# EXAMINATION

# VALIDATION

# GUIDE

## FOR

# PERSONNEL CERTIFICATION BODIES

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# INDEX

## Preamble

The purpose of this guide is to present some of the methods that may be used for the validation of the exams prepared by the Personnel Certification Bodies searching for ISO/IEC 17024 accreditation and contribute that they make a reliable and fair exam practice.

This guide includes clues as to the steps in which the examination (personnel evaluation) system should be set up, as well as some of the statistical techniques that can be used in the analysis of items that are necessary for the establishment of question banks.

The use of the information contained in this guide is the sole responsibility of the user. The user should not forget that there are many statistical methods and validation methods that are not included in this guide and it is recommended to conduct a literature search according to the exam method to be applied. The user should consider this guidance document only as an initial point and deepen his own research through different sources.

The scope of this Validation Guide is limited to the "job analysis" component of certification schemes, and does not discuss requirements for administration of examinations, including performance-based assessments, oral examinations, and remote assessments.

IPC would like to thank the membership of the Working Group that developed this Guide, consisted by the following experts:

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## Definitions

### 1. Fairness
(ISO/IEC 17024:2012, Clause 3.16)
Equal opportunity for success provided to each candidate (3.14) in the certification process (3.1)

### 2. Validity
(ISO/IEC 17024:2012, Clause 3.17)
Evidence that the assessment (3.8) measures what it is intended to measure, as defined by the certification scheme (3.2)
NOTE In this international Standard, validity is also used in its adjective form "valid".

### 3. Reliability
(ISO/IEC 17024:2012, Clause 3.18)
Indicator of the extent to which examination (3.9) scores are consistent across different examination times and locations, different examination forms and different examiners (3.10)

### 4. Standard deviation
Index of variability in a set of numbers. Computationally, this is the square root of the sum of deviations of each score and the mean, divided by the number of data points in the set.

### 5. Mean
The average score for a set of numbers.

### 6. Standard error of measurement (SEM)
This is the estimate of the variance of a person's scores if the person took many tests of a similar size. It is computed with the reliability coefficient of a test and the standard deviation of the set of obtained scores.

### 7. Item
The smallest measurable component of a test that can be scored is called an item.

### 8. Item analysis
Several characteristics of (usually) multiple-choice items that indicate the quality of the item and of the whole test.

## Introduction

The examination process always affects a candidate seeking certification of personnel because of the importance of the fairness and reliability of the evaluation process.

The validity of an examination depends on the quality of its sections that make up the exam. In other words, the properties of the exam vary depending on the properties of the substances that make up the exam. But most of all, the exam has to measure the requirements defined in the relevant job/task analysis. In other words, there is a direct connection between the job/task definitions and the exam.

There are prescribed steps in linking the relatedness of the exam to the knowledge and skills required for a job. These steps lead us to an exam that has been "validated" in that its content accurately measures the necessary knowledge and skill required for the job.

## Examination Process Requirements in the ISO/IEC 17024: 2012 standard

*(ISO/IEC 17024:2012, Clause 9.3.1)*

- Examinations shall be designed to assess competence based on, and consistent with, the scheme, by written, oral, practical, observational or other reliable and objective means. The design of examination requirements shall ensure the comparability of results of each single examination, both in content and difficulty, including the validity of fail/pass decisions.

*(ISO/IEC 17024:2012, Clause 9.3.5)*

- Appropriate methodology and procedures (e.g. collecting and maintaining statistical data) shall be documented and implemented in order to reaffirm, at justified defined intervals, the fairness, validity, reliability and general performance of each examination, and that all identified deficiencies are corrected.

## What is exam (assessment) in personnel certification process?

A test or examination (informally, exam or evaluation) is an assessment intended to measure a test-taker's knowledge, skill, aptitude, or classification in many topics. The goal of the exam is is to determine if an individual has sufficient knowledge, skills, and abilities (KSAs) to be professionally competent at an entry-level in the specified field. An exam may be administered verbally, on paper, on a computer, or in a predetermined area that requires a test taker to demonstrate or perform a set of skills.

There is no general consensus or invariable standard for test formats and difficulty. Often, the format and difficulty of the test is dependent upon the requirements of accreditation or industrial association. Standardized tests are usually used by the personnel certification bodies to determine if a test taker is allowed to practice a profession, to use a specific job title, or to claim competency in a specific set of skills. It is a direct method of assessment of knowledge, skills, ability and personal behaviors. The assessment types that can be used in personnel certification programs are as follows.

***Criterion-referenced tests*** are designed to measure candidate's performance against a fixed set of criteria or industry standards or certification schemes, based on a construct of "minimal acceptable competency "It is possible for all test takers to pass, just like it is possible for all test takers to fail. A criterion-referenced test will use questions which will be correctly answered by candidates who are competent in the specific subject.

***Standardized test*** is a test that is administered and scored in a consistent, or "standard", manner. Standardized tests are designed in such a way that the questions, conditions for administering, scoring procedures, and interpretations are consistent and are administered and scored in a predetermined, standard manner. Any test in which the same test is given in the same manner to all test takers, and graded in the same manner for everyone, is a standardized test. A standardized test may be any type of test: a written test, an oral test, or a practical skills performance test. The questions can be simple or complex. Standardized tests are designed to permit reliable comparison of outcomes across all test takers, because everyone is taking a test which is designed to assess the same competencies. Criterion-referenced scoring is used because criterion-referenced score is concerned solely with whether or not this particular candidate's answer is correct and complete.

***Performance-based assessment*** is the evaluation process of objective data collecting from the actual or simulated application site on the knowledge, skill, attitudes.

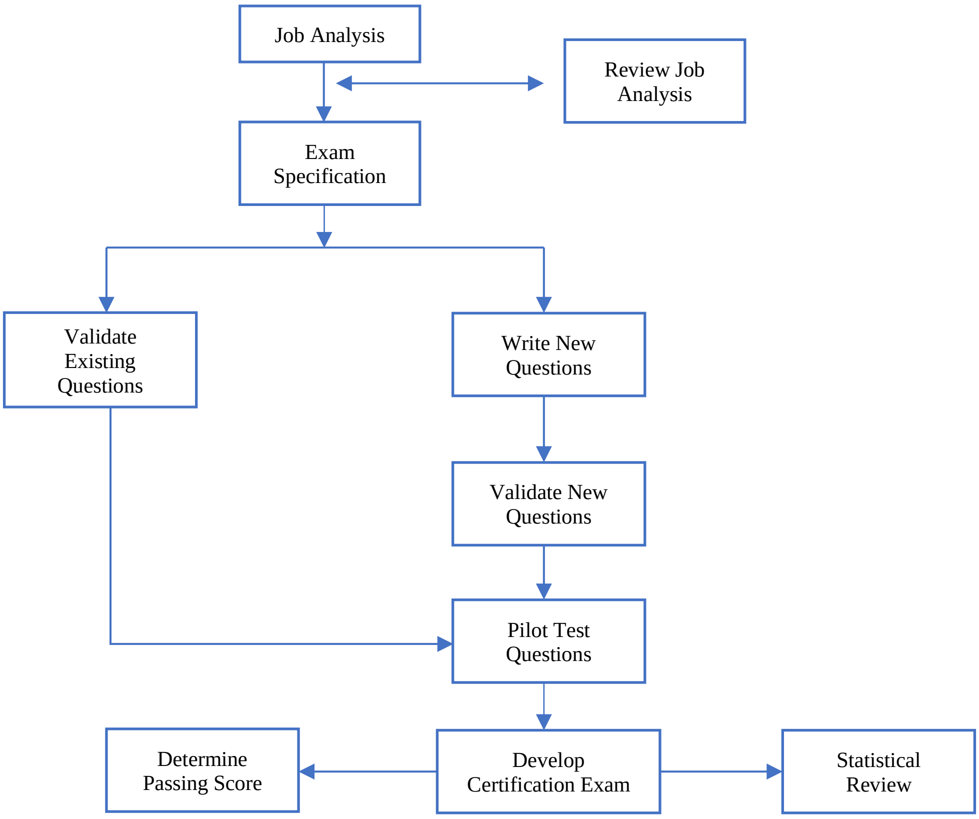
A personnel certification exam has to design as criterion-referenced standardized test or in combination with the criterion-referenced performance-based assessment.

