The relevance of product tests in the construction of educational artifacts in professional master and doctorate degrees in Brazil

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Abstract – Although they are mandatory requirements for obtaining a master's or doctor's degree in stricto sensu postgraduate courses of a professional nature, educational products are still an area to be explored in terms of their literature at the national level. This study highlights the relevance of performance tests for evaluating educational artifacts. The conceptual bibliographic method was used, which consists of four stages. These phases are a) definition of research questions, b) data collection on scientific bases, c) organization and analysis of data, and d) generation of answers to the research's guiding questions. The execution of these procedures allowed the construction of the study's theoretical framework, which brings the conceptual scope of the terms "educational product" and "product tests." In addition, this textual production lists and describes the types of existing tests to measure the quality and effectiveness of educational products. The types of tests presented are related to: a) effectiveness, b) efficiency, c) usability, d) market, f) compliance, and g) reliability. The study concludes that for a prototype (initial version of an educational artifact) to be considered a product, it must pass all these tests before having its final version released to its target audience.
Kewords: Educational Product. Effectiveness Assesment. Quality Assesment. Technological Product. Types of Product Tests.

A relevância dos testes de produto na construção de artefatos educacionais nos mestrados e doutorados profissionais no Brasil

Resumo – Embora sejam requisitos obrigatórios para a obtenção do título de mestre ou doutor nas pós-graduações stricto sensu de natureza profissional, os produtos educacionais ainda se mostram uma área a ser explorada no que tange a sua literatura no âmbito nacional. O presente estudo tem por objetivo evidenciar a relevância dos testes de desempenho para a avaliação de artefatos educacionais. Para a consecução deste intento, utilizou-se o método bibliográfico conceitual, o qual é constituído por quatro etapas. Estas fases são a) definição das perguntas de pesquisa, b) coleta de dados em bases científicas, c) organização e análise dos dados e d) geração das respostas para as questões norteadoras da pesquisa. A execução desses procedimentos permitiu a construção do marco teórico do estudo, que traz o escopo conceitual dos termos “produto educacional” e “testes de produto”. Além disso, a presente produção textual elenca e descreve os tipos de testes existentes para mensurar o nível de qualidade e efetividade dos produtos educacionais. Os tipos de teste apresentados são os relativos a: a)

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eficácia, b) eficiência, c) usabilidade, d) mercado, f) conformidade e g) confiabilidade. O estudo conclui que para que um protótipo (versão inicial de um artefato educacional) passe a ser considerado como produto, é necessário que o mesmo seja aprovado em todos estes testes antes de ser ter sua versão final divulgada para o seu público-alvo.
Palavras-chave: Produto Educacional. Avaliação da Efetividade. Avaliação da Qualidade. Produto Tecnológico. Tipos de Testes de Produto.

Introduction

Differently from what happens in lato sensu graduate programs, professional master's and doctorates require the generation of a product as a mandatory requirement for granting a master's or doctor's degree. Some themes concerning this theme have already been worked on in the national literature. Among them, the issue of the challenges inherent in creating and disseminating products stands out (Gonçalves *et al*., 2019). Another recent study in the field of products concerns the steps required to develop a science-based technological artifact (Silva *et al*., 2019). This study aims to demonstrate the significance of product tests for constructing educational artifacts. Although the scientific production regarding the generation of products is expanding, a gap in theoretical and empirical studies that describes the importance of each mandatory step for materializing educational artifacts. This study was produced to collaborate with the national state of the art (Santana, 2017).

Two reasons, one of a theoretical nature and the other of a practical nature, motivated this work. The first aims to explain in an objective and didactic way the reason for the need to carry out tests on educational products. It is necessary to measure a technology's efficiency, effectiveness, and usability (Nascimento-e-Silva, 2020). The practical aspect aims to help master and doctoral students regarding the correct procedures to be adopted in the testing phase of their educational devices. It is opportune for the researcher to know the types of existing tests, the magnitude of each one for the product to be successful, and what each category of test proposes to evaluate.

