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Research Article

USING MATHEMATICAL DATA IN THE DESIGN OF PSYCHOLOGICAL DIAGNOSTIC TOOLS

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ABSTRACT

The article presents the relationship between Mathematics and Psychology, especially Diagnostic Psychology. Based on the understanding of the design in psychological diagnostic tools, the mathematical content has always been used as data to solve problems and prove hypotheses proposed by researchers and psychosocial diagnoses. There is a close relationship between Mathematics and Psychology. Diagnostic psychology uses mathematical linguistic data in designing psychological diagnostic tools and vice versa. Mathematics through being used in psychological science demonstrates its wide range of applications not only in the General Sciences but also in the Social Sciences and Humanities.

Keywords: design; linguistic data; mathematical; psychological diagnostic tools

1. Introduction

Diagnostic psychology is an area of applied psychological science formed during experimental psychological processes to survey and measure (quantitative and qualitative) individual psychological characteristics. When specifications are recorded through experiments, the processing and analysis of such data will lead to consultation results to understand the nature of a psychological feature to be investigated (Quang Duong, 2003).

Globally, experimental studies on intelligence (IQ) of Francis Galton and later Alfred Binet and Theodore Simon (in the late 19th century) have opened the trend of scientific and disciplined research on human intelligence through fast calculation experiments or measuring the sharpness of thinking when observing images and solving problems. It was

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not until the end of the 20th century that scientists had shown that a human being was not capable enough to succeed because of a low IQ. Therefore, Goleman (1995) published a new work on Diagnostic psychology, EQ – Emotional intelligence quotient. In his study, Goleman used measurement manipulations on the ability to manage human emotion. Thus, applying mathematical tools in psychological diagnosis, especially in the study of Intellectual psychology of many developed countries, has partly reflected the relationship between Mathematics and Psychology in discovering human thinking capacity and intelligence.

In Vietnam, many Psychology – Education researchers have considered and applied Diagnostic Psychology to psychological diagnosis through multiple-choice test tools for testing in Vietnam for Vietnamese subjects. For example, Duong Thieu Tong's Test and Measurement of Academic Achievement (1996) introduced scientific methods for measuring academic results by statistical probability. Most recently, Doan (2019), with the study of Psychological Tests, has provided a new approach to psychological research and diagnosis using mathematical tools and SPSS software. It could be seen that the research directions in psychological diagnosis in Vietnam not only acquire achievements in Diagnostic psychology but also use mathematical data resources in researching, testing, and diagnosing intelligence and career orientation characteristics.

By summarizing research trends of psychological diagnosis in the world and Vietnam, it could be concluded that there is a close relationship between psychological diagnosis and mathematics. Diagnostic psychology used data measurement and data processing tools of Mathematics to produce results and analyses. While Mathematics is based on the development of Psychology in general, Diagnostic Psychology in particular further affirms the importance and scientific significance of the sector as it could be applied both in the natural sciences and can, at the same time, be applied in social science studies, proving the diverse application of the sector.

This articleanalyses mathematical data and psychological diagnostics and the use of mathematical and linguistic data to design psychological diagnosis tools to demonstrate the close relationship between the two areas in a human study.

2. Using mathematical data in the research of social sciences

Mathematics consists of many disciplines. The more it develops, the deeper the division is. In the division for research, mathematicians draw the link and unity between different disciplines and theories (Le, 2005). On the other hand, in the past, all mathematical theories were stemmed from solving problems. The concepts are applied in practice or other sciences (Le, 2005). Therefore, a new trend of Mathematics currently applied in other sciences is interdisciplinary and practical integration (Nguyen, 2004).

Mathematics is a highly abstract science. The abstraction in Mathematics is independent of all material of objects except quantitative relations in the form of structure (Rich & Yadav, 2020). The high level of abstraction makes Mathematics universal and applicable in different areas of life. For example, the knowledge of proportional correlation can be applied to Chemistry orElectricity. The group research results could be applied to objects of nature: arithmetic, vector, matrix, and displacement (Nguyen, 2004).

Not only applied in the field of general sciences, Mathematical data is also applied in the social sciences and humanities fields due to its high level of abstraction as an effective tool in research and application:

In Astronomy, astronomers used mathematical calculations and formulas to measure the distance between the sky and the Earth's surface, between the Earth and stars, the distance between day and night, moon-tidal cycles, and tide. Mathematical data was also applied in simulating the length of the distance, space-traveling time, serving the field of Space Travel, and exploring assumptions about the universe (Zeilik, Schau, & Mattern, 1999).