## Fairness

The fairness of an exam refers to its freedom from any kind of bias. The exam should be appropriate for all qualified examinees, without regard for factors which are irrelevant to professional competency, such as race, religion, gender, or age. The test should not disadvantage any examinee, or group of examinees, on any basis other than the examinee's lack of the knowledge and skills the test is intended to measure. Item writers should address the goal of fairness as they undertake the task of writing items. In addition, the items should also be reviewed for potential fairness problems during the item review phase. Any items that are identified as displaying potential bias or lack of fairness should then be revised or dropped from further consideration.

## Validating an exam

**Exam Validation Process Flow Chart**




## Basic steps in exam validation process

1. ***Job Analysis***: Conducting a job analysis is an essential first step in establishing the content validity of certification exams. Job analysis is the foundation for defining the "certification scheme" (ISO/IEC 17024 sec. 8). A job analysis will define the important elements of professional competency through a series of discrete "job tasks" and the associated knowledge, skills and abilities (KSAs) required to perform these tasks. Metrics used for ranking the importance of job tasks should consider their "relevance" (to professional competency), "frequency" (how often these are done), and "criticality" (significance to professional success and to the protection of public health, safety, and welfare). In this process, job tasks should be eliminated from consideration in an examination when the KSA is adequately assessed by governmental licensing agencies (such as driving skills), and when no valid means of assessing competency in the task is identified. The rationale for eliminating tasks from consideration must be documented. Job analysis information may be gathered by direct observation of people currently in the job, interviews with experienced supervisors and job incumbents, questionnaires, personnel and equipment records, and work manuals. Workshops are held to identify specific job tasks and capabilities required for successful job performance. During these workshops, subject matter experts verify that the task statements developed are technically correct, unambiguous, and accurately reflect the job. identification of capabilities must be done on a task-by-task basis, so that a link is

established between each task statement and requisite capability. Job analysis information is central in deciding what to test for and which tests to use.

2. ***Review and Ranking of Job Tasks***: Ranking of the importance of job tasks may be accomplished through surveys or through structured focus-group interviews of a representative panel of competent practitioners. One common approach is the “delphi research method” to build consensus and to document the conclusions. When surveys are used, these should be relayed to a representative group of practitioners (both highly experienced and entry-level) and impacted parties (the employers of certified persons). Job analysis must be periodically reviewed within a certain period of time. If the certification body is not the owner of the certification scheme, it must ensure that the owner of the scheme reviews the job analysis.
3. ***Exam Specification***: Ratings are used to identify number of questions to appear on tests for each subject area. The specification (often called a “test blueprint”) must clearly link the examination to the job analysis (both tasks and associated KSAs).
4. ***Validate Existing Questions***: Existing questions are reviewed for relevance, accuracy, and style by subject matter experts.
5. ***Write New Questions***: New exam questions are developed according to the Job Analysis.
6. ***Validate New Questions***: All new questions must be reviewed by subject matter experts for relevancy, accuracy, and style.
7. ***Pilot Test Questions***: Pilot tests allow to statistically review each question and entire test results through the volunteers.
8. ***Develop Certification Exam (Test Blueprint)***: Examination blueprints are compiled from job analysis results, then validated through committee meetings and workshops. Use and review pilot test results. Operators, supervisors, and trainers should participate in the workshops.
9. ***Determine Passing Score***: The passing sore for an exam should be set in accordance with the purposes of the exam. The passing score is defined as the minimum score required to pass an exam to assure that the certificate-holder is professionally competent.
10. ***Statistical Review***: Statistically review results of exams to identify problem questions. Questions which are performing poorly should be discontinued from current use. These may be relayed back to the examination committee for further review and refinement.

## Details of exam validation process

It is essential to involve subject matter experts in all parts of the validation process. To qualify as a subject matter expert, a person must have direct, up-to-date experience with the job, and enough experience to be familiar with all of the tasks. Subject matter experts may include operators, supervisors, trainers, or other individuals with specialized knowledge about the job.

The principal steps normally taken for exam validation include:
1. Conduct a job analysis
2. Develop and validate items
3. Develop an exam
4. Establish a passing (cut) score

### Step 1. Conduct a job analysis

Conducting a job analysis is an essential first step in establishing the content validity of certification exams. A job analysis often lists the capabilities (i.e., knowledge, skills, and abilities) required to perform work tasks. Job analysis information may be gathered by direct observation of people currently in the job, interviews with experienced supervisors and job incumbents, questionnaires, personnel and equipment records, and work manuals.

Workshops are held to identify specific job tasks and capabilities required for successful job performance. During these workshops, subject matter experts verify that the task statements developed are technically correct, unambiguous, and accurately reflect the job. identification of capabilities must be done on a task-by-task basis, so that a link is established between each task statement and requisite capability.

Job analysis information is central in deciding what to test for and which tests to use.

### Step 2. Develop and validate items

Exam items are developed from the results of the job analysis so that exams are representative of job tasks. Once the new items are written, they must go through a validation process, which includes:

1. Linking new questions to the results of the job analysis. The purpose of this is to ensure that all questions on the certification exam measure at least one important aspect of an operator's job. During this process, subject matter experts are asked to rate the extent to which the questions reflect specific tasks in the job.

2. Analyzing questions for technical accuracy, style, readability, and possible bias to sub-groups. Determine that the correct answer is the best answer that the distractors (incorrect answers) are wrong, and that the question is free from bias with respect to race, gender, and culture.

3. Reviewing items for job importance. Importance ratings should reflect how well the question distinguishes between effective and ineffective job performance and if the knowledge tested in the question is necessary for competent job performance. The continued relevance of questions that have been validated must be ensured through periodic reviews of the items by subject matter experts. Evaluation of questions should also be conducted through statistical analysis. Of particular importance are the difficulty index (the ratio of examinees that answer each question correctly) and the discrimination index (how well the question distinguishes between the more knowledgeable and less knowledgeable examinees).

### Conduct the item analysis

In this phase statistical methods are used to identify any test items that are not working well. If an item is too easy, too difficult, failing to show a difference between skilled and unskilled examinees, or even scored incorrectly, an item analysis will reveal it. The two most common statistics reported in an item analysis are the item difficulty, which is a measure of the proportion of examinees who responded to an item correctly, and the item discrimination, which is a measure of how well the item discriminates between examinees who are knowledgeable in the content area and those who are not.

***Item Difficulty index ($p_J$)*** is the level of question difficulty affects test validity. If the exam is merely composed of difficult or easy questions, the distinction among the applicants cannot be determined clearly. The exam is expected to have an intermediate level of difficulty and this level helps determine the distinction among the applicants. Also, it is used for internal consistency formula.

