A technological platform for the creation and evaluation of psycho-technical tests

Fernando Almeida*, INESC TEC, University of Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal.
Daniela Castelo, Higher Polytechnic Institute of Gaya, Av. dos Descobrimentos 333, 4400-103 V.N.Gaia, Portugal.

Abstract

This paper proposes the development of a technological platform for support of psycho-technical tests in higher education institutions. This subject deals with a topic extremely important for the institution and for students, because the platform will serve internally to assist students in preparing them for the professional life. The application is web hosted and exclusively built using open source technologies. The application allows teachers to create new psycho-technical tests in various technical and scientific fields. Each psycho-technical test is composed of several multiple-choice questions, and the teacher may specify the list of alternative answers and indicate a maximum response time for each question. For its part, the students can visualise the list of psycho-technical tests available organised by subject. The platform registers the performance of students in several domains and allows students to practice and improve their skills. In this way, students may be better prepared for job interviews and, consequently, for the job market.

Keywords: Psycho-technical tests, web applications, software engineering, student evaluations, information technology.

* ADDRESS FOR CORRESPONDENCE: **Fernando Almeida***, INESC TEC, University of Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal. *E-mail address*: almd@fe.up.pt / +351 22 557 0800

1. Introduction

Currently, organisations are constantly seeking employees who can add value to their business, due to the high competitiveness in the labour market and the need for excellence in the services provided. For that, it is essential that the recruitment process could be conducted in an effective way. One of the tools that have been used in this direction is psychometric tests, which can contribute to more accurately evaluate the profile of the candidates.

Psychometric tests are, in essence, exercises that the future employer proposes to the candidate to be able to measure and evaluate the different aspects that he considers relevant for the performance of the function in question. They are usually written tests, timed and there is only one correct answer. Each test measures a single characteristic, however, the fact that it has a time limit allows to perceive how the candidate reacts in situations of pressure, how fast his reasoning was, the type of time management, etc. They require technical resources designed and validated for this purpose (Van der Merwe, 2002). Its contents may not be directly related to the function to occupy. They are also the tools used by professional psychologists for research and evaluation of individual differences.

However, the use of psychometric tests in the recruitment and selection (RS) process is not entirely consensual. Tests used in personnel selection area are quite criticised because there are few built for this or that activity field and professional area (Pasquali, 2001).

The primary goals to be achieved in the development of the platform are as follows.

- It should allow performing the tests by the final user.
- It should record the evaluation of each user and keep history.
- It should provide statistic or relevant information about a certain user, etc.

The paper is organised as follows: First, we perform a literature review in the field of psycho-technical assessment tools followed by the identification of the main related work and applications available in the market. Then, we present the adopted methodology followed by the discussion of the main results of the project. Finally, we draw the conclusions of our work.

2. Background

Testing is an English word meaning 'Proof', derived from the Latin 'testis' and is used internationally to refer to a well-known measurement modality today in various scientific and technical fields. A measurement is only called if testing is used primarily to find about the individual instead of answering a general question (Miller & Tsang, 2010). The science behind psycho-technical testing is called psychotechnics, which has origins in the psychophysics of German psychologists Ernst Heinrich Weber and Gustav Fechner.

The modern psychotechnics has two elements: the classical test theory (CTT) and item response theory (IRT). CTT is engaged in the interpretation of the final answer, meaning that the sum of the items says about the subject; on the other side, IRT is intended to measure the ability of the subject according to the responses to each item. That is, the end result CTT parses and analyses IRT parts and probabilities that generate the final result (Sartes & Souza-Formigoni, 2013).

Skills can be defined as inherent characteristics of an individual that can be made for their abilities, traits, personalities, social role he or she uses to achieve its goals (Rigby & Sanchis, 2006). The skills can be divided into two groups: 1) soft skills and 2) hard skills. Soft skills are the behavioural and social skills of the professional. They are associated with the mental and emotional abilities of each person. They are more difficult to teach and to be measured, often corresponding to a person's innate abilities. On the other side, hard skills are the person's technical skills. These technical skills are taught at school, in training, or at a job and can be easily measured in candidates and tested in a job interview. They are especially important in fields such as engineering, technology, law or medicine.

