systems; technology enhanced learning.

I. Introduction

Owing to modern technologies, ever-growing computing power, miniaturization, innovation in network infrastructures and networking solutions, people and things are connected each other like never before. In this context, the most advanced solutions, such as the use of applications based on the Internet of Things (IoT) and the exploitation of the semantic web capabilities, can give a new impulse to e-learning [1] and push the interaction of people with both learning objects and learning environments, in a real semantic web of things [2]. Moreover, information and data are created and spread at high speed, in settings with less and less boundaries. After analyzing this general scenario in a previous work, we observed the actual teaching model at universities. We found some weaknesses and strengths, and we identified the main building blocks for the definition of a reference model of what we called a "Smarter University" [3]. In our study, we refer to smarter university, instead of smart university, due to the fact that, generally speaking, today's universities widely adopt cutting-edge technologies and systems, thus we can consider they already have the desired smartness characteristics. However, that may be not enough and they should become "smarter" to improve their effectiveness, to enhance their performances, to be more flexible, and, last but not least, to be able to cope with novel and emerging needs of both society and labor market. In fact, according to the current situation, university teachers perform on-the-edge research activities, which make them the exclusive holders of knowledge, and they act consequently. If regarded from a theoretical point of view, it looks like a good model but, in the actual conditions, the fact of having very specific and very deep knowledge in a very narrow research sector does not match with the labor market needs that are focused on flexibility and require more and more interdisciplinary competences. At present, it is not so easy to find university courses that provide people with such skills. In fact, people with such skills should come from both technical faculties, such as, e.g., engineering, and social sciences ones; but at the same time they should hold knowledge and abilities in management, social behavior and human interaction, communication, teamwork, problem posing and solving, creativity, lateral thinking, and resilience.

This it the hard work that universities are challenged to do. And "How should they achieve it?" is the big question. Beside the disciplinary matters and the strategies leading to the choice of a suited mix of classes in specific courses, we are convinced that one of the most powerful enabling factors to find a solution is the tight collaboration between academia and industry, on common projects, with common objectives, to drive students to learn how to apply theoretical concepts for the solution of some real world problems.

In such a vision, universities, organizations and companies should cooperate to develop together an ecosystem in which they could learn from each other. In this way, universities will be able to achieve the new "smarter" level and be ready to teach novel design and methodologies and new reasoning paradigms, while industry and organizations could find new market shares to conquer. Finally people could find new jobs.

According to this vision, and making reference to the pillars of smarter universities listed in the previous work, we focus our attention on a specific technological issue. In particular, we consider a novel research trend that is gaining consensus in the scientific community and that we expect to have a prominent role in the very next future, that is, the exploitation of the Platform-as-a-Service (PaaS) paradigm in software production [4]. This will allow using remote virtual machines in place of

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local hardware and software, thus avoiding time-consuming and expensive installation procedures as well as annoying maintenance tasks. More in details, in this paper, we are going to showcase the outcome of an educational activity that we carried on in a distributed environment based on cloud computing and services. Specifically, we make reference to the most recent stage of a long-term project aimed to empowering collaboration skills in software engineering students, the ETC (Enforcing Team Collaboration) project [5]. In this project, students are grouped together to create small teams regardless of they might be from different universities as well as from different countries. Then, within the tasks they are assigned to, they must cooperate to achieve common objectives, which include, among others, the development of working prototypes of some web-based applications. All the students that enrolled to the laboratory could rely on a bunch of professional tools specifically crafted to support software development and for the management of the software lifecycle, which are made freely available at their universities through the IBM academic initiative. In this framework, in the past, we started experimenting throughout the Jazz ecosystem in conjunction with the renowned open source Eclipse IDE (Integrated Development Environment) and, in the last year, we started using also the IBM Bluemix platform and its relevant facilities.

The remainder of the paper is the following. Section II explores related works then, in Section III we present the ETC Project and the framework in use. Section IV describes the Eclipse framework as a learning environment and Section V outlines the ETC-BLUE project. A summary of the results is reported in Section VI and, finally, a glance on future work concludes the paper.