It is denoted as;

$$p_{\mathrm{j}} = \frac{n(D)}{N}$$

$n(D)$ : The number of participants that true answered item
$N$ : The number of all participants that take exam

*Evaluation of Item Difficulty Index*

| **Item Difficulty Index** | **Item Difficulty Level** |
|---|---|
| Close to 1.00 | easy |
| About 0.50 | medium |
| Close to 0.00 | difficult |

***For example***, consider an exam with 20 participants that contains multiple choice questions. If a question had 9/20 test takers answer it correctly, this would then result in an Item Difficulty Index (pj) of 0.45, which would then classify this question as Medium Difficulty. If a question, on the other hand, had 19/20 test takers answer it correctly, this would result in a pj of 0.9, which would classify it as an Easy Difficulty question.

***Item Discrimination Index (r)*** is the efficiency of test questions in determining the distinction among the applicants. It expresses the relationship between the overall score and single question scores. It is a measure of how well an item is able to distinguish between examinees who are knowledgeable and those who are not, or between masters and non-masters. Item discrimination efficiency is to be high for test reliability. When an item is discriminating negatively, overall, the most knowledgeable examinees are getting the item wrong and the least knowledgeable examinees are getting the item right. A negative discrimination index may indicate that the item is measuring something other than what the rest of the test is measuring. More often, it is a sign that the item has been mis keyed.

When interpreting the value of a discrimination it is important to be aware that there is a relationship between an item's difficulty index and its discrimination index. If an item has a very high (or very low) p-value, the potential value of the discrimination index will be much less than if the item has a mid-range p-value. In other words, if an item is either very easy or very hard, it is not likely to be very discriminating.

There are over twenty discrimination indices used as indicators of the item’s discrimination effectiveness such as the index of discrimination ( $D$ ), Henryson discrimination index ($r_{jx}$), the point-biserial correlation coefficient ( $r_{pbis}$ ), biserial correlation coefficient ( $r_{bis}$ ), etc..

*Evaluation of Item Discrimination Index*

| **Item Discrimination Index** | **Item Discrimination Level** |
|---|---|
| 0.4 and above | very well |
| 0,30 - 0,39 | reasonable |
| 0,20 - 0,29 | should be corrected |
| 0,19 and below | very poor, remove from test |

Some of the statistical formulas are given below.

**Henryson discrimination index** ( $r_{jx}$ )

It is denoted as.

$$r_{jx} = \frac{\bar{X}(d) - \bar{X}}{S_x} \sqrt{\frac{p_j}{q_j}}$$

$\bar{X}(d)$ : Exam scores average of those who answers the correct item
$\bar{X}$ : Arithmetic mean of the exam scores
$S_x$ : Standard deviation of the exam scores
$p_j$ : Item difficulty index of the item
$q_j$ : 1- $p_j$

***For example***, consider an exam with 20 participants that contains 45 multiple choice questions. If the arithmetic mean of the exam scores is taken to be 32.85 and that standard deviation of the scores to be 6.651, the DI Level of certain questions can then be examined based on the item difficulty index, and the exam score average of correct answerers as follows:

| Question Number* | **Pj** | **qj** | $\bar{X}(d)$ | **rjx** | **DI Level** |
|---|---|---|---|---|---|
| 1 | 0.45 | 0.55 | 35.78 | 0.40 | Very well |
| 2 | 0.75 | 0.25 | 32.20 | -0.17 | Very Poor |
| 37 | 0.95 | 0.05 | 33.26 | 0.27 | Should be Corrected |
| 38 | 0.75 | 0.25 | 34.33 | 0.38 | Reasonable |
| 42 | 0.8 | 0.2 | 33.75 | 0.27 | Should be Corrected |
| 43 | 0.9 | 0.1 | 33.27 | 0.19 | Should be Corrected |
| 44 | 0.85 | 0.15 | 33.52 | 0.24 | Should be Corrected |
| 45 | 0.8 | 0.2 | 34.5 | 0.49 | Very well |

*Questions selected typically from a total of 45.

**Index of discrimination** ( $D$ )

While calculating the discrimination index according to the Simple Method, the respondents are divided into two groups as lower and upper groups according to the method. In this method, first, the total scores are calculated according to the results obtained from the measurement tool and ranked from the highest to the lowest. The 27% group with the highest success is taken as the upper group and the 27% group with the lowest success is taken as the subgroup. The remaining 46% group is excluded from the calculation.

It is denoted as.

$$D = P_u - P_l$$

$P_u$ : the proportion in the upper group who get the item right
$P_l$ : the proportion in the lower group who get the item right

***For example***, consider an exam with 20 participants that contains multiple choice questions. If a question had 67% of the upper group getting it correct (Pu = 0.67) and 33% of the lower group getting it correct (Pl = 0.33) the Item Discrimination Index would be 0.33 which would classify the discrimination as reasonable. Meanwhile if both the upper and lower groups all got the question correct (Pu = Pl = 1) this would result in an Item Discrimination Index of 0 and imply that said item discriminates very poorly.

**Point-biserial Correlation Coefficient** ( $r_{pbis}$ )

Point biserial in the context of an exam is a way of measuring the consistency of the relationship between a candidate's overall exam mark (a continuous variable – i.e. anywhere from 0-100%) and a candidate's item mark (a dichotomous variable i.e. with only two possible outcomes). It gives an indication of how strong or weak this correlation is compared to the other items in that exam. In other words, does the way candidates answer that item help to indicate whether they are strong or weak candidates?

It is denoted as;

$$r_{pbis} = \frac{M_1 - M_0}{S_n} \sqrt{pq}$$

$M_1$ : mean (for the entire test) of the group that received the positive binary variable (i.e. the "1").
$M_0$ : mean (for the entire test) of the group that received the negative binary variable (i.e. the "0").
$S_n$ : standard deviation for the entire test.
$p$ : item difficulty index
$q$ : $(1 - p)$

***For example***, consider an exam with 20 participants that contains 45 multiple choice questions. If the arithmetic mean of the exam scores is taken to be 32.85 and that standard deviation of the scores to be 6.651, the DI Level of certain questions can then be examined based on the item difficulty index, the mean of the group of test takers that answered correctly, and the mean of test takers that answered incorrectly, as follows:

| Question Number* | **Pj** | **qj** | $M_1$ | $M_0$ | **rpbis** | **DI Level** |
|---|---|---|---|---|---|---|
| 1 | 0.45 | 0.55 | 35.78 | 30.45 | 0.40 | Very well |
| 2 | 0.75 | 0.25 | 32.20 | 34.80 | -0.17 | Very Poor |
| 3 | 0.45 | 0.55 | 35.78 | 30.45 | 0.40 | Very well |
| 25 | 0.75 | 0.25 | 34.33 | 28.4 | 0.38 | Reasonable |
| 26 | 0.85 | 0.15 | 33.23 | 30.66 | 0.136 | Very Poor |
| 27 | 0.65 | 0.35 | 34.76 | 29.28 | 0.39 | Very well |
| 37 | 0.95 | 0.05 | 33.26 | 25 | 0.27 | Should be Corrected |
| 38 | 0.75 | 0.25 | 34.33 | 28.4 | 0.38 | Reasonable |

*Questions selected typically from a total of 45.

**Biserial Correlation Coefficient** ( $r_{bis}$ )

It is almost the same as point biserial correlation, but one of the variables is dichotomous ordinal data and has an underlying continuity.

It is denoted as.

$$r_{bis} = \frac{(M_1 - M_0)(\frac{pq}{Y})}{S_n}$$

$M_1$ : mean (for the entire test) of the group that received the positive binary variable (i.e. the “1”).
$M_0$ : mean (for the entire test) of the group that received the negative binary variable (i.e. the “0”).
$S_n$ : standard deviation for the entire test.
$p$ : item difficulty index
$q$ : $(1 - p)$
Y : Y ordinate of the normal distribution corresponding to the p value.