For context, psycho-technical tests are used in several areas of the branch of human resources (HR). HR Management is a field of study that form trained professionals to manage people and handle all processes related to the management of the staffs of a company. Psychotechnic tests are one of the techniques used in the area of RS, the stage of recruitment used by HR companies in conjunction with other techniques such as interviews, medical examinations and other.

RS practices adopted in Portugal are relatively little known given the lack of studies of data availability. Thus, it highlights three important studies (Cardeira, 2011; Matosinhos, 2012; Silva, 2015). The most complete study involved 71 public and private organisations of all sizes of employment and various activity sectors in the region of Lisbon and Setubal. Data were collected by postal survey sent to organisations in those regions. The response rate in this study was 31%. The most used recruitment media are placing ads (67%), the use of unsolicited applications (62%) and obtaining professional references (57.1%; Matosinhos, 2012).

The most common psycho-technical tests used are as follows.

- **Personality tests** are those that obviously measure personality traits such as emotional, social and pathological characteristics, mainly as aggressiveness, inhibition, exhibitionism, personal organisation, respect for hierarchy, behaviour in different social interaction situations and many others.
- **Objectives or direct tests** are questionnaires, scales or inventories where it is clear to the person assessed that the goal is to analyse their personality, since they are made related questions directly to their ways, feel and analyse their life and the world around them and it is often used to Likert scale that associates to figure outone's opinion about the item.
- **Projective or indirect tests** are called projective tests based on theory, which the person being tested when looking process ambiguous information, or conducting a manual task not clearly related to a test as the PMK, the coloured pyramids test of Pfister.
- **Reasoning tests** are those used to measure the mental abilities of a particular person. Usually, as the domain of verbal language of deductive abstract thinking and spatial reasoning. These tests are more robust through the preliminary study evaluation.
- **Specific skills tests** are the nomenclature used for the tests that do not fall into the above categories and are related to the evaluation of memory and attention in its various forms.

The use of computer-based tests (CBTs) has been tested in several higher education institutions. CBT is seen as a catalyst for change, bringing transformation of learning, pedagogy and curricula in educational institutions (Scheuermann & Pereira, 2008). CBT is also stated as more stable and consistent in terms of internal and external validity and stimulates the participation of students (Piaw, 2012).

3. Related Work

Through the study were identified some IT applications that allows to make psycho-technical tests: 1) Vienna testing system (VTS)[1]; 2) Psychotechnic online[2] and 3) testworlds[3].

VTS is a computerised psychological testing system developed on the second standard models at European level and certified with the quality management system medical devices, which supports all types of tests. VTS is available in seven languages and has also been adapted to different world cultures. This provides a multitude of tests covering various areas of diagnostics and psychological evaluation, organisational psychology, diagnostic skills, among others. The software consists of modules, testing, evaluation and examined the settings list.

---

[1] https://www.schuhfried.com
[2] https://www.practiceaptitudetests.com/psychometric-tests/
[3] http://es.testsworld.net

Almeida, F. & Castelo, D. (2018). A technological platform for the creation and evaluation of psycho-technical tests. *Global Journal of Computer Sciences: Theory and Research.* 8(1), 53-61.

Psychotechnic online has been online since 1992 and provides a wide range of courses to classroom and online psycho-technical tests, providing custom test platforms. *Psychotechnic online* has partnerships with the largest recruitment companies operating in Portugal such as Adecco, Vedior and SHL Solutions.

Testworld is a website that offers a wide variety of tests and questionnaires through the online platform such as intelligence tests and many more.

Table 1 presents a comparative analysis of the similar tools above presented according to criteria such as: 1) available online; 2) desktop version and 3) authentication need.

Table 1. Descriptive statistical analysis of technical competency dimension

Tools	Available online	Desktop version	Authentication need
VTS	No	Yes	Yes
Psychotechnic	Yes	Yes	No
Testworld	Yes	No	No

4. Methods

4.1. Physical architecture

The physical architecture describes the set of source files, data files, libraries, executables and others that physically compose the software.