This study is organized into six topics, starting with this introductory section. The second moment of the investigation lists the concepts concerning the theme of educational products. In the third step of the text, the conceptual scope immanent to product tests is exposed. The fourth phase of this textual production describes the methodological procedures adopted to carry out this work. The fifth item of the study describes the types of existing product tests and their applicability and relevance. The piece ends with the conclusion obtained after explaining the themes worked here, followed by the references that constitute the theoretical mainstay of the present study.

Materials and methods

This study used the bibliographic and conceptual method developed by Nascimento-e-Silva (2012; 2020). It should be noted that the method mentioned above consists of four steps: a) definition of the research question, b) data collection, c) data organization and analysis, and d) generation of responses. The definition of the guiding research questions (Brei; Vieira; Matos, 2014) focused on three questions: "What is an educational product?", "What are product tests?" and "What are the existing types of product testing?". With these questions in hand, the next step consisted of collecting the answers to these questions in the databases, which are the places recommended by science to find reliable and valid scientific knowledge (Nascimento-e-Silva, 2012; 2020). The database used for the production of this study was Google Scholar. Due to the scarcity of answers at the national level, it was decided to search for answers in international studies for the most part. With the answers found, the next step consisted of organizing and analyzing the statements collected. For this purpose, a reference material called data mass (Nascimento-e-Silva, 2012; 2020) was used, represented by a table composed of two

columns. The first column brings the references of each work consulted, according to the rules of the Brazilian Association of Technical Standards (ABNT). In the second column, the statements collected in the previous phase are transcribed between quotation marks and accompanied by their respective page numbers.

Concerning the analysis of the collected data, we verified the terms of equivalence (Nascimento-e-Silva, 2012; 2020) in each localized answer. Through this technique, it was possible to identify the underlying logic of each collected concept and to detect the similarities and differences present in each analyzed statement. With the verification of the most repeated terms in each account, the next step was to generate answers for each question defined at the beginning of the research process. After these procedures, the parts that make up the study were written. The theoretical framework brings the interpretations of each concept extracted from the search for the state of the art (Santana, 2017) of each topic researched. The methodological procedures describe the steps taken to materialize the study. The conclusion highlights the inferences made by the authors of this work after its completion, followed by the references that support this textual production. The introduction provides the reader with an overview of the themes addressed in this text. Finally, the summary objectively summarizes the main parts of this work on testing educational products.

Educational Product: conceptual scope

Araújo, Rodrigues, and Lorenzano (2014) point out that the educational product is mandatory for obtaining a master's or doctor's degree in stricto sensu postgraduate courses. In addition to being an essential requirement, an educational artifact must be noted for its ease of access and handling. It suggests that a product whose usability is complex or whose accessibility requires the execution of several steps needs to undergo improvements (Paraschivescu; Cotîrlet, 2015) so that these nodal points are resolved. In addition, these authors consider that the product needs to become known for helping the teaching and learning processes. The educational product needs to be developed to solve a problem (Lukosevicius, 2018) in its application environment.

Lin *et al*. (1999) and Chang (2019) consider that before the educational product is presented, its creators must survey the entire methodological path until the artifact's materialization. It ranges from the definition of the problem (Lukosevicius, 2018) that will be addressed in the research field to the dissemination of the final version of the product to its target audience (Nascimento-e-Silva, 2020; Silva *et al*., 2019). The authors mention that the presentation of the product is an opportunity for its creators to reflect on how the artifact dialogues with its users, whether to convey ideas or content or to carry out some improvement (Paraschivescu; Cotîrlet, 2015) in teaching and learning processes.

Plom (2010) and Nieveen (2009) list the characteristics of a consistent educational product. For these authors to assess the efficiency of an artifact of this nature, it is necessary to consider three dimensions: a) expectations, b) reality, and; c) conditions. The expectation is well evaluated when the educational product meets the needs (Albuquerque *et al*., 2018; Silva *et al*., 2019) of its users. In this particular reality corresponds to the performance of the artifact when handled by its target audience. And the term "conditions" is related to the product's performance without oscillations under different conditions.

Complementing the speech of Plom (2010) and Nieveen (2009), Delgado (2014) states that the educational product must generate a positive impact on its operating environment. With this information in hand, it is considered that by meeting the needs (Albuquerque *et al*., 2018; SILVA et al., 2019) that it proposes to meet, the product provides a positive impact on the spaces and contexts in which it is applied. Let's see a practical example: a portfolio of extension courses aims to strengthen the university's relationship with the surrounding community. In the interaction between the institution and the external environment, the organization that offers the extension courses and the community members formed by these initiatives benefit.