II. RELATED WORKS

The Computer Supported Collaborative Learning (CSCL) strategy implemented through the PaaS paradigm can be found in the literature in other related works. According to Silverman [6], *"the adoption of a collaborative learning strategy can be useful in many situations (and it can be realized with or without the use of technology)."* Moreover, Dong et al. [7] assert *"the current models of e-learning ecosystems lack the support of underlying infrastructures, which dynamically allocate the required computation and storage capacities for an e-learning ecosystem. Cloud computing is a promising infrastructure which provides computation and storage resources as services."* In addition, in [8] the authors conclude that *"e-learning systems can use benefits from cloud computing using: Infrastructure (i.e. use an e-learning solution on the provider's infrastructure), Platform (i.e. use and develop an e-learning solution based on the provider's development interface), Service (i.e. use the e-learning solution given by the provider)".* Given these general considerations, we observe that, the use of the IBM Bluemix platform (the same one we used in this work) is also reported in [9] where the authors describe how their students worked on a database in the cloud, in a virtual laboratory environment and in [10] where the author says: *"by hosting the entire development environment, PaaS increases productivity, lets organizations release products faster, and reduces software's cost."* Considering these results, this work proposes a smart education model which creates a CSCL and exploits the tools available in the IBM Bluemix platform to create applications in Java, which run over the Android operating system, and to achieve the following advantages: shorter learning time, better quality of the prototypes/products, and implementation of the T-shaped model [11]. In [12] the authors say that *"seamless and pervasive intelligence is already proving disruptive in education, with traditional campus-based education models changing as new teaching methods evolve, augmented by automated and interactive learning outside the classroom and distance participation"* and also *"we also project that courses will involve less instruction and lecturing and more dialogue with expert professors, resulting from the ability to use technology for interaction outside the classroom".* The perspective is that education will be seamless and ubiquitous for those who can afford information technologies. To conclude this quick review, we mention [13] where the author says that *"the potential of cloud computing for improving efficiency, cost and convenience for the educational sector is being recognized by a number US educational (and official) establishments."* and *"there is also an increasing number of educational establishments that are adopting cloud computing for economic reasons."*

III. ENFORCING TEAM COLLABORATION

The Enforcing Team Collaboration (ETC) project was created with the need of developing cooperation skills between university students when they are required to work in groups. Teamwork ability is an essential skill for students to acquire; learning and practicing this skill can give a glance to their future team-working experience. In particular, we are talking about students involved in software engineering activities and, consequently, the ETC project creates an effective CSCL system for higher education that targets the area of software engineering, computer programming, and team cooperation for software analysis and software development [14]. In the rest of the paper we will refer to this particular case study. However, the same principles applied by ETC to the above areas, can be applied, with different tools, to other areas beyond computer programming.

We can face the problem of developing such skills from different points of view. On one hand, from the educational perspective, we observe that people must be duly trained to acquire competences in software engineering models and techniques, as well as in project management and human relations. On the other hand, from the technological perspective, we observe that a complex system is needed to enable and support collaboration as well as to ease interactions between the participants. Finally, we observe that distributed architectures and cloud computing can foster new behavioural paradigms in acquiring and disseminating knowledge and sharing experiences, thus they are needed in the learning process as well [15]. In support to this we consider the vision on how recent advancements in grid and cloud computing and mobile communications have significantly changed many concepts at the basis of e-learning as presented in [16]. In particular, we can envisage new learning models, which ease the implementation of hands-on activities and can fully exploit users' interaction, due to the absence of located machineries, physical devices and structures as well as working environments such as computer rooms with limited number of seats and time constraints access. We want to demonstrate that this can improve learning outcomes and accelerate the education process, while making more flexible the design of courses, lectures and practical activities to be assigned to students for the assessment and evaluation of their competences. Moreover, sharing resources and collaboratively constructing reusable learning assets, can significantly reduce costs in terms of both time and money [17].

The project was born by noticing that, in many cases, the software production process can become hard due to lack of a full integration among the tools and meta-tools of different teams such as database, interface, processes, knowledge sharing, and so on. This has nothing to do with being able to design and write good code and can cause significant loss of time and demotivation during the learning process. Hence, the proposed solution is teaching both teamwork and computer programming in parallel. Based on novel programming paradigms and tools specifically created for supporting teamwork, a suited software platform, enabling effective team working, was setup in order to coordinate the cooperation in developing code among students that study in different universities, have different working time-frames, and may be from different countries.