## Using item analysis on essay types questions

Personnel certification bodies may want to evaluate their candidates by various types of questions like essay type, modified essay type, short answer type and multiple-choice questions. Among these questions Multiple Choice Questions (MCQ) are very common and preferred type questions used in exams due to the efficiency and reliability of scoring and simplicity of analysis.

One of the most common tools used for assessment of knowledge is the essay questions. Their evaluations depend upon test and item analysis which is consisting of analysis of individual questions and analysis of the whole test. Although this activity is more precisely could be done in objective type questions also it can apply to essay type, structured essay type, and short answer questions.

What is required for item analysis is to determine the intermediate score ranges in accordance with the maximum score that can be given to the essay type or short answer question. List all the test takers' marks for individual question and according to aggregate marks scored, arrange test takers in rank order with highest score given on the top. Divide test takers into High Ability Group (HAG) and Low Ability Group (LAG).

***For example***, if a question is given 5 points, for each question test takers achieve 5 to 3.5 marks will be considered as correct answer i.e., A. For each question test takers achieve 3 to 2 marks will be considered as near to correct answer i.e., B. For each question test takers achieve 1.5 to 0.5 marks will be considered as near to incorrect answer i.e., C. For each question test takers achieve 0 marks will be considered as incorrect answer i.e., D. For each question, count the no. of test takers obtained marks of A, B, C, D category.

| Marks range | | 5.0 -3.5 | 3.0-2.0 | 1.5-0.5 | 0 | Total no. of considered test takers |
|---|---|---|---|---|---|---|
| Designated sign | | A | B | C | D | |
| No. of HAG test takers | Q1 | 11 | 14 | 0 | 0 | 25 |
| | Q2 | 15 | 9 | 1 | 0 | 25 |
| | Q3 | 5 | 14 | 5 | 1 | 25 |
| | Q4 | 16 | 9 | 0 | 0 | 25 |
| | Q5 | 8 | 10 | 7 | 0 | 25 |
| | Q6 | 22 | 3 | 0 | 0 | 25 |
| | Q7 | 16 | 8 | 1 | 0 | 25 |
| | Q8 | 4 | 20 | 1 | 0 | 25 |
| No. of LAG test takers | Q1 | 1 | 3 | 12 | 9 | 25 |
| | Q2 | 1 | 22 | 2 | 0 | 25 |
| | Q3 | 0 | 5 | 15 | 5 | 25 |
| | Q4 | 2 | 13 | 8 | 2 | 25 |
| | Q5 | 0 | 2 | 20 | 3 | 25 |
| | Q6 | 4 | 18 | 3 | 0 | 25 |
| | Q7 | 3 | 14 | 3 | 5 | 25 |
| | Q8 | 0 | 12 | 11 | 2 | 25 |
| Level of Correctness | | Correct answer | Near to correct answer | Near to incorrect answer | Incorrect answer | |

For all given questions, no. of test taker obtained marks in different range

The indices Facility Value (FV) and Discrimination Index (DI) are calculated in the following formulas.

***Facility Value (FV)***: It is number in the group answering a question right. Facility value is a measure of how easy or how difficult a question which is given to test takers, so it is also called as Difficulty Index. Higher the FV, easier is the question.

It is denoted as.

$$FV = \frac{HAG + LAG}{N} \times 100$$

$HAG$ : Higher ability group
$LAG$ : Lower ability group
$N$ : Total no. of considered test takers

FV value is expressed in percentage. Its range is 0-100. Its recommended value is 45-60 and its acceptable value is 25-75.

***Discrimination Index (DI)***: This index indicates the ability of a question to discriminate between a higher and a lower ability student.

It is denoted as;

$$DI = \frac{2 \times (HAG - LAG)}{N}$$

DI value is expressed in as a fraction. Its range is 0-1.0.

Its maximum value is 1.0, which indicates an ideal question with perfect discrimination between HAG and LAG. Its value could extend from -1.00 to + 1.00. This minus value is called as negative discrimination which means that more test takers in the lower group are answering that item correctly than test takers in the higher group.

Recommended value is > 0.25
Acceptable with revision is 0.15 - 0.25
Discard the question < 0.15

These item analysis helps in detecting specific technical flaws in the questions and provide information for improvement. It also increases the skill of examiners in item writing. No clear-cut guidelines in formulating item analysis. However, regular exercise over this analysis would contribute to personnel certification body in formulation of appropriate questions.

### Step 3. Develop the exam

After the job analysis survey is evaluated, the results are used to develop valid certification exams. Specifications for certification exams are based on the results of the job analysis and reflect how often a task, knowledge, skill, or ability is needed in practice and how much impact it has on effective job performance.

### Step 4. Establish the passing (cut) score

The cut score is defined as the minimum score required to pass an exam. Defining the cut score required for certification is one of the most important but difficult aspects of the validation process.

## Setting the passing (cut) score of an exam

Standard setting is the process used to select a passing score for an exam. Of all the steps in the test development process, the standard setting phase may be the one most like art, rather than science; while statistical methods are often used in conducting a standard setting, the process is also greatly impacted by judgment and policy.

The passing score (also known as the passing point, the cutoff score, or the cut-score) is used to classify examinees as either masters or non-masters. An examinee's score must be equal to or greater than the passing point, in order for that examinee to be classified as a master, or to pass the test. If an examinee is misclassified, that is referred to as a classification error.

Typically, the passing score is set at a score point on the exam that the judges determine reflects the minimum level of competency to protect the public from harm or to provide minimal competency at the occupational level being assessed. For the standard setting to be conducted successfully, the panel of judges should be carefully selected and then thoroughly prepared and trained to their task.

There are a number of approaches to standard setting, including: informed judgment, conjectural, and contrasting groups methods. All of these methods require the insight of a representative panel of competent practitioners, representing appropriate demographics and experience, ranging from those who have recently entered the profession to those who have competently practiced for many years.

## Methods for standard setting

***Types of Classification Error:*** The passing score for a test should be set in accordance with the purposes of the exam and considering relative risks to the public from incompetent practice. It should not be set arbitrarily, but rather should be carefully determined by a panel of judges who are familiar with the content of the exam as well as the characteristics of the occupation concerned.

Two types of classification error can occur when the passing score is applied.

One type of misclassification is termed a false-positive (i.e., an error of acceptance). An example of a false-positive error would be an examinee who was not minimally competent, but who passed the test.

The second type of misclassification is termed a false-negative (i.e., an error of rejection). In this type of misclassification, an examinee who actually has the level of competence fails the test.