Andelković, Radosavljević, and Arsenijević (2018) discuss another aspect relevant to educational products: their longevity. In other words, when an educational artifact is presented at the end of a master's or doctoral degree, it should not be considered an end. In other words, delivering a master's or doctor's degree does not exempt the product creator from constantly updating and improving (Paraschivescu; Cotîrlet, 2015) the product he developed. These updates are necessary for two reasons. The first relates to the product's interface with its users since if an artifact disseminates concepts and reports no longer in force, its credibility is weakened. The second factor is linked to the artifact's quality (Slack; Chambers; Johnston, 2009) since science and technology are dynamic and constantly evolving.

If well applied, it contributes assertively to the materialization of an educational device. Egupova (2012) considers that the educational product results from a student's scientific and pedagogical activity. The scientific aspect of the products resides in the researcher's obedience to specific rules and methods (Nascimento-e-Silva, 2012; 2020). The expression "pedagogical" suggests that the educational product needs to include some activity concerning education as a field of application. These activities include teaching, research, extension, innovation, or technological entrepreneurship (Nascimento-e-Silva, 2017).

Sousa (2013) reports that the educational product combines theoretical knowledge and professional practices. The theoretical aspect of the product is linked to the field of research, through which the master's or doctoral student will appropriate the concepts concerning the topic they want to study or the problem (Lukosevicius, 2018) that they propose to solve. The practical part of product development involves the researcher going to the field to collect data with a group of respondents or test the product with their target audience. Sousa (2013) mentions that this process must be contextualized and reflective. Contextualization concerns the coherence of the product with the objectives of the study. At the same time, reflection can be understood as knowledge about the context or environment in which the educational product will be applied.

Patel (2019) makes a pertinent observation regarding the theme of educational products. According to this definition, the idea of a product applied to a particular branch of education or teaching is not the same as that used for goods manufactured in the industrial sphere. However, a product can generate resources if it is patented according to the principles of intellectual property. Although in the production of an educational artifact, some concepts related to product engineering are applicable (Tonetto; Romano; Marçola, 2018), the main objective is not to generate profit but rather to provide increments in the many fields in which education and teaching are deficient.

For this study, an educational product can be understood as the result of scientific research, which will generate a technology to be applied in a given field of activity to improve existing teaching and learning processes. It is emphasized that the generation of a product consists of the agglutination between theoretical knowledge and practical experiences. It will allow a more robust understanding of the problem you propose solving or the subject you want to deepen. The realization of an educational product requires the observance of good practices in the field of science, which will help the researcher in the research, elaboration, tests, adjustments, and dissemination of the final version of his educational artifact. The tests and retests, as well as the adjustments and readjustments, transform prototypes into products.

Biswas, Udai, and Kumar (2020) consider that product testing is one of the most critical points in developing educational artifacts. Criticality indicates that this part of the technology creation process must be systematically and planned. It is necessary so that, in the event of any unforeseen occurrences during the testing phase, the dissertation or thesis project is not jeopardized, especially regarding its delivery deadline. In addition, the researcher needs to choose the most appropriate strategy to evaluate their educational artifact since this type of material is only considered approved if it passes the performance tests to which it is submitted

(Nascimento-e-Silva, 2020).

Lubwama (2020) synthesizes the concept of product testing in its practical sense. It demonstrates the tested technology's assertive aspect and makes unnecessary adjustments to the product. In summary, testing products means finding out if they work as expected. Here there are only two possibilities to be considered. The first happens in cases where the artifact satisfactorily meets its target audience's needs (Albuquerque *et al*., 2018; Silva *et al*., 2019). The second situation occurs when an artifact is tested and indicates a lack of improvement (Paraschivescu; Cotîrlet, 2015) in some components. When this happens, the master's or doctoral student must identify where his artifact needs reinforcement to provide the necessary rectifications. Suppose the number of required corrections is high. In that case, it is recommended to re-plan (Nascimento-e-Silva *et al*., 2013) the work developed until the testing phase to obtain better results.