In Geography, mathematical data has been applied in population charts, meteorological – hydrological charts, industrial – agricultural – service production charts, population forecasts – climate forecasts, and economic forecasts. Mathematics provided Geography a source of formulas and different ways of analyzing and interpreting charts to solve population, economic, and social problems. Mathematics accompanies both the field of Natural Geography (altitude of mountains, sea level, temperature, and climate) and Social Geography (population, economy), helping Geography to confirm its value (Blatt, 2013).

In Education, mathematical data has been applied in testing and assessing the quality of human education as well as helping education to prove its training results in society. In addition, educators also used Mathematics as an effective quantitative research support tool, a measure of teaching, pupil differentiation, and examinations – selection of input-output quality (Doan, 2019).

In Psychology, mathematical data has been used to study human psychology, especially in the field of Intellectual Psychology and Diagnostic Psychology. Mathematics provided psychology with formulas and calculations, estimated the number of human psychological features, and was a tool to determine the reliability and usability of human psychology filtering, measuring, and evaluating tools. Currently, there is a field of psychology that specializes in mathematical problems, the relationship between mathematics and human psychology – Geometric psychology – the field of studying the relationship between human psychology (personality characteristics, intelligence) and geometric symbols (Tran, 1992).

In short, the practical studies of Mathematics have provided only formal knowledge and did not help people develop the necessary skills to solve problems arising from their daily life.

Based on understanding and summarizing, the use of mathematical, linguistic data in the field of social sciences and humanities can be modeled in four steps as follows:

- Step 1: Build an intermediate model of problems, i.e., identifying the most significant factors in the system and establishing the rules that we must follow.
- Step 2: Building a mathematical model for the problem in question, i.e., re-expressing in mathematical language for the intermediate model. There may be different mathematical models for the problem in question, depending on which system factors and the relationship between them are considered essential.
- Step 3: Use mathematical tools to survey and solve problems created in step 2. Based on the built model, it is necessary to select and build appropriate solution methods.
- Step 4: Analyze and re-test the results obtained in step 3 Here one must determine the model's suitability and the results of calculations to actual problems or apply expert analysis methods.

3. Using mathematical data in the design of psychological diagnosis tools

Based on the synthesis of studies on the relationship between Mathematics and Psychology, there is a close relationship between the two sciences. Psychology uses tools of Mathematics to support its research results. In particular, in psychological diagnosis (Diagnostic Psychology), mathematical data is not only a tool to prove that the diagnostic results are valuable and meaningful. However, it is also a science that provides terms, rationales, and tools for psychological diagnosis researchers to build rationales and diagnostic tools for human psychological characteristics. Mathematical data used in the design of psychological diagnosis tools is as follows:

Psychological diagnosis, also called a psychological test, is a system of tools that have been standardized technically, defined in terms of content and practices to objectively measure one or more aspects of the complete personality (Johnstone, 2018). A psychological test shall meet the following properties:

- Objectivity (the test is not dependent on the tester)
- Separability (the test allows classification of surveyed groups)
- Effectiveness (the test truly evaluates characteristics to be surveyed)
- Ease of use (the test is easy to use, straightforward, less expensive).

The test is one of the experimental and measurable forms. The test indicates not only the presence but also the level of a psychological indicator. Thus, from the basic properties of a psychological test, we can realize that mathematical, linguistic data is used in all four properties: objectivity – operations of testing differences in multiple-choice designs;

separability – operations, formulas that help to sample groups of objects; effectiveness – operations of testing differences before and after application, multiple-choice tests; ease of use– operations on the cost of building and applying that test).

3.1. The process of designing a test – psychological diagnosis tool

According to Wise and Plake (2015), the standards of designing the test are:

- Normativeness means test results on a large group of people representing the population. It is the standard for any individual judgment.
- The validity is measurement content and measurement accuracy.
- Reliability of the test is the stability of test results.

According to psychologists such as Grinffin, Izard, and Bestein, the following steps should be taken to design a test:

Step 1. Analyze psychological content to be researched and design tests

Building a test starts with identifying the goals to be tested and limits the scope of psychological manifestations that will be tested by the test.

The test builder must then formulate a working hypothesis about the nature of the manifestations and must define which activities are most favorable for revealing such manifestations. Without this qualitative analysis for test exercises, it is impossible to define the validity of the test. That preliminary analysis is of a natural hypothesis, the accuracy of which needs to be proven and completed step by step.

Based on the hypothesis, the test builder outlines the test and specifies what the test must cover. A draft test includes the name, primary purpose, and aspects of the content to be included in the test (Nguyen, 1996).

It can be noticed that in step 1, mathematical, linguistic data is used from basic terms such as test, hypothesis, scope limitation, accuracy, and validity. It is most important to answer the question: "What does this test measure?"