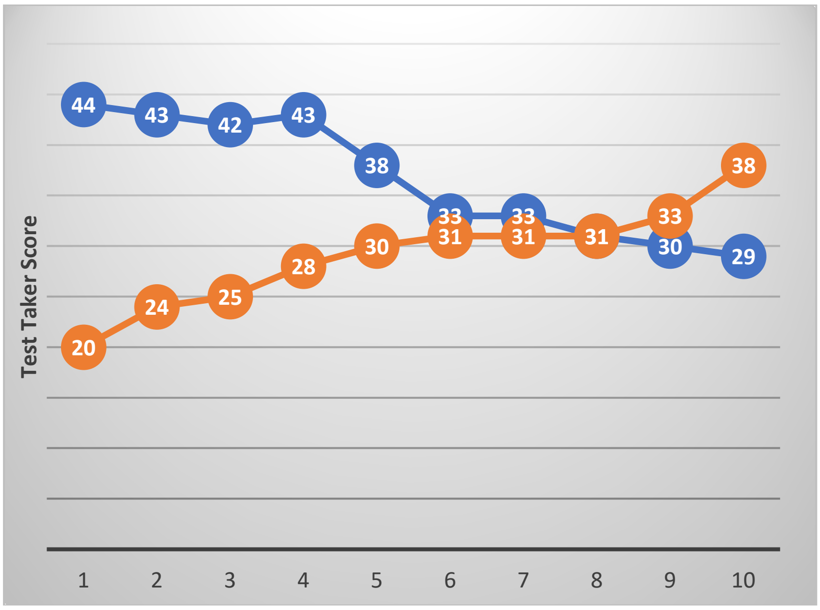
Depending upon the nature of the exam program, one of these types of errors may be far more problematic than the other. Awareness of these potential consequences may be used to influence the determination of the final passing score, after the panel of judges has made their recommendation. Policy makers at the exam program may adjust that recommended passing point based on other factors, possibly including operational test score data when it becomes available.

***Informed Judgment Method:*** The informed judgment method is a test-based approach. A panel of judges, or stakeholders, reviews the overall test and its content. Based on their holistic reviews, the judges then each suggest a percentage of items on the test that he or she believes ought to be correctly answered by a minimally competent examinee. This percent-correct score on the total test can be viewed as the individual judges' recommended passing score. Once you have these recommended passing scores from the panel you can use them, perhaps along with additional information, to set the final passing score. The informed judgment method might be difficult to rationally defend when it is used in isolation. However, it may be a very appropriate method for use in combination with other methods, particularly the contrasting groups method.

***Conjectural (Modified Angoff) Method:*** The modified Angoff method is the most commonly used of the conjectural methods, all of which are item-based approaches to standard setting. A panel of judges is assembled and is asked to review the test, one item at a time. For each item, each judge gives an estimate of the probability that a minimally competent examinee would be likely to respond correctly. (Alternatively, the judges may be asked to imagine a hypothetical group of minimally competent examinees and then to indicate the percentage of that group who would be likely to respond to the given item correctly.) When judges are not in agreement regarding the pass/fail standard, those with disparate ratings are given the opportunity to explain their rankings, with the voting process repeated, building consensus. Typically, one or more additional rounds of review are undertaken. These passing scores are then averaged across the individual judges to arrive at the full panel's recommended final passing score.

***Contrasting Groups Method:*** The contrasting groups method is an examinee-based approach to standard setting. This method in particular requires that the panel of judges be highly familiar with the target test population. The panel of judges identifies a set of examinees who are clearly non-masters and another set of examinees who are clearly masters; borderline examinees are not included. It is especially important that the non-masters be carefully selected. While these non-master examinees would not yet be considered minimally competent in the occupational area, they should nevertheless be members of the target test population. If, instead, the examinees who are identified as non-masters are completely unknowledgeable in the exam's content area, the passing score may be set at an artificially low point. After the two groups of examinees have been identified, they are then administered the test. The two resulting test score frequency distributions are plotted on the same continuum. The passing score can be set at the intersection point of the two distributions; or, alternatively, the final passing score can be adjusted somewhat, based on the relative cost of false-positive and false-negative classification errors. While the contrasting groups method can be used independently, it may also be used as a complement to the informed judgment or other standard setting method.

***For example***, consider an exam with 20 participants that contains 45 multiple choice questions. A list can be created, including the descending order of scores of experienced test takers (pictured in blue, below) and the ascending order of scores of other test takers (pictured in orange below).




Notice that the lists intersect at a score of 31, which can then be used as a cut off score.

## Test reliability

Test Reliability is an index of the consistency of scores produced by the test, with a higher value being desirable. A value of 1.0 indicates a perfectly reliable test. A value of 0.0 indicates the test essentially produces random scores

The test measures what it claims to measure consistently or reliably. This means that if a person were to take the test again, the person would get a similar test score.

Reliability refers to how dependably or consistently a test measures a characteristic. If a person takes the test again, will he or she get a similar test score, or a much different score? A test that yields similar scores for a person who repeats the test is said to measure a characteristic reliably.

How do we account for an individual who does not get exactly the same test score every time he or she takes the test? Some possible reasons are the following:

- ***Test taker's temporary psychological or physical state***. Test performance can be influenced by a person's psychological or physical state at the time of testing. For example, differing levels of anxiety, fatigue, or motivation may affect the applicant's test results.
- ***Environmental factors***. Differences in the testing environment, such as room temperature, lighting, noise, or even the test administrator, can influence an individual's test performance.
- ***Test form***. When tests are administered on multiple dates, for security reasons additional forms of the test may be necessary. It is expected that test forms will be revised at least annually. Test forms must be assembled to the same "test blueprint." Different forms of a test are known as parallel forms or alternate forms. These forms are designed to have similar measurement characteristics, but they contain different items. Because the forms are not exactly the same, a test taker might do better on one form than on another.

- ***Multiple raters***. In certain tests, scoring is determined by a rater's judgments of the test taker's performance or responses. Differences in training, experience, and frame of reference among raters can produce different test scores for the test taker.

These factors are sources of chance or random measurement error in the assessment process. If there were no random errors of measurement, the individual would get the same test score. The degree to which test scores are unaffected by measurement errors is an indication of the reliability of the test.

## Types of reliability estimates

There are several types of reliability estimates, each influenced by different sources of measurement error. The acceptable level of reliability will differ depending on the type of test and the reliability estimate used.

1. ***Test-retest reliability*** indicates the repeatability of test scores with the passage of time. This estimate also reflects the stability of the characteristic or construct being measured by the test. For constructs that are expected to vary over time, an acceptable test-retest reliability coefficient may be lower than is suggested in table.1

2. ***Alternate or parallel form reliability*** indicates how consistent test scores are likely to be if a person takes two or more forms of a test. A high parallel form reliability coefficient indicates that the different forms of the test are very similar which means that it makes virtually no difference which version of the test a person takes. On the other hand, a low parallel form reliability coefficient suggests that the different forms are probably not comparable; they may be measuring different things and therefore cannot be used interchangeably.

3. ***Inter-rater reliability*** applies most often to examinations which through examiners (vs. objective multiple-choice examinations).  Inter-rater reliability indicates how consistent test scores are likely to be if the test is scored by two or more raters. On some tests, raters evaluate responses to questions and determine the score. Differences in judgments among raters are likely to produce variations in test scores. A high inter-rater reliability coefficient indicates that the judgment process is stable, and the resulting scores are reliable. Inter-rater reliability coefficients are typically lower than other types of reliability estimates. However, it is possible to obtain higher levels of inter-rater reliabilities if raters are appropriately trained.

4. ***Internal consistency reliability*** indicates the extent to which items on a test measure the same thing. A high internal consistency reliability coefficient for a test indicates that the items on the test are very similar to each other in content (homogeneous). It is important to note that the length of a test can affect internal consistency reliability. For example, a very lengthy test can spuriously inflate the reliability coefficient.

## Interpretation of reliability

The reliability of a test is indicated by the reliability coefficient. It is denoted by the letter “r,” and is expressed as a number ranging between 0 and 1.00, with r = 0 indicating no reliability, and r = 1.00 indicating perfect reliability.

Generally, you will see the reliability of a test as a decimal, for example, r = .80 or r = .93. The larger the reliability coefficient, the more repeatable or reliable the test scores.