Racat and Capelli (2020) mention two types of product tests. The first is the physical test, which is seen as more realistic. When the artifact produced is handled by its users, topics such as quality, usability, and response time are immediately perceived by the people who use it. Regardless of whether the artifact is physical or virtual (Racat; Capelli, 2020), the product must be subjected to tests that can certify the scientist of its efficiency and effectiveness in the fields in which it is applied. It reinforces the need for educational products to stand out for their ease of handling and accessibility (Araújo; Rodrigues; Lorenzano, 2014). Hammad *et al*. (2020) reinforce the need for product tests. The study of these authors highlights that carrying out the tests is necessary to identify eventual errors or defects in the functioning of the artifact produced to be improved. They describe the process of evaluating the performance of the software. Hammad *et al*. (2020) cite as an example of failure in product tests the existence of hidden errors, which need to be investigated to be detected.

In the view of Fallahudin, Admaja, and Iwandana, product testing is an appropriate step, which integrates a total of 8 stages for creating a product. The phases are a) survey of information in the field, b) a decision on which products will be built, c) a development of initial product versions, d) validation, e) small-scale trials and reviews, f) large-scale trials and reviews, g) manufacture of the final product, and h) performance of efficacy tests. A procedural logic can be seen in this sequence of steps, which, if well performed, will necessarily generate a result (Brito *et al*., 2016; Silva, 2019), which in this specific case is the educational product resulting from a master's dissertation or professional thesis doctorate.

Nascimento-e-Silva (2020) lists three reasons that justify testing in the generation of new technologies. The first of them concerns the functioning of the artifact produced. In other words, it means knowing whether the product works or not. The second factor is related to how the artifact works. In other words, the tests aim to measure whether the product can repeatedly present the same degree of performance without oscillations. And the third reason that attests to the need to carry out tests on products concerns the detection of defects or low points that need reinforcement. Nascimento-e-Silva (2020) mentions the term prototype (Rogers; Sharp; Preece, 2019; Silva *et al*., 2019) when describing the necessary steps to generate technological artifacts. He states that every prototype is an unfinished version of the product. It means that the prototype needs to pass the tests it is subjected to be transformed into a product. Only then can the prototype be released to its target audience.

For this study, product testing is a mandatory step in developing educational products, which aims to ascertain the artifact's working conditions and identify errors that need correction. For a prototype to be considered a product, passing the performance tests is a sine qua non-condition. It reinforces the significance of product tests in developing and validating educational artifacts since, without them, technology cannot be considered able to be disseminated to its respective public of interest.

Types of product tests and their applicability

The production of this research stage was used as a reference to the study by Nascimento-e-Silva (2020), which didactically detailed the meaning of each phase necessary to develop educational products through the scientific-technological method. In summary, this method consists of two dimensions. The first one is scientific and aims to produce the necessary knowledge to support the product to be generated consistently (Nascimento-e-Silva, 2020). This dimension consists of four steps previously described in this study's "Methodological procedures" section.

The reason for carrying out the phases that make up the scientific dimension is to ensure that the educational product has the necessary theoretical consistency to meet the objectives of the thesis or dissertation. In addition, the execution of the scientific dimension items is essential for two other reasons. The first is the research and writing of the master's or doctoral student's textual production. The second factor is methodological and aims to help the researcher organize the knowledge necessary for constructing his artifact. Nascimento-e-Silva (2020) explains that two possibilities can happen in this dimension. The first considers that scientific knowledge is already available and only needs to be organized logically and then encapsulated in a technological artifact. The second possibility occurs in cases where the knowledge has not yet been generated, which will require the master's or doctoral student to have a research plan for the production of each piece of knowledge necessary for the materialization of their product.

The researcher's next topic to be worked on is the execution of items related to the technological dimension. Nascimento-e-Silva (2020) narrates that after completing the acquisition of knowledge, the researcher needs to define how he will encapsulate this knowledge in an artifact, which may be physical or virtual (Racat; Capelli, 2020). This decision should consider the type of product that the master's or doctoral student intends to develop. The idea here is that the technology to be tested needs to be easy to handle and contextualized with the objectives of the dissertation or thesis (Araújo; Rodrigues; Lorenzano, 2015; Sousa, 2013).