Many different systems and tools are available for the coordination of the software development process activities. At the same time recent integrated environments are shifting the focus to remote cooperation, which is considered the best way to cut down time and money. For such environments to be effective, we need something like an "orchestra director" over the development process. Generally speaking, the orchestra director is the one who knows exactly when each instrument must be played, and how to leverage the quality of the overall execution. Specifically, we found all of these features within the Jazz development platform. This complex platform, released by IBM, is usually adopted worldwide by IBM researchers for the development of software in cooperation. Before the ETC project was launched, such a kind of complex platform had never been used in an academia setting for a geographically distributed project. Consequently, in the ETC project, together with the Jazz environment, we adopted the renowned open source Eclipse IDE as a development platform. It is worth noticing that, in addition to writing clean and working lines of code in the preferred programming language, students have to cope with other tasks such as debugging, compiling, and, finally, the deployment of activities on specific hardware platforms and operating systems. This requires the inclusion of resources necessary to run experimental distributed software architectures.

Based on such considerations, we can summarize that the ETC project consists of experimenting with the realisation of collaborative activities based on the Eclipse community and tools in which different teams have to complete a group of tasks that have to be integrated with systems or subsystems developed by other teams. To reach the project main objective the IBM Rational software tools were integrated into software engineering academic projects. The project was sponsored By IBM Italia and the University Federico II of Naples received an IBM Faculty award in 2011 for the project. A variety of Italian universities participated in the project, such as: the University of Napoli Federico II, the University of Milano Bicocca, the University of Bologna Alma Mater, the University of Bergamo, the University of Genova and its regional campus in Savona, the University of Bari and its regional campus in Taranto. Each university formed teams of students from different courses. Specifically, the course of software engineering from the University of Napoli Federico II, the University of Bologna and the University of Milano Bicocca; the course of web design for the University of Genova and the University of Bari; the course of advanced programming and testing from the University of Bergamo. Heterogeneous teams were composed of students from different universities with one teacher as a tutor for each group. Moreover, for each University, a *champion student* (usually a computer engineering or computer science Ph.D. student) is put in charge of corresponding with a teacher and acts as a responsible for each local group and support. One computer engineering Ph.D. student is put in charge of the technical direction of the entire ETC platform (both software and hardware).

Based on the encouraging results deriving from the ETC experience, we aimed at building wider team cooperation projects from lessons learned in open communities of practice [21] and we have extended the original project by designing new activities for groups of students that included the Kent State University, thus creating a more complex and broad working environment. The project was called ETC-plus [22].

IV. The Eclipse Framework as a Learning Environment

In this Section we discuss how the Eclipse IDE can be considered as the inner center of a learning framework where students of computers programming write down their code and can easily interface with a number of external tools and services for a wide variety of different purposes. In fact, Eclipse is an open universal platform for tool integration, is an open and extensible IDE, and an open source community as well. The aim of Eclipse creators, and hence of the Eclipse-based tools, is to give to developers the freedom of choice in a multi-language, multi-platform, multi-vendor environment supported by multiple vendors. In addition, Eclipse provides a unique environment for members of the academic community to build new tools for teaching, doing research, and fostering further growth of the Eclipse community [18]. We point out that integration is part of the software development process and it occurs through tools inside and outside the IDE. In order to maximize the collaboration results with the minimal effort, we have joined the Jazz project, which seeks to integrate collaborative capabilities into the Eclipse IDE, thus enabling small teams of software developers to work together in a more productive way [19]. In brief, team cooperation in the context of ETC is enabled by the Jazz platform via the following tools:

(i) Rational Team Concert (RTC);

(ii) Rational Quality Manager (RQM);

(iii) Rational Requirement Composer (RRC).

These three tools assist teams in developing in cooperation software specifications while maintaining quality constraints. An overview of the results obtained with the use of Eclipse on the Jazz platform is presented in [20].

After having successfully used and developed systems on the Eclipse-and-Jazz integrated platform in the ETC-plus project [21, 22], since last October 2014, we have joined the IBM Bluemix program. The use of the IBM Bluemix platform has made easier to cope with issues related with the management of data, infrastructures, connectivity, and servers. In fact, its use allows a paradigm shift so that now we can exploit advanced solutions according to the Software as a Service (SaaS) model, on a Platform as a Service (PaaS) environment. Consequently, we do not have to worry about managing servers, databases, virtual machines, and multiple releases of instances. Furthermore, the extensive use of the cloud relieves from data management issues, including security of both network and software.