Step 2. Select the type and form of the test

There are four main types of psychological tests: individual tests, group tests, verbal tests, and action tests.

At the same time, there are seven forms of tests: fill-in-the-blank questions, "true - false" questions, multiple-choice questions, expression questions, complex questions, picture questions, and paired questions.

Depending on the purpose of psychological diagnosis, the test taker will choose an appropriate type and form of test. At the same time, the test's type and form also depend on the psychological characteristics of the test item (Le, 2013).

Step 3. Describe and verify test exercises

The fact shows that the number of draft tests must be 2.5 to 3 times more than the number of completed tests. This is essential to replace the tests that contain many shortcomings and need to be removed.

To increase the value of variables to be measured, it is required to design many questions on a topic. Using a single question may not cover all aspects of a variable to be studied and may increase inaccuracy. In some cases, it is more effective to use (borrow) questions from other tests than build a new set of questions. The advantage of borrowed questions is the appropriated clarity. However, researchers must consider making the questions more popular with the populations. So it is not always easy to choose questions to borrow. Researchers must be careful when arranging the order of questions. The questions must be easy to answer, suitable to the research problem, and enjoyable if possible. The difficult questions which may cause embarrassment and frustration should be asked at last. Even questions about age and education level are sometimes asked at the end. The questions must be natural for test items to create a smooth movement from item to item.

The set of approved tests must be tested on a representative sample. This population includes test takers with gender, age, education level, social and cultural environment, and life experience corresponding to the number of people to be tested by the test. The purpose of prior testing is to test the usability, reliability, and validity of the test. Each exercise must be tested on the following aspects:

- Firstly determine the difficulty of the exercises. Exercises that are too difficult to be solved by none and exercises that are too easy to be solved by all test takersmust be removed immediately from the test. Usually, a test must consist of exercises so that no more than 80-85% and no less than 10-15% of test items are correctly solved (Gary, 2003). Exercises of equal difficulty are distributed in parallel series of the test.
- Determine the homogeneity or non-homogeneity of the exercises. This means identifying the similarities and differences in each exercise compared to the previous test.
- Regarding the number of exercises and distribution order in a test, attention is paid to the relative difficulty so that the measurement results correspond to the normal distribution.
- When determining the number of exercises for a test, we must attend to the time limit for taking the test and ensure reliability. For a test with increasing difficulty, the time is extended so that almost all test takers can answer all the exercises.

In step 3, we can notice that mathematical, linguistic data is applied in: Arranging questions from easy to difficult in an exercise; testing the usability, reliability, and validity of the test in the first test step; a set of exercises must ensure the degree of difficulty (not exceeding 80-85% and not less than 10-15% test items correctly solve), the number of exercises must be appropriate for the time taken.

Step 4. Developing a direction of performing a test

This is the final step to finish the preliminary preparation for a test. The most important part of the instruction is an example of solving exercises for test takers. It is required to eliminate distracting factors, the ability to see and copy each other between the test takers.

3.2. Test verification

Verifying a psychological diagnosis test is checking and evaluating its effectiveness. This is the step of applying the most mathematical linguistic data to design a diagnostic tool. According to Gary (2003), the evaluation process consists of five steps: 1 - Determining evaluation objectives; 2 - Collecting data sets; 3 - Arranging and classifying data; 4 - Analyzing data; and 5 - Reporting the results.

Assessing a test is usually based on the following three essential characteristics (Doan, 2019): Validity, Reliability, and Usability.

a. Validity: The accuracy level of a test must be in its exact evaluation scope. In other words, does the test measure what it needs to measure. Statistical methods can

b. determine validity. The correlation coefficient calculates the validity of a test between the measurement result of the test and another objective assessment with the same capability or psychological characteristics tested in the test.

c. Reliability: a highly stable test is indexed without fluctuation over time. As well as validity, reliability is determined by statistical methods. The reliability of a test is calculated by the correlation coefficient between the test results of the same test taker because the experiments are repeated by the same test or by two equivalent value series of the test.

Unlike validity, the reliability of a test is calculated without the support of external standards. This coefficient indicates the stability of the coefficients of each test items in experiments repeated by the same test or by equivalent tests. The formula of reliability coefficient (R) is:

$$R = \frac{2r}{1 + r}$$

In which:

r: reliability of two half-tests (correlation between the score of even-numbered sentences and that of odd-numbered ones)

R: general reliability of the test.

d. Usability: time and resources needed to carry out that test (Doan, 2019). The usability of a test is shown in the following four points:

- The test form is shown through; the arrangement of questions, the group of questions clearly and logically, instructions for answering clearly, the length of appropriate tests.
- The test must be easy to manage and easy to test the performance process.
- The test must be easy to score.
- The obtained results are easy to comment on.

