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USE OF BLUEPRINT IN CREATING A REFERENCE MATRIX AND ORDERING ITEMS FOR A PROGRESS TEST IN BIOMEDICAL SCIENCE

USO DE BLUEPRINT NA ELABORAÇÃO DE UMA MATRIZ DE REFERÊNCIA E ENCOMENDA DE ITENS PARA UM TESTE DE PROGRESSO EM BIOMEDICINA

USO DEL BLUEPRINT PARA CREAR UNA MATRIZ DE REFERENCIA Y ORDENAR PREGUNTAS PARA UNA PRUEBA DE PROGRESO EN BIOMEDICINA

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ABSTRACT: This paper aims to report the blueprint's applicability in preparing a reference matrix and subsequent ordering and preparation of structured evaluation items. This is an experience report from a group of educators working in a biomedicine course at a community higher education institution located in the interior of the State of São Paulo. The use of blueprints allowed for the systematic development of items more integrated with the educational objectives and competencies of the course as outlined in the teaching plans and pedagogical project. The motivation of the teaching staff is a determining factor for the creation, application, and use of a reference matrix such as the blueprint and subsequent preparation of assessment items.

KEYWORDS: Blueprint. Progress tests. Evaluative items.

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RESUMO: *O objetivo deste trabalho é relatar a aplicabilidade do blueprint na elaboração de uma matriz de referência e posterior encomenda e elaboração de itens avaliativos estruturados. Trata-se de um relato de experiência de um grupo de educadores atuantes em um curso de biomedicina de uma instituição de educação superior comunitária localizada no interior do estado de São Paulo. O uso do blueprint permitiu a elaboração sistematizada de itens mais integrados aos objetivos educacionais e às competências do curso, conforme previstos nos planos de ensino e no projeto pedagógico. A motivação do corpo docente é fator determinante para a feitura, aplicação e utilização de uma matriz de referência como o blueprint e subsequente elaboração de itens avaliativos.*

PALAVRAS-CHAVE: *Blueprint. Testes de progresso. Itens avaliativos.*

RESUMEN: *El objetivo de este trabajo es informar la aplicabilidad del modelo en la elaboración de una matriz de referencia y posterior ordenamiento y elaboración de ítems evaluativos estructurados. Este es un informe de experiencia de un grupo de educadores que trabajan en un curso de biomedicina en una institución de educación superior comunitaria ubicada en el interior del estado de São Paulo. El uso del blueprint permitió la elaboración sistemática de ítems más integrados con los objetivos educativos y las competencias del curso previstas en los planes de enseñanza y el proyecto pedagógico. La motivación del profesorado es un factor determinante en la creación, aplicación y utilización de una matriz de referencia como lo es el plano y posterior elaboración de los ítems de evaluación.*

PALABRAS CLAVE: *Blueprint. Pruebas de progreso. Elementos evaluativos.*

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INTRODUCTION

Progress Tests (PT) are assessments that can be employed both summatively and formatively. Assessment instruments, such as PT, enable the qualitative and/or quantitative detection of the level of knowledge and cognitive skills and allow for the (re)positioning of students, educators, and the teaching and learning process in undergraduate and other programs (Reberti et al., 2020; Troncon, 2016).

Nevertheless, the individual and/or collective construction of integrated and structured assessment items, whether open-ended or guided multiple-choice questions, is a complex process. It depends on multiple regulatory documents and presents challenges regarding standardization among faculty members, courses, and higher education institutions (HEIs) (Brazil, 2023; Feliciano et al., 2023).

In this regard, the use of reference matrices for the standardization, commissioning, and construction of assessment items serves the purpose of facilitating the process of question development, making them more precise and aligned with the educational objectives and competencies intended to be assessed within a set of curricular components or a Pedagogical Course Project (PCP) (Peçanha et al., 2022).

The blueprint is a visual mapping instrument that can be used to guide, define, and verify the content of a given assessment, specifying weights or, simply, the presence or absence of educational objectives or competencies, the integration between competencies and curricular components, and the degree of complexity of the questions via taxonomies and/or other tools (Ismail et al., 2020; Peçanha et al., 2022; Raymond & Grande, 2021).

The blueprint originated from architectural and service provision schemes, aiming to record, evaluate, and correct gaps between services offered and clients (Handy, 2006; Peçanha et al., 2022). In education, it has been widely employed in medical courses but reports on the use of the blueprint in health-related courses in Brazil, such as biomedical sciences, are still scarce (Feliciano et al., 2023).