According to CAPES (2013) and Gonçalves *et al.* (2019), the following artifacts are considered educational products:

- Educational media: (videos, simulations, learning objects; animations);
- Educational prototypes;
- Teaching proposals (didactic sequences; proposals for experiments and interventions)
- Textual material (teaching guides, manuals, textbooks, para-didactics, comics);
- Interactive materials, such as games and kits;
- Extension activities;
- Application development;
- Event organization;
- Radio and T.V. programs;
- Research reports;
- Patents
- Technical services.

Faced with these examples, the master's or doctoral student needs to decide which of these 12 possibilities best suits the objectives of their dissertation or thesis. It is appropriate to mention in this sense the relevance of the qualification exams since it is in this event that the student obtains the approval of an examining board to proceed with his research project. In addition, another relevant point of the qualification is the suggestions for improvements (Paraschivescu; Cotîrlet, 2015) proposed by the members of the examining board, which must be appreciated by the future master or doctor together with their advisor.

The steps that make up the technological dimension in the process of building educational artifacts are a) prototype generation, b) prototype tests, c) prototype adjustments, and d) dissemination of the final product (Nascimento-e-Silva, 2020; Silva, 2019; Souza, 2020). After

deciding which product will be generated, the stricto sensu professional graduate student must test the material produced to certify the performance level achieved. For this, it is recommended to carry out the tests proposed by Nascimento-e-Silva (2020).

The first test is that of effectiveness. Here the logic is: the prototype to need does what it sets out to do. For example: conducting a distance course in the MOOC modality (Pino, 2017), which is the acronym of the term Massive Online Open Courses, must unequivocally meet the needs that it proposes to meet. The effectiveness test consists of knowing whether or not the product meets the purpose for which it was designed. The primary purpose of a MOOC is to disseminate knowledge through open educational resources (Zancanaro, 2015). Therefore, some elements are mandatory, such as a virtual learning environment, communication between the tutor and the student, and didactic materials that help understand the MOOC subjects. Suppose the product developed is a didactic sequence with methodologies aimed at students in Youth and Adult Education classes. In this case, the expected result is increased student learning, performance, and assessments.

The second test is efficiency. Nascimento-e-Silva (2020) reports that to be efficient is to obtain high performance with the lowest possible consumption of resources. In other words, the educational product is efficient when its user handles the technology easily, without significant effort. It corroborates the speech of Araújo, Rodrigues, and Lorenzano (2015), highlighting the ease of operating the educational product as one of the requirements to be observed by masters and doctoral students. Let's see another example: if the educational product is an application, it must be interactive with the people who will use it. Commands executed by the user must be answered in milliseconds. Another item to consider is the application's appearance, which encompasses design concepts.

The third type of testing is usability testing. The idea regarding this test is that the more accessible and more straightforward the user's experience handling the product, the better its evaluation will be. In this test, it is recommended to ask people who participated in the prototyping phase (Nascimento-e-Silva, 2020) of the artifact if they had any difficulty using the product. The relevance of this test consists in identifying any item that needs adjustment since the user's handling experience with the product needs to be as easy as possible. If the product is difficult to operate or has a complex operating logic, the experience of people using the artifact will not be positive.