The application adopts a 3-tier architecture. In this kind of architecture, despite the complexity of the environment, the division of tasks into layers allows for greater distribution of system processing. In the client layer, we have only the forms that will be opened in the execution of the program. The application server layer is for the execution of the business rule, calculations, processes, reports in addition to communicating with the database layer.

The physical architecture of the system is depicted in Figure 1. The application adopts a MySQL database, PHP language for the application server layer and the HTML5, JavaScript and CSS are used in the front-end layer (http://html.com/css/; https://www.w3.org/TR/html5/; https://www.javascript.com; http://www.mysql.com).
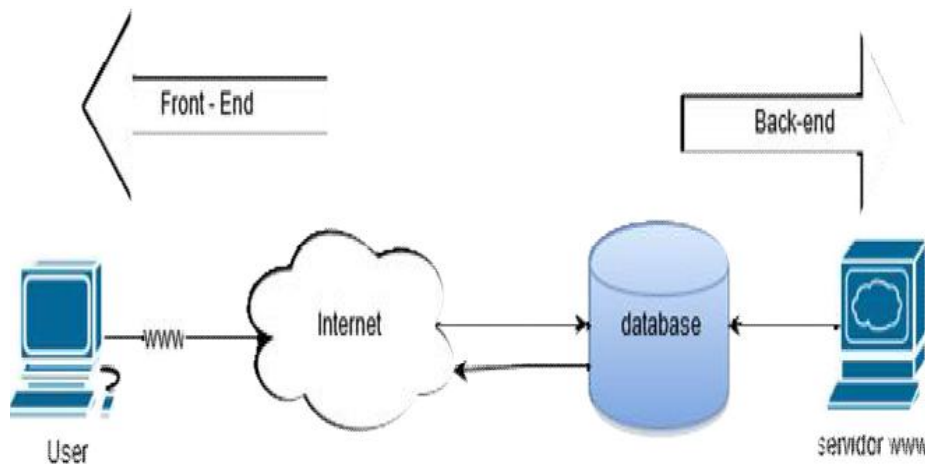

Figure 1. Physical architecture of the application

MySQL, it is the database management system that uses the SQL language as an interface. MySQL allows an easy integration with PHP. The database serves as storage throughout the system information and users.

PHP is an interpreted and free language, originally used only for the development of present and active applications on the server side, capable of generating dynamic web content.

HTML5 is a language for structuring and presenting web content and is a key technology of the Internet. This technology will help us as our tool will be web based. Web-based systems can be handled at anytime, anywhere and developed entirely in web/Internet platform.

JavaScript is the third development layer that handles the first two layers, HTML and CSS. It is a client-side programming language, that is, it is processed by the browser itself. With JavaScript, we can create special effects for our web pages and we can provide greater interactivity with our users.

CSS is a technology used to format HTML, XML and XHTML documents, its main benefit is provider separation between the format and content of a document.

Besides those technologies, NetBeans is used as the development environment. NetBeans is an integrated and free development environment that enables us to develop software in languages, Java, PHP and others and also offers tools needed to create professional desktop applications, web and mobile.

4.2. Logical architecture

Figure 2 is a demonstration of the events that happen when the user is logged in the system. The system must load the user according to their type of the management module or to user module. The management module allows administrator to manage all the information necessary to operate the system, from data entry and maintenance. User modules are used to establish communication with the end-user.
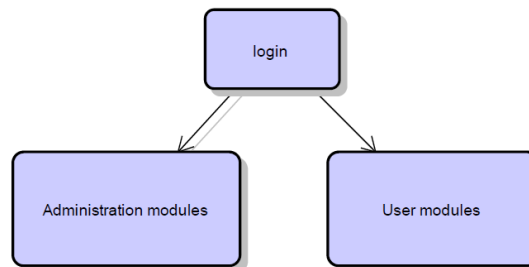

Figure 2. Logical architecture of the application

4.3. Class diagram

The web platform uses a MySQL database consisting of the following tables.

- Table *tests* allow the creation of the tests and define their characteristics, such as execution time and state.
- Table *areas* allow the establishment of study areas where tests and questions are created.
- Table *users* save information regarding the users who access the system.
- Table *type_users* allow the user to assign its kind for access to the platform.
- Table *historic* stores information of the tests.
- Table *historic_answers* save the answers given by each authenticated user for each performed test.
- Table *questions* let the teacher to create new questions on the platform.
- Table *tests_questions* allow the storage of questions raised in the system, which can be later included in tests.