Thus, the objective of this report is to describe the applicability of the blueprint in the development of a reference matrix and the commissioning of structured and integrated items aligned with the competencies and educational objectives described in the course syllabi and in the PCP of a biomedical sciences program at a community HEI located in the city of Sorocaba (SP).

Progress Tests within the Course

In the aforementioned undergraduate program, assessments are continuous, systematic, and aim to: i) stimulate student self-assessment; ii) diagnose and record students' difficulties, and guide them on the necessary procedures for overcoming such difficulties, in

addition to guiding the faculty members to reformulate the planning of the content delivered, if necessary.

In the course in question, the PT is referred to as the Integrative Progress Assessment (IPA). The IPA was established by the faculty members of the Structuring Teaching Core (STC) to assess the cognitive aspect of all students, from the first to the last module of the program. In this usage model, it is expected that students in the final module achieve more correct answers than those in earlier stages. Feedback in this assessment model is fundamental. Through this exchange, the course is (re)shaped to address the identified difficulties.

IPA assessment items are individually developed by faculty members and are multiple-choice in format. However, despite the care taken in the individual and nonstandardized preparation of the items, in most cases, the integration of curricular components does not advance beyond the problem text and does not enable the integration of different curricular components and competencies desired for the student and graduate.

In 2021, a group of educators from the program's board decided to study the blueprint and apply it in the development of a reference matrix and the subsequent commissioning of assessment items. The proposal brought by authors involved with medical programs was subsequently adapted from the literature to the reality of the biomedical sciences program, given the limited number of publications on the topic in health courses focused on non-medical professions.

Use of the Blueprint in the Development of a Reference Matrix

Considering the particularities of the Biomedical Sciences program as described in the PCP, the faculty members of the program's collegiate established three structural axes for the development of the reference matrix, namely: (I) the level of complexity, using Bloom's taxonomy as a reference; (II) the competencies of each area of biomedical qualification offered during internships, as outlined in the PCP; and (III) the integration of different curricular components. Since axis II uses the competencies of each qualification area of the program offered in internships as a reference, the collegiate decided to create four blueprint matrices, one for each area (Clinical Analysis, Imaging, Acupuncture, and Research). Furthermore, it was planned to construct ten assessment items for each area, totaling forty items, which would ultimately comprise the set of IPA questions.

The first axis of the blueprint (top horizontal axis) took into account the different levels of complexity initially described by Benjamin Bloom and collaborators in the 1950s, and later updated in 2001, which are widely used to this day in the teaching-learning process (Anderson & Krathwohl, 2001; Bloom, 1986). These levels of complexity refer to the extent to which the student is able to associate the objectives of Bloom's Taxonomy pyramid from the base to the

top, according to the degree of difficulty; that is, at the highest level of complexity, the student is expected to have already mastered all the previous levels.

As shown in Table 1 (top horizontal axis), questions or assessment items 1 and 2 (Q1 and Q2) were classified as low complexity, thus forming the base of the pyramid; items 3 and 4 (Q3 and Q4) as medium complexity, referencing the base and middle of the pyramid; and items 5 and 6 (Q5 and Q6) as high complexity, indicating the top. In this way, each assessment item must respect the corresponding level of complexity in its construction, addressing the different dynamics of the teaching-learning process.

The second axis of the blueprint (left vertical axis) was established based on the educational objectives or competencies of each biomedical qualification area of the program offered during internships, as outlined in the PCP. Table 1 presents a sample of competencies that students are expected to develop throughout the course, specifically in the area of Clinical Analysis. In this sense, this axis will determine one or more objectives or competencies to be addressed in the theme of each assessment item.

Lastly, in the third axis (bottom horizontal axis), the integration point of the curricular components was established (Table 1). Thus, each assessment item, in addition to incorporating a level of complexity in its construction (top horizontal axis) and one or more competencies from the Clinical Analysis area (left vertical axis), must also include, within its theme, the integration of two or more curricular components from the course matrix (bottom horizontal axis), through their educational objectives or competencies, although these are not described in the blueprint.

After constructing the matrix or blueprint, the faculty members of the program's collegiate responsible for the Clinical Analysis area were able to request the assessment items that would be part of the IPA, marking with an "x" the mapping of the questions to be developed, which would encompass a given level of complexity (top horizontal axis), one or more educational objectives or competencies (left vertical axis), and curricular components (bottom horizontal axis). Table 1 provides an example of the blueprint.