V. THE ETC-BLUE PROJECT

The lessons learned from past experiences have driven us to the definition of a new scenario, which takes into account that requirements change very quickly due the fact that activities are bounded learning tasks. Also in this case we found a solution on the IBM shelf in the recently released IBM Bluemix platform, which allows developers to use a combination of the most prominent open source computer technologies to power their apps, by handling in a seamless way the integration with apps and systems running elsewhere and managing data in the cloud [23]. We believe that the adoption of the IBM Bluemix platform will foster further developments and increase the educational results achievable through collaborative work activities, resulting in students that learn faster and acquire competences and skills in different fields.

To prove the validity and the effectiveness of the presented concepts, we have created the most recent release of the ETC project, called the ETC-Blue project. The idea behind the experiment is that of "grafting" a university course in a formalized company internal training process with the aim of getting T-shaped students. In this experiment we involved a pool of university students of a software engineering degree course with the main objective of:

(i) strengthening the vertical part of the T, which is made of a deep and narrow knowledge of computer programming and operating systems;

(ii) completing the horizontal layer of the T by developing skills in project management, collaboration, and leadership.

The project participants are the University of Naples Federico II and IBM Italia. The participating students are the ones enrolled in the "Computer programming - I" course of the Software Engineering degree at the Univ. of Naples. IBM has supplied the students with a crash course on the Bluemix platform to make them aware of the features of the platform and to speed up the learning curve. In this way students could quickly focus on the design phase and start implementing sophisticated functionalities for their apps without having to worry about databases, server connections, security issues, etc., which are ready-to-use available services of the platform and, thus, transparent to the developer. Moreover, the IBM Bluemix platform is accessed trough a web browser and no software has to be installed on local machines, allowing students to bring their own computers without having to rely on the university facilities. In addition, they can continue studying and experimenting at home or anywhere else, at any time, e.g., at nighttime. Another positive side effect is that universities are not any more requested to maintain a huge number of machines with specific configurations in students' laboratories, according to the model of virtual laboratories, saving money and resources that could be used more fruitfully. This should increase the students' satisfaction, which can get better services.

In more details, the crash course took two days, for a total of eight hours of lectures, including hands-on lab and it was given two times in November 2014. The students who attended the course were 120 but a total amount of 150 people was involved, including, among these, professors from local and nearby universities (i.e., the University of Cassino), Ph.D. students and professionals as well coming from different cities, such as, i.e., from Milan.

As a follow up of the crash course, many students have started individual projects in small groups immediately after. It is worth noticing that one of the above-cited projects involves the Kent State University at Stark, USA, and this should be regarded as an example of really distributed team collaboration. In fact, working together, in this case, implies significant geographic distances, different time, and different languages spoken as well. The collaborative environment, which was already intensively tested in the previous years with the ETC-plus project, has proved once more to be very effective and the first results achieved within this cooperation are really encouraging.

VI. ACTIVITIES AND RELEVANT RESULTS

After the above-cited crash course, 92 students were arranged in 26 groups, each of these made by 4/5 people. Then, for each group we selected 2 students and assigned them the roles of team leader and deputy, so that they assumed the responsibility for the management of the whole project and for the external communications (i.e., with the teacher) too. In the following we list some of the running projects to give a flavor of the type of activities carried on, also providing short descriptions.

1) **Knowledge Hound**. This work aims to facilitate the community building around specific activities carried on in the university for both education and research. In fact, if some students may need support to the solution of specific problems, it is possible that some other students are working on the same problem. For example, there are students who, while working at a master thesis, have acquired a deep knowledge about that issue. Through the Knowledge Hound, knowledge can easily circulate and students teach themselves exchanging and merging own individual competences. In this respect, the project has the aim of developing a proximity-based app in which every student can state personal abilities and skills and search for the missing ones in other students' profiles. The development of this project has started over the IBM Bluemix platform and the expected outcome is an Android app running on different devices such as smartphones, tablets, laptops and desktop computers. In Figure 1 we show some screenshots.