4.4. Functional requirements

The system offers seven modules, like it is described below.

- Test management allows the characterisation of a test, how to create, change, remove and list.
- Management area enables adding new thematic areas for the tests as Portuguese, mathematics, general culture, etc. It also lets the administrator to create, change, remove and list areas.
- User management enables adding users to the system such as administrators, teachers, students; all those who interact with the tool, to the management level as the end-user level.
- Statistics shows the history to a broader level of actions taken on the tool, i.e., the students have access to a report about their performance.
- Management of questions lets the teacher to create questions that will appear in the tests. The questions will be created according to the areas of necessary tests.
- Testing allows users to perform the tests on the tool. The available tests will be organised by subjects.
- History lets each user to store his/her personal history since it is on the platform, as well, keeping relevant information as the score over time, as their evolution.

4.5. Non-functional requirements

Non-functional requirements define the overall qualities/attributes of the resulting system. They place restrictions on the product being developed, the development process and specify external constraints that the product must meet (Sommerville, 2015).

In the context of this project, the following non-functional requirements were defined as follows.

- Security, we need to ensure data security and access permissions functionality, by encrypting passwords, define access to the menus of the system according to the user's hierarchy, creating data editing rules in the system, etc.
- Usability, necessary requirement which intends to guarantee an easy system that dispenses many graphics capabilities, if possible adding descriptions to the buttons and shortcut keys.
- Effectiveness is reflected on reducing response time and processing that the application will use, as well as the number of resources used and the duration of its use in the execution of functions for creating authentication tests etc.
- Portability, the application must be adaptable to different environments, with the ability to be viewed on different devices with Internet facility.
- Maintenance, this requirement is reflected in the ease with which the program can be corrected if an error occurs, as well as the agility to make the necessary changes and desirable, or even be adjusted environment changes.

5. Results and Discussion

In this section, we will demonstrate how the proposed tool fulfils both functional and non-functional requirements. At the functional level,, we implemented all modules and features required.

Unit testing is the most elementary way to test an IT application. At this level, each software module or component is tested individually. The purpose is to validate that each software module runs as expected. The unit testing process offers basically four benefits: 1) ensure that problems are discovered early; 2) make it easier to maintain the code; 3) serve as documentation; and 4) help to improve code design (Jorgensen, 2013).

Unit tests were performed using functional level, such as entering data, create tests, conduct tests and consult historical and statistical and according to applications requirements have been implemented with success.

Figure 3 shows the main page of the application, where the user must provide his access id and password. The interface is in Portuguese language, but can be easily customised by the user to English.
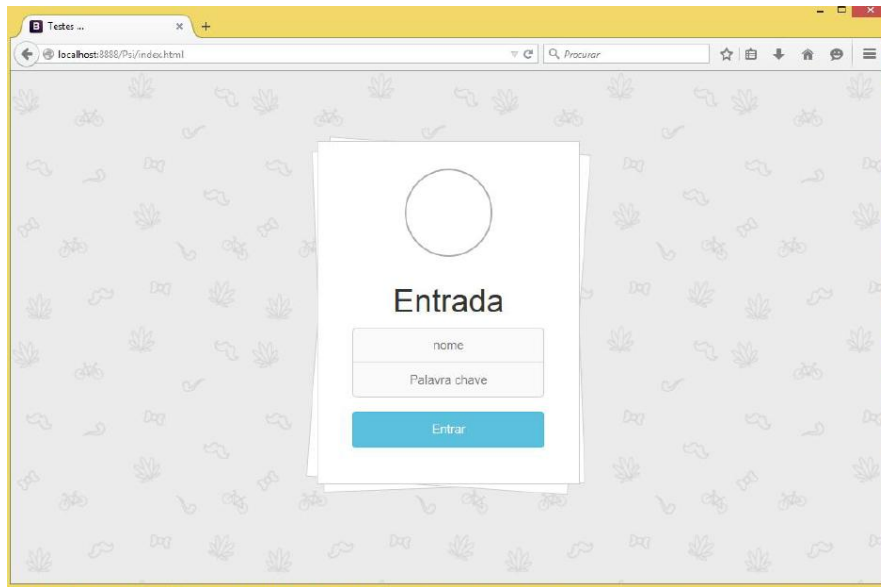