Table 1: Blueprint for ordering axle issues

Level of complexity →		**Low Complexity**		**Medium Complexity**		**High Complexity**	
Questions →		**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Objective 1	Evaluate and interpret results from different areas obtained by analytical techniques.	**X**	**X**	**X**	**X**	**X**	**X**

Objective 2	Understand physiological, pathological, and pathophysiological processes.			X	X		
Objective 3	Compare the laboratory alterations detected and associate them with pathological and physiopathological processes.	X	X	X	X	X	X
Objective 4	Interpret laboratory alterations using normal organic parameters.	X	X		X		
Objective 5	Interpreting and using protocols and working instruments.	X				X	X
Integration between educational objectives of curricular component →		Objectives and/or Disciplines	Objectives and/or Disciplines	Objectives and/or Disciplines	Objectives and/or Disciplines	Objectives and/or Disciplines	Objectives and/or Disciplines

Source: author's elaboration.

Aiming to facilitate the visualization of the curricular components that were integrated into questions 1 to 6 (Q1 to Q6; bottom horizontal axis), the subjects are listed below in Table 2. It is worth noting that Tables 1 and 2 do not present the educational objectives or competencies of each curricular component, but only the names of the subjects. Mapping the educational objectives or competencies would make the process of developing the assessment items more precise, less subjective, and less dependent on the random selection of the instructor.

Table 2: Blueprint for the ordering of questions (cont.)

Integration between educational objectives of curricular components →	**Low Complexity**	**Q1**	Parasitic diseases of biomedical importance; Clinical practice 2 (urinalysis and clinical parasitology).
		Q2	Laboratory techniques applied to biomedical microbiology; Clinical Practice 1 (microbiology and clinical immunology).
	Medium Complexity	**Q3**	Clinical Practice 1 (microbiology and clinical immunology); Clinical Immunology; Laboratory techniques applied to biomedical microbiology.
		Q4	Clinical biochemistry, urinalysis, and cavitary fluid analysis; Clinical practice 2 (urinalysis and clinical parasitology).
	High Complexity	**Q5**	Basic immunology; Clinical practice 1 (microbiology and clinical immunology).
		Q6	Clinical biochemistry, urinalysis, and cavitary fluid analysis; Clinical practice 3 (hematology, clinical biochemistry, and analytical toxicology).

Source: author's elaboration.

After the development of the reference matrix, the questions were divided among the faculty members of the course committee responsible for the Clinical Analysis area, who then individually developed the assessment items according to the specifications of the blueprint (Table 3). It is worth noting that, for each biomedical qualification area offered during the internship as outlined in the PCP (Clinical Analysis, Imaging, Acupuncture, and Research), the group of faculty members of the course committee responsible for the respective area developed a corresponding blueprint.