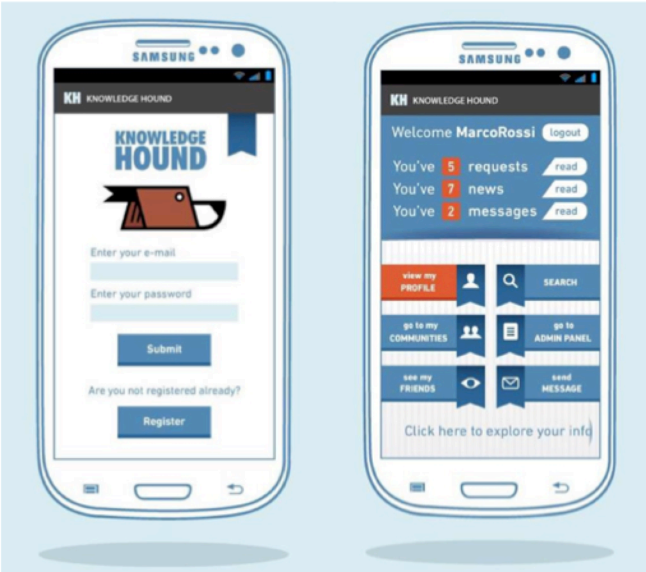

Figure 1: The login/registration page and the home page of the Knowledge Hound app

2) **K12**. This is a project launched in collaboration with the Kent State University at Stark, which fully exploits the features offered by the IBM Bluemix platform. The objective of this activity is defining innovative educational materials supporting both teachers and students in their relevant learning activities. According to its name, the project addresses K12 students by providing students and teachers with open source and reusable learning resources. Learning activities include, among the others, quizzes at different difficulty levels, which can be customized to individual students' profiles. In Figure 2 we show some screenshots from the student app, composed by a main screen, a quiz screen and a chat.

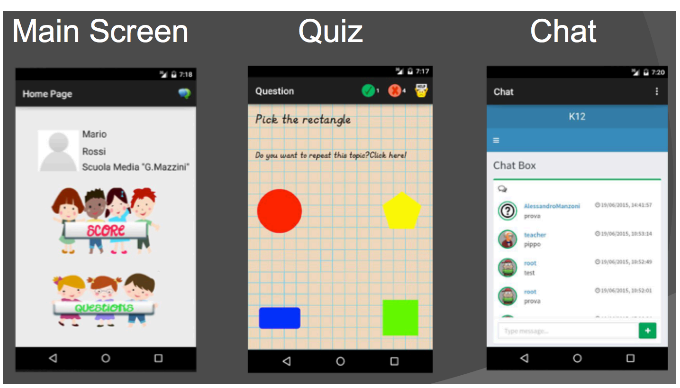

Figure 2: The K12 app for math. Particular attention was given to the graphical interface, to be attractive for kids.

3) **SmartApp**. This project has the objective of developing an app really useful, not only a mere academic exercise, which can be delivered through the application stores to a wide public. The project is in charge to 2 different groups of 5 students each. The target public should be composed of tourists or, generally speaking, traveling people. The main functionality of the app is collecting apps based on location criteria. "Where are you? And, hence, what specific apps could you need now?" Possible suggested apps could be, e.g., local transportation routes and timetables, local museums, local weather forecast, and others. In addition the app can ask, "Who are you?" and provide the user customized replies listing, e.g., only apps related to music rather than sport events, find contents in your language and suited to your age or other criteria.

4) **ElectionUp**. This project involves 5 groups of 5 students each, and is the design of an app made to follow in real-time ballots in elections. This involves real-time communication with a shared database and the need of suited tools and algorithms for data analysis and visualization. Moreover, data should be accessible through common interfaces and APIs to other systems and a friendly user interface is needed. Figure 3 and Figure 4 show the user interface and the data visualization screen.

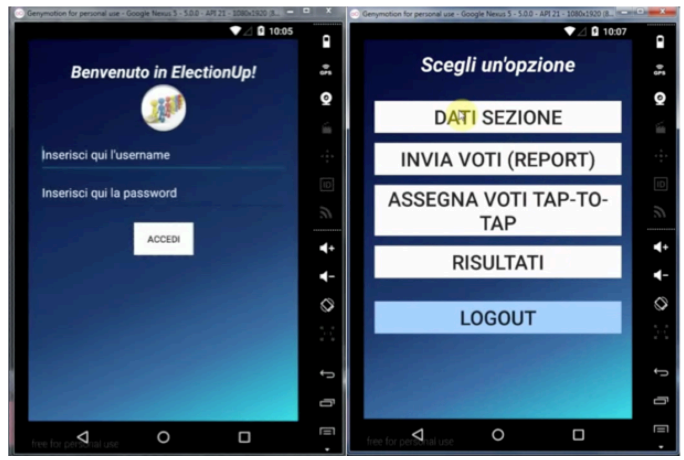

Figure 3: The ElectionUp app for Italian system election. Particular attention was given to the graphical interface, to be user friendly.