Figure 3. Login page

Figure 4 provides the statistical analysis of the tests performed by the user. On the left side, we can consult and perform a search by the total number of tests performed in each area. On the right side, we can see a graphical representation of this information using a pie chart.
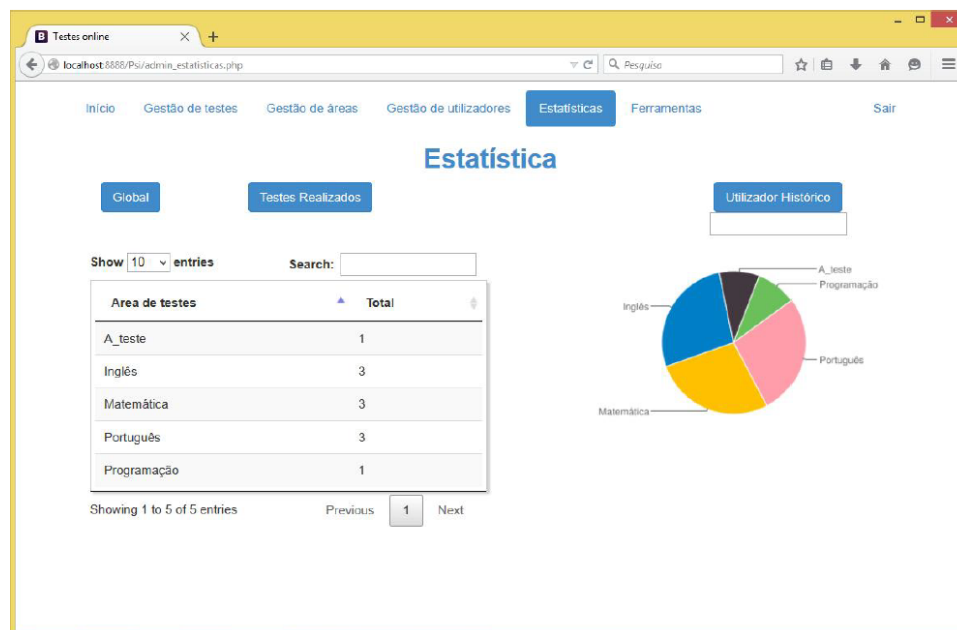

Figure 4. Statistics page

Almeida, F. & Castelo, D. (2018). A technological platform for the creation and evaluation of psycho-technical tests. *Global Journal of Computer Sciences: Theory and Research. 8*(1), 53-61.

In order to test the non-functional requirements, we created two scenarios as follows.

- Scenario 1: Five students who always respond the same test in which the answers are positive. In the first interaction, three in five students had the same score with different times, meaning that all the responses were given within the established time. In second interaction, five students obtained different scores with diverse times. This situation implies that some answers exceeded the average time defined for each question, which results that the overall score was penalised by the time spent doing the test.
- Scenario 2: Ten students filled three tests with very uneven results among them. They had different overall scores, because they were penalised by the number of wrong answers and the time that they took to do the tests.

In addition, tests were also carried out in terms of portability, performance and security. A brief description of them is given below.

- Portability tests: With the help of the screenfly tool[4] from quicktools online testing platform, we can test the site's behaviour in different devices such as Tablets, ipad and cell phones of different brands and waxes size. The results have been successful because it was possible to take any action on site through any the tested devices, because of our responsive technology.
- Performance tests: They were performed with the help of BadBoys tool[5], performance testing and usability and response time from the server to a client station when we conducted an action. Table 2 summarises the average and maximum time of the responses of each of the application modules.