Table 3: Items developed via blueprint

Question 1	
Problem text	Observation of the physical aspects of the feces should be given particular attention and precede the dilution of the sample, since the appearance, consistency, odor or even color when inspecting the feces macroscopically can be just as relevant as the possible presence of mucus, blood, pus or even whole adult worms or their fragments.
Command	Of the following parasites, the only one that does not shed eggs in its adult stage is:
Correct answer a)	*Giardia lamblia.*
Distractor b)	*Schistosoma mansoni.*
Distractor c)	*Trichuris trichiura.*
Distractor d)	*Ascaris lumbricoides.*
Distractor e)	*Enterobius vermiculares.*
Question 2	
Problem text	Law No. 10.205, March 21, 2001, regulates § 4 of art. 199 of the Federal Constitution, relating to the collection, processing, storage, distribution, and application of blood, its components, and derivatives, establishes the institutional order indispensable for the proper execution of these activities and makes other provisions. Bill 2353/2021 amends Law 10.205 to prohibit discrimination based on the sexual orientation of blood donors. These legal regulations aim to guarantee the structure for the safe collection and supply of blood products within a context that reduces the risk of transmission of infectious agents in the process. To this end, a serological evaluation of the donated sample is carried out.
Command	The infectious agents investigated by serology are:
Correct answer a)	*Treponema pallidum, Trypanosoma cruzi,* hepatitis B virus, hepatitis C virus, HIV and HTLVI/II.
Distractor b)	*Treponema pallidum, Trypanosoma cruzi,* hepatitis B virus, hepatitis C virus, HIV and HPV.
Distractor c)	*Treponema pallidum, Trypanosoma cruzi,* hepatitis B virus, hepatitis C virus, HPV and HTLVI/II.
Distractor d)	*Treponema pallidum,* Plasmodium, hepatitis B virus, hepatitis C virus, HIV and HPV.
Distractor e)	Plasmodium, hepatitis B virus, hepatitis C virus, HIV, HPV and *Mycobaterium tuberculosis.*
Question 3	
Problem text	A 37-year-old teacher went to see a hematologist, reporting the following symptoms: easy tiredness, malaise, indisposition, pallor of the skin and mucous membranes, and excessive sleepiness for a year, with progressive worsening. She reports heavy periods, with regular 26-day cycles. Breakfast: coffee, milk, bread, and butter; lunch: rice, beans, pasta, and salads; dinner: snacks with cheese or soups. Laboratory tests show normal red blood cell count (5.0 million/uL); low hemoglobin =8.5 g% and hematocrit below normal (25%).
Command	Analyze the clinical case and write down the correct alternative:
Correct answer a)	Poor diet combined with excessive blood loss and laboratory tests strongly suggest iron deficiency anemia.
Distractor b)	The patient eats poorly and does not eat any meat, which suggests anemia due to a lack of vitamins and folic acid.
Distractor c)	The red blood cell count is normal, so we can't think of a diagnosis of anemia.

Distrator d)	Only blood loss from heavy menstruation can lead to iron deficiency anemia.
Distrator e)	The patient's clinical symptoms may be the result of the teacher's busy life and the stress caused by the students.

Question 4

Problem text	Routine laboratory urine analysis can provide a wide range of information about different pathological processes.
Command	With regard to this laboratory assessment, it is correct to say:
Correct answer a)	During urinary sediment microscopy, the high presence of renal tubular epithelial cells indicates the existence of tubular damage.
Distractor b)	High urine density can be seen in diabetes insipidus.
Distractor c)	The presence of erythrocyte cylinders in the urine indicates contamination with the menstrual flow.
Distractor d)	The first urine of the morning, because it is the least concentrated, is usually discarded for the test.
Distractor e)	Leucine crystals are shaped like greenish, four-sided flat plates.

Question 5

Problem text	Severino, 30, single, sought routine medical attention. During the interview, he reported moderate alcohol consumption, unprotected sexual activity, and more than 10 partners in the last two years. In view of the patient's report, laboratory tests were ordered, and the results were as follows: Rapid test for syphilis (IgG): Reagent; anti-HCV: Not reactive; anti-HAV IgG: Regent; anti-HaV IgM: Not reactive; HBsAg: Reagent; HBeAg: Non-reactive; total anti-Hbc: Reagent; anti-Hbs: Reagent; anti-HIV: Non-reactive.
Command	Based on the results of the tests, we can say that Severino has:
Correct answer a)	Hepatitis B, requiring confirmation by molecular testing, as well as positivity for a treponemal test for syphilis, requiring confirmation by a non-treponemal test.
Distractor b)	Hepatitis A in the acute phase requires confirmation by molecular testing, as well as positivity for a non-treponemal test for syphilis, requiring confirmation by treponemal testing.
Distractor c)	Hepatitis C requires confirmation by molecular testing, as well as positivity for a treponemal test for syphilis requiring confirmation by a non-treponemal test.
Distractor d)	Hepatitis B in the acute phase requires confirmation by molecular testing, as well as positivity for a non-treponemal test for syphilis, requiring confirmation by treponemal testing.
Distractor e)	Previous hepatitis A requires confirmation by molecular testing, as well as positivity for a non-treponemal test for syphilis requiring confirmation by treponemal testing.