*General Guidelines for Interpreting Reliability Coefficients*

| Reliability Coefficient Value | Interpretation |
|---|---|
| .90 and up | excellent |
| .80 - .89 | good |
| .70 - .79 | adequate |
| below .70 | may have limited applicability |

One measure of reliability used is Cronbach’s Alpha. This is the general form of the more commonly reported KR-20 and can be applied to tests composed of items with different numbers of points given for different response alternatives. When coefficient alpha is applied to tests in which each item has only one correct answer and all correct answers are worth the same number of points, the resulting coefficient is identical to KR-20.

Estimates of test reliability are only meaningful when there are a sufficient number of examinations administered, typically requiring data from at least 100 candidates. While newly formed certification bodies may not have access to sufficient data to estimate reliability, it is expected that more mature programs will estimate and consider statistical reliability in their validation process.

**Kuder-Richardson method**

Kuder-Richardson Formula 20, or KR-20, is a measure reliability for a test with binary variables (i.e. answers that are right or wrong). Reliability refers to how consistent the results from the test are, or how well the test is actually measuring what you want it to measure.

The KR20 is used for items that have varying difficulty. For example, some items might be very easy, others more challenging. It should only be used if there is a correct answer for each question — it shouldn’t be used for questions with partial credit is possible or for scales like the Likert Scale.

**KR20 Scores:** The scores for KR-20 range from 0 to 1, where 0 is no reliability and 1 is perfect reliability. The closer the score is to 1, the more reliable the test.

It is denoted as.

$$KR20 = \left[\frac{n}{n-1}\right] . \left[\frac{1 - \Sigma(p.q)}{Var}\right]$$

$n$ : sample size for the test
$p$ : proportion of people passing the item
$q$ : proportion of people failing the item
$Var$ : variance for the test
$\Sigma$ : sum up (add up). In other words, multiple Each question's p by q, and then add them all up. If you have 10 items, you'll multiply p.q ten times, then you'll add those ten items up to get a total.

**KR21 Scores:** If all questions in your binary test are equally challenging, use the KR-21.

It is denoted as.

$$KR21 = \left[\frac{n}{n-1}\right] . \left[\frac{1 - (M.(n-M)}{n.Var}\right]$$

$n$ : sample size for the test
$Var$ : variance for the test
$M$ : mean score for the test

***For example***, consider an exam with 20 participants that contains 45 multiple choice questions. Since all questions in this situation are equally challenging, we would choose to use the KR-21 score. If however, we take the summation of the product of people passing and failing each item to be 8.0325 and the Variance to be 42.0275, we could deduce the KR20 score for this exam to be -0.17, further verifying it is incorrect to use KR-20 in this scenario. Knowing that that mean is 32.85, we could then deduce the KR-21 score to be 0.5299, indicating average reliability of the test.

**Cronbach's Alpha:** measures reliability, or internal consistency. If you have a test with more than two answer possibilities (or opportunities for partial credit), use Cronbach's Alpha instead. Cronbach's alpha is used to see if multiple-question Likert scale surveys are reliable.

It is denoted as.

$$\alpha = \frac{k}{(k-1)}[1 - \frac{\Sigma\sigma_j^2}{\sigma_T^2}]$$

$k$ : the number of items on the test
$\Sigma\sigma_j^2$ : the sum of the j item score variances

$\sigma_T^2$ : the variance of the total test scores

***For example***, consider an exam with 20 participants that contains 14 questions with more than two answer possibilities (or opportunities for partial credit). If the sum of the j item score variances is taken to be 42.9 and the variance of the total test scores is 161.4, Cronbach's Alpha can be calculated to be 0.7907, which would indicate adequate to good reliability.

## Test validity

Validity tells you if the characteristic being measured by a test is related to job qualifications and requirements for entry-level, competent practitioners. Validity gives meaning to the test scores. Validity evidence indicates that there is linkage between test performance and job performance.

It is important to understand the differences between reliability and validity. Validity will tell you how good a test is for a particular situation; reliability will tell you how trustworthy a score on that test will be. You should be careful that any test you select is both reliable and valid for your situation.

## Methods for conducting test validation studies

The validity of a certification examination requires analysis of the entire process, including the supporting research for the examination (job analysis and scheme-development) as well as the security and integrity of the process for administering and scoring examinations.  A wholistic-approach is necessary.  Because of the diversity of facets which impact validity, statistical indicators of validity of an examination are rarely employed but may be useful.

Broad constructs for analyses for certification examinations are often defined as "face validity", "criterion-related validity", "content-related validity" and "construct-related validity."  The simplest of these is "face validity" – whether or not the examination appears (to examination candidates) to relate to important elements of professional practice.  This is a qualitative metric which is important for public acceptance and reputation of the examination.  The remaining constructs include quantitative metrics.

1- ***Criterion-related validation*** requires demonstration of a correlation or other statistical relationship between test performance and job performance. In other words, individuals who score high on the test tend to perform better on the job than those who score low on the test. If the criterion is obtained at the same time the test is given, it is called concurrent validity; if the criterion is obtained at a later time, it is called predictive validity.

The criterion-related validity of a test is measured by the validity coefficient. It is reported as a number between 0 and 1.00 that indicates the magnitude of the relationship, "r," between the test and a measure of job performance (criterion). The larger the validity coefficient, the more confidence you can have in predictions made from the test scores. However, a single test can never fully predict job performance because success on the job depends on so many varied factors. Therefore, validity coefficients, unlike reliability coefficients, rarely exceed r = .40.

It is denoted as.

$$Correl\ (X,Y) = \frac{\Sigma\ (x-\bar{x})(y-\ \bar{y})}{\sqrt{\Sigma\ (x-\bar{x})^2\Sigma(y-\ \bar{y})^2}}$$

$x$ : Exam score of test taker in group 1

$\bar{x}$ : Arithmetic mean of the exam scores of group 1

$y$ : Exam score of test taker in group 2

$\bar{y}$ : Arithmetic mean of the exam scores of group 2

As a general rule, the higher the validity coefficient the more beneficial it is to use the test. Validity coefficients of r=.21 to r=.35 are typical for a single test.

***For example***, consider an exam that contains 45 multiple choice questions with two exam groups of 20 participants each. If we take the square of the summation of the difference of individual scores to the mean score to be 840.55 in group 1 and 779.2 in group 2, and also take the summation of their products to be 792.4, we can derive a correlation of 0.98 which is incredibly beneficial.

*General Guidelines for Interpreting Validity Coefficients*

| **Validity coefficient value** | **Interpretation** |
|---|---|
| above .35 | very beneficial |
| .21 - .35 | likely to be useful |
| .11 - .20 | depends on circumstances |
| below .11 | unlikely to be useful |

2- ***Content-related validation*** is a non-statistical type of validity and requires a demonstration that the content of the test represents important job-related behaviors. In other words, test items should be relevant to and measure directly important requirements and qualifications for the job.

3- ***Construct-related validation*** requires a demonstration that the test measures the construct or characteristic it claims to measure, and that this characteristic is important to successful performance on the job.

Professionally developed tests should come with reports on validity evidence, including detailed explanations of how validation studies were conducted. If you develop your own tests or procedures, you will need to conduct your own validation studies.

## Standard error of measurement (SEM)

All examinations are imperfect measures of professional competency. It is important that certification bodies are aware of this and use available statistics to estimate the level of error when this is possible. For traditional multiple-choice examinations, a statistical estimate of this error is called the "Standard Error of Measurement" (SEM). The SEM is comparable to the statistical estimate "Uncertainty of Measurement" (MU) which is estimated by product-testing laboratories (ISO/IEC 17025).