Table 2. Results of performance tests

Administration tests	Avg. T(milliseconds)	Max. T(milliseconds)
Test management	1521	4655
Areas management	471	620
User management	1006	2015
Statistics	800	800
Tools	563	782
Tests	567	5627
Total	4928	14499

- Security: For safety tests, we try to make only one variable at a time, user or password, the system had the expected behaviour because of the login, the system accepts only the fulfilment of two variables since the user exists in the database. For the SQL injection tests in the test log by putting the username 1 'or' 1 '=' 1 ')) and 1' or '1' = '1')) - and 1 'or' 1 '=' 1 ')) / *, and the result was positive because we are using the *real_escape_string*, on the other hand we are using to access the BD MySQLi which increases the security.

6. Conclusions

The proposed approach intends to help students with the use of a platform that will assist them as a training tool in their preparation for the professional career. The idea was to develop a user-friendly platform, which not needs to be installed, it is intuitive and will not cause navigation issues to students. In addition, the adoption of open source technologies allows us to guarantee the absence of software costs by the university institutions and a greater capacity in the integration with other applications, and facilitates the development of additional modules.

---

[4] http://quirktools.com/screenfly/
[5] http://www.badboy.com.au

Almeida, F. & Castelo, D. (2018). A technological platform for the creation and evaluation of psycho-technical tests. *Global Journal of Computer Sciences: Theory and Research. 8*(1), 53-61.

The greatest motivation for this implementation is the idea to develop a tool with a broad potential, but, at list initial stage, we primarily focus on university audiences. The project offers two distinct access interfaces for the administrator and user. The administrator, a role that can be performed by psychology offices of a university institution, allows designing personalised tests according to the several technical, social and behavioural areas. The user, a role that can be performed by students, allows them to respond to each test. After that, users can view their history and statistics in the application.

For future improvements, there are some features that could be implemented, namely: 1) improve data insertion rules or restriction; 2) inclusion of questions with images and videos and 3) improve the statistical module to allow the indusion of information regarding the average score of a given user in different test areas.

References

CSS. Retrieved from http://html.com/css/ on 20 August 2017.

HTML5. Retrieved from https://www.w3.org/TR/html5/ on 20 August 2017.

Javascript. Retrieved from https://www.javascript.com on 20 August 2017.

MySQL. Retrieved from http://www.mysql.com on 20 August 2017.

Cardeira, D. (2011). *Praticas de recrutamento e selecao em Portugal*. Retrieved from http://www.repository.utl.pt/handle/10400.5/4511 on 20 August 2017.

Jorgensen, P. (2013). *Software testing: A Craftsman's approach*. Boca Raton, FL: CRC Press.

Matosinhos, H. (2012). *Praticas de recrutamento e selecao em consultadoria de gestao de recursos humanos*. Retrieved from https://repositorio-aberto.up.pt/handle/10216/70720 on 20 August 2017.

Miller, K. & Tsang, E. (2010). Testing management theories: Critical realist philosophy and research methods. *Strategic Management, 32*(2), 139–158.

Pasquali, L. (2001). *Tecnicas do Exame Psicologico—TEP manual*. Sao Paulo, Brazil: Casa do Psicologo.

Piaw, C. (2012). Replacing paper-based testing with computer-based testing in assessment: Are we doing wrong? *Procedia—Social and Behavioral Sciences, 64*(9), 655–664.

Rigby, M. & Sanchis, E. (2006). The concept of skills and its social construction. *European Journal of Vocational Training, 37*(1), 22–33.

Sartes, L. & Souza-Formigoni, M. (2013). Avancos na psicometria: da teoria classica dos testes a teoria da reposta ao item. *Psicologia: Reflexao e Critica, 26*(2), 241–250.

Scheuermann, F. & Pereira, A. (2008). *Towards a research agenda on computer-based assessment—challenges and needs for European educational measurement* (JRC Scientific and Technical Report, 23306).

Silva, M. (2015). *Contributos para um referencial de boas praticas no recrutamento profissional nas redes sociais*. Retrieved from http://repositorio.ipvc.pt/handle/20.500.11960/1306 on 22 August 2017.

Sommerville, I. (2015). *Software engineering*. London, UK: Pearson Education.

Van der Merwe, R. (2002). Psychometric testing and human resource management. *SA Journal of Industrial Psychology, 28*(8), 77–86.