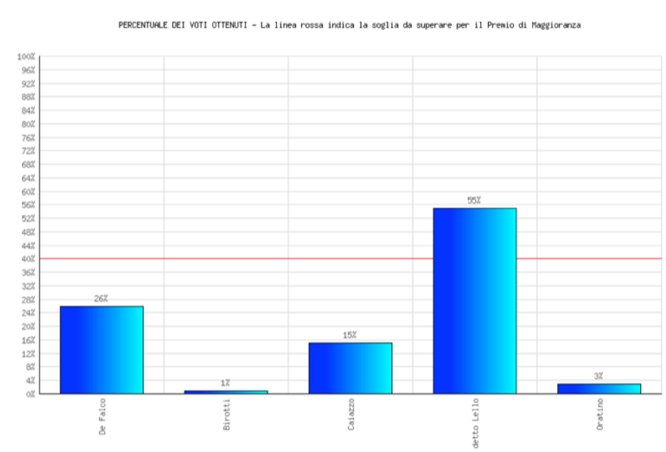

Figure 4: The ElectionUp app for Italian system election: the percentage of votes obtained.

Specifically, 12 groups are on the "Knowledge Hound", 2 groups are on the "K12 math" (plus a team of 4 from the American side), 2 groups are on the "SmartApp" and 5 groups are on the "ElectionUp". Summarizing, a total amount of 92 people have been working on the IBM Bluemix platform and duly finished their assigned tasks. After the first stage, those students who have finished the activity they were assigned to, assume the role of project managers for the newly entering teams of students and charge other fifty people with new tasks to improve their previous works, fixing bugs, finishing uncompleted tasks and implementing new features, for the refinement of existing prototypes, based on the results of previous evaluation and assessment. It is worthwhile noticing that evaluation of software performances and usability happens between peers, while assessment is in charge to the teacher.

Based on this philosophy, projects outcome can be incremental and every team can start the assigned work, inheriting parts already developed by previous ones, adding or improving functionalities of an app that will become more and more complete, easy to use, and powerful. At the actual stage, two different teams have laid the foundations for a fan of projects. The former developed some basic building blocks and a common knowledge base, which constitute the substratum for the forthcoming groups to operate on. The latter, developed a variety of interfaces for the Android operating system, exploiting the Eclipse ADT (Android Development Tools) and the foundations provided by the IBM Bluemix boilerplates.

From the educational perspective, we highlight that, beside the development of the above-cited components, students involved in this first stage developed specific training materials to enable other future students to use the common workspace. In addition they also setup suited tools for the management and coordination of groups. But this educational activity has interesting points even if regarded from the software engineering perspective. In fact, the groups involved used the IBM Bluemix life cycle management illustrated during the initial crash course, passing through Jazz and DevOps.

As an example, in Figure 5 we show a screenshot taken from the IBM Bluemix dashboard. The picture illustrates the modules used within the above-cited Knowledge Hound project. Each tile gives access to the configuration environment for the relevant service. They include services for:

(i) Mobile Application Security,

(ii) Mobile Quality Assurance,

(iii) Mobile Data,

(iv) Push, and

(iv) an SQL database server.

Of course, all of them are provided, as a service, by the Bluemix platform itself and this is a great advantage from the point of view of maintenance but also for the achievement of software engineering skills and design capabilities, since students are free to think of their computer programs in terms of architecture and high level interfaces, regardless specific implementation issues and the software available at their universities. Moreover, we highlight that the adoption of cloud-based solutions for software services and storage could solve a huge number of problems to computer laboratories of universities that should not install and maintain numerous software packages for many different purposes. One sad note about this from the authors is that in Italy having large bandwidth connections is still a serious problem in many geographical areas and this could slow down the deployment of cloud services.