SEM provides an estimate of the margin of error that you should expect in an individual test score because of imperfect reliability of the test.

The SEM represents the degree of confidence that a person's "true" score lies within a particular range of scores. For example, an SEM of "2" indicates that a test taker's "true" score probably lies within 2 points in either direction of the score he or she receives on the test. This means that if an individual receives a 91 on the test, there is a good chance that the person's "true" score lies somewhere between 89 and 93.

The SEM is a useful measure of the accuracy of individual test scores. The smaller the SEM, the more accurate the measurements.

It is denoted as.

$$SEM = S_D\sqrt{(1 - r_{xx})}$$

$S_D$ : standard Deviation of tests scores
$r_{xx}$ : the reliability or precision of the test

$$r_{xx} = \frac{S_T^2}{S_X^2}$$

$S_T^2$ : variance of the true scores.
$S_X^2$ : variance of the observed scores

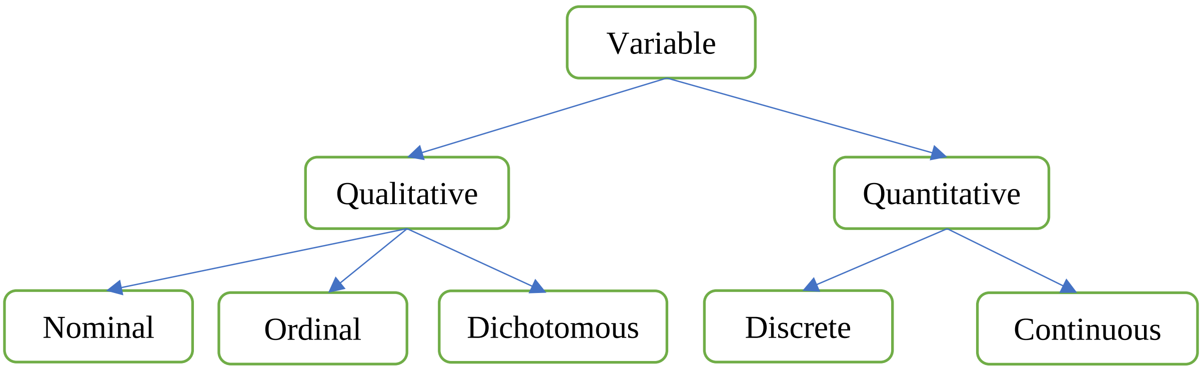
We use the SEM to calculate confidence Intervals around obtained scores.
68 % CI = Score ± SEM
95 % CI = Score ± (1.96*SEM)
99 % CI = Score ± (2.58*SEM)

***For example***, consider an exam with 20 participants that contains 45 multiple choice questions. If we take the standard deviation of the scores to be 6.65128 and the reliability of the test to be 0.52988, we can then calculate the standard error of measurement to be 4.6. This would imply that the true score would be raw score ± 4.6 for score in 68% Cl, raw score ± 9.02 for score in 95% Cl, and raw score ± 11.87 for raw score in 99% Cl.

# Annex 1

## *Statistical Terms and Definitions that need to know*

***Data***
Data are obtained by measurement, counting, experimentation, observation or research. Data collected by measurement or counting and reporting a numerical value are called **quantitative data**, and data that do not report a numerical value are called qualitative (categorical) data.



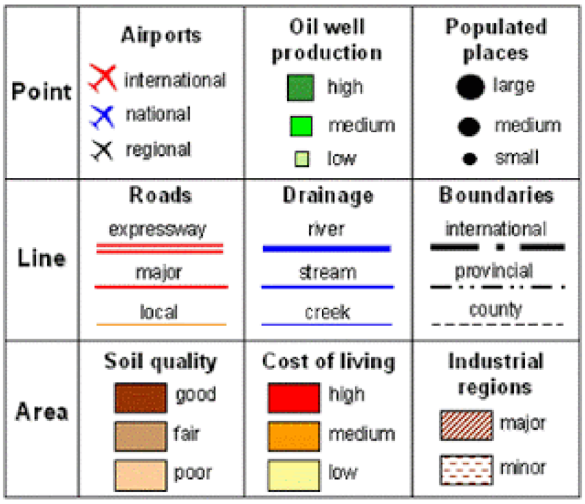

***Qualitative (Categorical)Variables***
Variables that are not numerical and which values fits into categories.

***Nominal Variables***
Nominal variables are variables that have two or more categories, but which do not have an intrinsic order.

| Office | Revenue | Revenue |
|---|---|---|
| Whalen | $4,400.00 | $4,400.00 |
| Hartstein | $13,000.00 | $13,000.00 |
| Fay | $6,000.00 | $6,000.00 |
| Raphaely | $11,000.00 | $11,000.00 |
| Khoo | $3,100.00 | $3,100.00 |
| Baida | $2,900.00 | $2,900.00 |
| Tobias | $2,800.00 | $2,800.00 |
| Himuro | $2,600.00 | $2,600.00 |
| Colmenares | $2,500.00 | $2,500.00 |
| Mavris | $6,500.00 | $6,500.00 |

***Ordinal Variables***
A categorical variable for which the possible values are ordered. Ordinal variables can be considered “in between” categorical and quantitative data.

Ordinal Data




### *Dichotomous Variables*

Dichotomous variables are nominal variables which have only two categories or levels. . Having only two possible values, e.g. “0/1, "Yes/No", "True/False" etc.

### *Quantitative Variables*

A variable that reflects a notion of magnitude, that is, if the values it can take are numbers. A quantitative variable represents thus a measure and is numerical.

### *Discrete Variables*

Variables for which the values it can take are countable and have a finite number of possibilities. The values are often (but not always) integers.

### *Continuous Variables*

Variables for which the values are not countable and have an infinite number of possibilities.

*P.S. Misleading data encoding*

*In datasets it is very often the case that numbers are used for qualitative variables. For instance, a person doing statistical analyze may assign the number “0” to the answer “False” and “1” to the answer “True. Despite the numerical classification, the variable answer is still a qualitative variable and not a discrete variable as it may look. The numerical classification is only used to facilitate data collection and data management.*

### *Median*

The value separating the higher half from the lower half of a data sample

1, 3, 3, **6**, 7, 8, 9

Median = 6

1, 2, 3, **4**, **5**, 6, 8, 9

Median = (4 + 5) ÷ 2

= 4.5

***Arithmetic Mean***
The sum of a collection of numbers divided by the count of numbers in the collection. Simply it calls as Average

$$A = \frac{1}{n}\sum_{i=1}^{n} a_i$$

***Weighted Arithmetic Mean***
The weighted arithmetic mean is similar to an ordinary arithmetic mean, except that instead of each of the data points contributing equally to the final average, some data points contribute more than others.

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i . x_i}{\sum_{i=1}^{n} w_i}$$

***Variance***
The expectation of the squared deviation of a random variable from its mean.

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

***Standard Deviation***
Standard deviation is a measure of dispersement in statistics. “Dispersement” tells you how much your data is spread out. Specifically, it shows you how much your data is spread out around the mean or average. For example, are all your scores close to the average? Or are lots of scores way above (or way below) the average score?

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

***Covariance***
A measure of the joint variability of two random variables. In other words, a measure of how much two random variables vary together. It’s similar to variance, but where variance tells you how a single variable varies, co variance tells you how two variables vary together.

$$C(X,Y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x}).(y_i - \bar{y})}{n-1}$$

***Correlation***

Correlation is a statistical technique that measures the relationship between two variables, such as X and Y, in terms of the units of measurement results for these variables.