Question 6

Problem text	Gestational Diabetes Mellitus is a carbohydrate intolerance of varying severity that begins during the current pregnancy, without having previously met the diagnostic criteria for Diabetes Mellitus. It is suggested that all women have their fasting blood glucose tested at their first prenatal visit. Also, during the gestational period, it is essential to monitor blood pressure levels, as well as routine urinalysis, in order to detect high-risk pregnant women.
Command	Considering the need for glucose monitoring and tracking other diseases that occur during the gestational period, identify the levels indicated for tracking gestational diabetes with complementary tests, such as the Oral Glucose Tolerance Test, as well as the possible biochemical alterations used to detect pre-eclampsia.
Correct answer a)	Glycemia > 86 mg/dL and presence of proteinuria.
Distractor b)	Blood glucose ≥ 100 mg/dL and presence of hemoglobinuria.
Distractor c)	Glycemia > 99 mg/dL and presence of hemoglobinuria - with elevated HBA1C - in the urine.
Distractor d)	Glycemia > 126 mg/dL and presence of microalbuminuria.
Distractor e)	Blood glucose between 160 – 180 mg/dL - with obvious glycosuria and proteinuria.

Source: author's elaboration.

Upon receiving each completed assessment item, the course board qualitatively analyzed each question, employing a checklist to characterize the presence of Axes I, II, and III (Table 4).

Table 4: Checklist of questions

	Axis I (Bloom)	Axis II (competence)	Axis III (components)
Item 1	Low complexity	Objectives 1, 3, 4 and 5.	Parasitic diseases of biomedical importance; Clinical practice 2 (urinalysis and clinical parasitology).
Item 2	Low complexity	Objectives 1, 3, 4 and 5.	Laboratory techniques applied to biomedical microbiology; Clinical Practice 1 (clinical microbiology and immunology).
Item 3	Medium complexity	Objectives 1, 2 and 3.	Clinical Practice 1 (microbiology and clinical immunology), Clinical Immunology and Laboratory Techniques applied to Biomedical Microbiology.
Item 4	Medium complexity	Objectives 1, 2, 3 and 4.	Clinical biochemistry, urinalysis, and cavitary fluid analysis; Clinical Practice 2 (urinalysis and clinical parasitology).
Item 5	Medium complexity	Objectives 1, 3 and 5.	Basic immunology; Clinical practice 1 (microbiology and clinical immunology).
Item 6	Medium complexity	Objectives 1, 3 and 5.	Clinical biochemistry, urinalysis, and cavitary fluid analysis; Clinical Practice 3 (hematology, clinical biochemistry, and analytical toxicology).

Source: author's elaboration.

Limitations

After the period dedicated to the development of the blueprint, the assessment items, and the administration of the IPA, the faculty members of the Biomedicine course board met to discuss limitations and strengths. Thus, despite the successful adaptation and implementation of the blueprint in the course, several limitations certainly influenced our perception of quality.

For the development of the blueprint, the faculty members had to meet more frequently and allocate time for the elaboration and eventual revisions of items after the creation

and critical analysis by the course board. This additional workload must be understood by the group as a fundamental investment in the learning and assessment-for-learning process.

In the lower horizontal axis of the blueprint, the board did not include the educational objectives of the selected curricular components. The lack of specification of these objectives made the item requests more subjective and susceptible to the inclusion of random educational objectives, which might not align with the competencies highlighted in the left vertical axis of the blueprint.

After the elaboration of the assessment items and the submission of the questions to the course board, the qualitative analysis of each question was restricted to this group. External analyses, as well as comparative evaluations directed at students and other faculty members of the course board and the program after the administration of the IPA, could provide more information regarding the quality and possible subjectivity of the questions.

Nevertheless, despite the list of limitations, the Biomedicine course board concluded that the benefits of adapting and implementing the blueprint far exceeded everyone's expectations, contributing to a less subjective, more integrated, and learning-catalyzing item development process.

FINAL CONSIDERATIONS

After several years of developing assessment items without a reference matrix, the use of the blueprint in the construction of IPA items has become essential. This is due to the fact that standardizing question development among a large number of faculty members, teaching plans, educational objectives, and competencies—including the use of taxonomies such as Bloom's—is an extremely complex task, requiring time, institutional support, training, and faculty motivation. Standardizations such as the one reported in this study must primarily originate from the team responsible for the course management, such as the coordination, the STC, and the faculty board.

Thus, as reported, it is evident that the time invested in the development of the blueprint and the assessment items enriched not only the course and the HEI but also the faculty members of the board, making the processes of teaching, learning, and assessment for learning less subjective, more accurate, and more aligned with the guiding documents for student education and graduate profile. In summary, the probable quality of the assessment items after the implementation of the blueprint provided the undergraduate Biomedicine program with tools for the IPA to become an effective means of offering support for the improvement of students, faculty, documents, and the course as a whole.

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