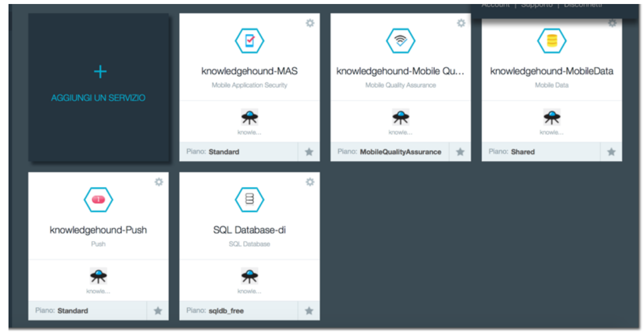

Figure 5: The services used in the Knowledge Hound app. The view from within the IBM Bluemix dashboard

VII. Conclusions and Future Work

In conclusion, the more important lesson learned is that the joint effort from university and industry together can give outstanding results for a wide range of reasons. Summarizing, the main motivations are: students learn to cooperate in small teams; the collaboration implies a split of tasks and drives everyone to make the best out of his effort and this implies that individuals' competences emerge; among these, leadership is one of the abilities which clearly appears and, consequently, portending e-leaders can be identified. In this newly developed framework the collaboration among university and industry has been give-and-take. University took the training course from industry, yet contributing to the definition of their contents, with the aim of readily exploiting them in specific projects for the dissemination at a students' level.

These preliminary results demonstrate that the use of the IBM Bluemix platform, tacked on the complex eco system based on the Eclipse IDE seamlessly integrated with the Jazz products and solutions that was developed in the past years, can greatly improve performances of the students, which gain core competences faster and in a realistic working environments.

Summarizing, we can say that ETC-Blue has reported several advantages and we observe that the most important part of the architecture is collaboration (smart ETC-Blue). In fact, collaboration has made possible the design and development of resources useful to the all of the teams. Moreover, ETC-Blue drives standards and forces open innovation networks, requires mature organizations and produces high quality products. It is noted that if there are mature organizations to act as a driver of an experience like that, one can get high quality products (i.e., software) but also students trained in an excellent manner as also reflected in the results achieved.

ETC-Blue fosters learning methods that are student-led versus instructor-led, with professors playing a mentor role in the learning process. This is a student-centric paradigm, which constitutes the basis for collaboration between people in teams and among groups. Within the large number of students involved in this experiment, we observed that some groups were *crawling*, other groups were *walking*, others were *running* and some were even *flying*. The teacher, acting as a coach, should identify those groups that fly and motivate them so that they can achieve quickly the best results and so that then they can spread to other groups, helping them to reach a superior level.

In a broader vision, we highlight that ETC-Blue can nurture the creation of smarter campuses, which are interconnected, enriched and fed by on the-ground knowledge being developed over social networks. ETC-Blue favors the creation of smarter universities and forces teachers to have the most updated and relevant curricula, which then attract the best students who then will have the best formations, creating a virtuous circle of collaboration between universities and companies. ETC-Blue implements team-based projects across geographical, disciplinary and institutional boundaries and sustains a community that enables the formation of "T-shaped" people. Finally ETC-Blue fosters leadership and e-leadership.

Future work will be dedicated to finalize projects that are still open and, besides, we want to reserve a specific space for a students' session within the forthcoming annual workshop of the Italian Eclipse community (*Eclipse-IT 2015* hosted in Rome, Italy, on October 14th, 2015), where they will have the opportunity to show what they did to a wide audience including academics and professionals. Moreover, we want to carry on new experiments involving more companies, and even startups, to prove that innovative working environments that push collaboration can enhance their productivity and that they can profit from the university think tanks through students' internships (or by other means of collaboration) even before they are graduate and, thus, participating in this way to the education process, which can bring a great added value to consolidated realities. It is worthwhile noticing that the same experience can be replicated in other settings, regardless the chosen PaaS platform.

Another target is to launch an IBM Bluemix ecosystem tracing previous experiences made with IBM Jazz in the various releases of the ETC projects depicted in this paper. In fact, merging these working environments has created a very powerful educational experience that students lived with enthusiasm attaining encouraging results. Moreover, at the end of their activity, we observed a high degree of satisfaction and a growth in personal appreciation as well. Despite this, some students complained about a steep learning curve. However, we have kept into account their feedback and we have taken specific actions to overcome this criticism. To this aim, we put a significant effort on the development of instructional materials, which have been duly realized in the form of video tutorials, user guides, handbooks on essentials, mind maps and more. Such learning assets will be readily available to future people involved in similar activities and they will be the starting point in their learning experience.

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