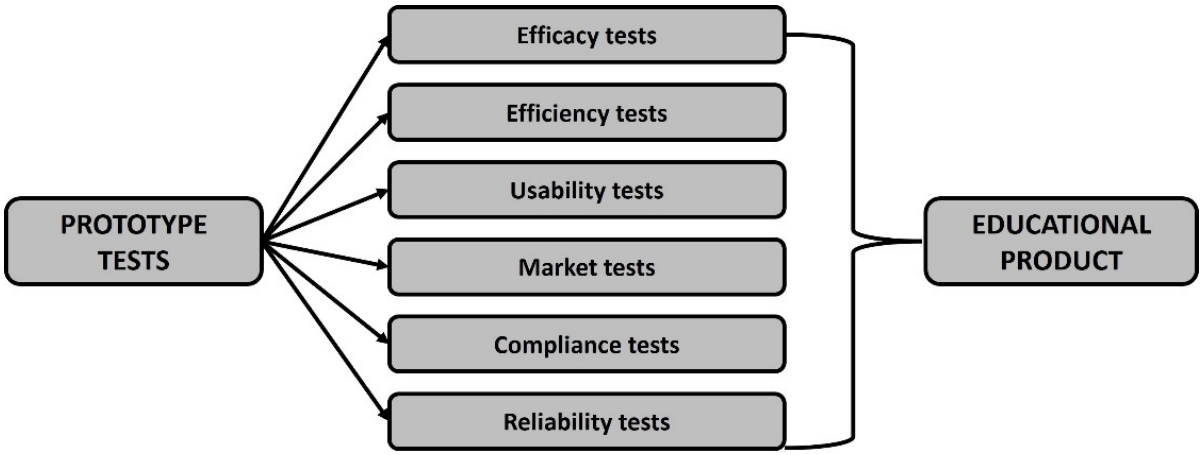
The fourth test is the market test. Nascimento-e-Silva (2020) explains that this test compares the technology produced with similar ones. This test aims to assess whether the product's performance is at the same level as the performance of competing artifacts. Let's go back to the example of the MOOC: as there are many distance courses, if the product generated in the master's or doctorate is in this field, its performance needs to be equal to or better than that of other existing MOOCs.

The fifth existing test is compliance. Briefly stated, this test verifies whether the product has the attributes and qualities expected of it (Nascimento-e-Silva, 2020). In this sense, people using the product need to perceive the minimum attributes that will make this artifact suitable for being disclosed to its target audience. In other words: having their needs (Albuquerque et al., 2018; Silva *et al*., 2019) fully met, the product users will attribute to it the aspect of quality (Slack; Chambers; Johnston, 2009). Otherwise, it is recommended that the researcher identify the low points of his artifact to provide the necessary rectifications (Nascimento-e-Silva *et al*., 2013).

The sixth and final type of test is reliability. It refers to the studies by Plom (2010) and Nieeven (2009), which consider meeting the expectations of users and their performance standards as essential elements of a product. In addition to this vision, Nascimento-e-Silva (2020) reports that the reliability test aims to measure whether the product can function whenever used. It attests that the educational artifact will not present a drop in its performance

under a specific condition or circumstance. It will make people who use the product attribute to it the aspect of trust, which is very positive for the success of a research project, whether in the field of master's or professional doctorate. The tests reported in this part of the study are summarized in Figure 1:

Figure 1 – Types of prototype testing



Source: Prepared by authors (2023).

It is imperative to state that while the artifact is in the testing phase, it should be called a prototype (Rogers; Sharp; Preece, 2013). Only after approval of the technology produced in all the tests shown in the figure can the material produced be considered a product. Nascimento-e-Silva (2020) says that after the end of the testing phase. This step is the disclosure of the final version of the product to its target audience. It means that the product is efficient, effective, easy to use, has market potential, complies with its attributes and characteristics, and is reliable from the point of view of its users. It makes the generated artifact a technology ready to be disseminated in its field of activity, in addition to being able to be replicated by other students who may show interest in making use of the product in their respective educational environments.

Conclusion

This study highlighted the existing types of product testing and their relevance for the construction of educational artifacts. In addition to ensuring that the product performs satisfactorily and meets the demands of its users, tests are necessary to ensure the reliability of the methodological procedures used to build the generated technology. It is essential not only to achieve the research objectives but also to make the tested artifact successful in its field of application.

In addition to listing and describing the types of existing product tests, this study addressed essential topics in constructing these items. It is considered that educational products are scientifically based technological productions aimed at application in a given field of knowledge. Although the purpose of educational products is not the same as that of goods produced in the business environment, it is recommended that applicants for a master's or doctor's degree pay attention to fundamental issues in their preparation. These questions cover aspects such as, for example, the ease of use of the artifact, its theoretical foundation and, mainly, its level of performance.

As for the tests described in this study, it is emphasized that no test is more critical than the other. In other words, all tests are relevant to ensure that the product unequivocally meets its intended needs. Each test evaluates a specific product dimension and precisely checks whether or not other educators can share and reproduce the artifact. Professional master's and

doctoral students are expected to use this material as a reference guide to assertively carry out their product tests to achieve the objectives of their research projects.

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