From the above analysis, to test whether the test can be used or not, the calculation of three essential characteristics is essential; a separate calculation formula shall calculate each characteristic, and there is, depending on each type of test, a formula for each. Thus, this is the stage of using the most mathematical data and is decisive to the quality of a psychological diagnosis tool.

3.3. Difficulty and discrimination index of exercises in a test

a. Difficulty

A good test is not a test that consists of difficult or easy exercises but includes moderately or averagely tricky exercises.

The method of calculating the difficulty of an exercise in a test is as follows:

$$P = \frac{F + f}{2n} \; x \; 100$$

In which:

F: the number of test items correctly answering in a strong group

f: the number of test items correctly answering in a weak group

n: number of test takers for each group.

The higher the difficulty (P) is, the easier the exercise is. So some people also call it an easy index or success index. According to the experience of western countries, it is not advisable to use exercises with difficulty less than 10% and over 90%. The difficulty of 25 to 75% is acceptable. In addition, if a test has a difficulty index of 50 to 60%, then its content or homogeneity is reliable (Duong, 1995).

b. Discrimination index

The discrimination index of an exercise to quantitatively assess the ability to distinguish the test results of different test groups with different capabilities. If an exercise that all good and bad test takers can do or cannot do, then the exercise is indistinguishable.

According to Wilson et al. (2018), the discrimination index can be calculated using the following formula:

$$E = \; 2\frac{F - f}{N}$$

In which:

F: the number of test items correctly answering in a strong group

f: the number of test itemscorrectly answering in a weak group

N: number of test takers of the two groups

E: discrimination index is limited from -1 to 1.

The discrimination index varies from -1 to 1; classify exercises based on the discrimination index as follows:

- From 0.35 and over, excellent exercise
- From 0.25 to 0.35: good exercise

- From 0.15 to 0.24: revision exercise
- Below 0.15: bad exercises should be carefully reviewed and probably eliminated.

The difficulty index and discrimination index are related to each other. An exercise is correctly solved by all test takers (difficulty is 100%), then this exercise certainly cannot distinguish between good and bad groups because both groups achieve the same results. Similarly, an exercise incorrectly answered by all test takers (difficulty is 0%) certainly has a discrimination index of 0. Thus, the exercises that are too easy or too difficult will all have a discrimination index of zero.

In general, to calculate the difficulty and discrimination index of a psychological diagnosis tool (test), the application of mathematical data - mathematical formulas is required because only specific numbers demonstrate the results at which researchers are aimed.

4. Conclusion

A psychological diagnosis tool is a test, but not every test is a diagnostic tool. In order to make a test a psychological diagnostic tool in its true sense, it is necessary to have a process of research, trial application for processing, and adding adjustments to complete the content and evaluation standards. Thus the test will meet the requirements of a psychological diagnosis tool: validity, reliability, and usability. In order to achieve the above requirements, it is necessary to test each exercise on some test takers and process results obtained by mathematical-statistical probability formula. In summary, we realize that the use of mathematical data in the design of psychological diagnosis tools demonstrates a close relationship between Mathematics and Psychology, creates a premise for the development of both fields not only in general science but also in the fields of social sciences and humanities.

❖ ***Conflict of Interest:*** *Authors have no conflict of interest to declare.*

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SỬ DỤNG NGỮ LIỆU TOÁN HỌC TRONG THIẾT KẾ CÔNG CỤ CHẨN ĐOÁN TÂM LÍ

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TÓM TẮT

Bài báo trình bày mối quan hệ giữa Toán học và Tâm lí học, đặc biệt là lĩnh vực Tâm lí học chẩn đoán. Dựa trên sự hiểu biết về thiết kế trong các công cụ chẩn đoán tâm lí, nội dung toán học luôn được sử dụng làm dữ liệu để giải quyết vấn đề và chứng minh các giả thuyết do các nhà nghiên cứu và chẩn đoán tâm lí xã hội đề xuất. Có một mối quan hệ chặt chẽ giữa Toán học và Tâm lí học. Tâm lí học chẩn đoán sử dụng ngữ liệu toán học để thiết kế các công cụ chẩn đoán tâm lí, và ngược lại, Toán học thông qua việc sử dụng trong khoa học tâm lí, nó thể hiện khả năng ứng dụng rộng rãi không chỉ trong khoa học cơ bản mà còn trong khoa học xã hội và nhân văn.

Từ khóa: thiết kế; ngữ liệu toán học; toán học; công cụ chẩn đoán tâm lí