***Correlation Coefficient that can be used according to variable types***

| **Variable Y/X** | **Quantitative X** | **Ordinal X** | **Nominal X** |
|---|---|---|---|
| **Quantitative Y** | Pearson r | Biserial $r_{bis}$ | Point Biserial $r_{pbis}$ |
| **Ordinal Y** | Biserial $r_{bis}$ | Spearman rho/Tetrachoric $r_{tet}$ | Rank Biserial $r_{rbis}$ |
| **Nominal Y** | Point Biserial $r_{pbis}$ | Rank Biserial $r_{rbis}$ | Phi, L, C, Lambda |

***Pearson Product Moment Correlation Coefficient (PPMC)***

Correlation between sets of data is a measure of how well they are related. It shows the linear relationship between two sets of data. In simple terms, it answers the question, Can I draw a line graph to represent the data?

$$r(X,Y) = \frac{n.\sum_{i=1}^{n} x_i.y_i - (\sum_{i=1}^{n} x_i).(\sum_{i=1}^{n} y_i)}{\sqrt{[n.\sum_{i=1}^{n} x_i - (\sum_{i=1}^{n} x_i)^2].[n.\sum_{i=1}^{n} y_i - (\sum_{i=1}^{n} y_i)^2]}}$$

***Point Biserial Correlation Coefficient ($r_{pbis}$)***

Is a special case of Pearson in which one variable is quantitative and the other variable is dichotomous and nominal. The calculations simplify since typically the values 1 (presence) and 0 (absence) are used for the dichotomous variable.

$$r_{pbis} = \frac{\bar{X}_1 - \bar{X}_0}{S_X}\sqrt{pq}$$

***Phi Correlation Coefficient (φ)***

A measure of association for two binary variables. is used for contingency tables when:

- At least one variable is a nominal variable.
- Both variables are dichotomous variables.

| **Y/X** | **0** | **1** | **Totals** |
|---|---|---|---|
| **1** | A | B | A+B |
| **0** | C | D | C+D |
| **Totals** | A+C | B+D | N |

*Contingency table*

$$\varphi = \frac{(B.C) - (A.D)}{\sqrt{(A+B).(C+D).(A+C).(B+D)}}$$

***Tetrachoric Correlation Coefficient ($r_{tet}$)***
An index reflecting the degree of relationship between two continuous variables that have both been dichotomized.

$$r_{tet} = \cos\left(\frac{180^\circ}{1 + \sqrt{\frac{B.C}{A.D}}}\right)$$

# Annex 2

## *Classical Test Theory*

Classical Test Theory (CTT), sometimes called the true score model, is the mathematics behind creating and answering tests and measurement scales. The goal of CTT is to improve tests, particularly the reliability and validity of tests.

**Reliability implies consistency**: if you take any test five times, you should get roughly the same results every time. A test is valid if it measures what it's supposed to.

***True Scores***
Classical Test Theory assumes that each person has an innate true score. It can be summed up with an equation:
$X = T + E$

Where:
X is an observed score,
T is the true score,
E is random error.

For example, let's assume you know exactly 70% of all the material covered in a statistics course. This is your true score (T); A perfect end-of-semester test (which doesn't exist) should ideally reflect this true score. In reality, you're likely to score around 65% to 75%. The 5% discrepancy from your true score is the error (E).

The errors are assumed to be normally distributed with a mean of zero; Hypothetically, if you took the test an infinite number of times, your observed score should equal your true score.

## *Statistics Used in Classical Test Theory*

Is your test measuring what it's supposed to?

Classical test theory is a collection of many statistics, including the average score, item difficulty, and the test's reliability.

***1.Correlation***
Correlation: shows how two variables X and Y are related to each other. Different measures are used for different test types. For example, a dichotomously scored test (e.g. yes/no answers) would be correlated with point-biserial correlation while a polytomously scored test (one with multiple answers) would be scored with the Pearson Correlation Coefficient.

***2. Covariance***
Covariance is a measure of how much two random variables vary together. It's similar to variance, but where variance tells you how a single variable varies, co variance tells you how two variables vary together.

***3. Discrimination Index***

Discrimination Index: the ability of the test to discriminate between different levels of learning or other concept of interest. A high discrimination index indicates the test is able to differentiate between levels.

***4. Item difficulty***

Item difficulty: a measure of individual test question difficulty. It is the proportion of test takers who answered correctly out of the total number of test takers. For example, an item difficulty score of 89/100 means that out of 100 people, 89 answered correctly.

***5. Reliability Coefficient***

Reliability coefficient — a measure of how well the test measures achievement. Several methods exist for calculating the coefficient include test-retest, parallel or alternate-form and internal analysis. Rules of thumb for preferred levels of the coefficient:
For high stakes tests (e.g. college admissions), > 0.85.
For low stakes tests (e.g. classroom assessment), > 0.70.

***6. Sample Variance / Standard Deviation***

The sample variance and sample standard deviation are measures of how spread out the scores are.

***7. Standard Error of Measurement***

Standard Error of Measurement (SEM): a measure of how much measured test scores are spread around a “true” score.

*Reference:*

Stephanie Glen. "Classical Test Theory: Definition" From StatisticsHowTo.com

# Annex 3

## *Item Response Theory (IRT)*

Item response Theory (IRT) is a way to analyze responses to tests or questionnaires with the goal of improving measurement accuracy and reliability. If you want your test to actually measure what it is supposed to measure (i.e. mathematical ability, a student's reading ability or historical knowledge), IRT is one way to develop your tests.

The first step in IRT is the development of a two-dimensional matrix, which lists examinees and correct responses. In this matrix, 1 represents a correct answer and 0 an incorrect answer:

| | **Item 1** | **Item 2** | **Item 3** | **Item 4** | **Item 5** | **Mean Proficiency Level (Q)** |
|---|---|---|---|---|---|---|
| **Person 1** | 1 | 1 | 1 | 1 | 1 | 1 |
| **Person 2** | 0 | 1 | 1 | 1 | 1 | 0.8 |
| **Person 3** | 0 | 0 | 1 | 1 | 1 | 0.6 |
| **Person 4** | 0 | 0 | 0 | 1 | 1 | 0.4 |
| **Person 5** | 0 | 0 | 0 | 0 | 1 | 0.2 |
| **Mean ID ($p_j$)** | 0.8 | 0.6 | 0.4 | 0.2 | 0 | |

A quick look at this table tells you that person 1 answered all 5 questions correctly (100% proficient) while person 4 answered 2 questions (40% proficiency). However, proficiency isn't the only factor in IRT theory: you must also take into account question difficulty. Let's say you had two test takers who both get 2/5. The first test taker may have answered two easy questions, and the second test taker may have answered two difficult questions. Therefore, although they both scored 40%, their proficiency is not the same.

Item response theory takes into account the number of questions answered correctly and the difficulty of the question.

There are many different models for IRT. Three of the most popular are:

- The Rasch model,
- Two-parameter model,
- Three-parameter model.

Some researchers of thought consider the Rasch model as being completely separate from IRT. This is mainly because the Rasch model uses only a single parameter (called a "threshold"), while general IRT models use three. Another reason is that IRT aims to fit a model to data, while The Rasch model fits data to a model. Despite these differences, both models are used in favor of Classical Test Theory — where test taker's scores vary from one test to another.

*Reference.*

Stephanie Glen. "Item Response Theory: Simple Definition" From StatisticsHowTo.com

***The Rasch model***

In item response theory, a model in which only one parameter, item difficulty, is specified. This is thought to be a parsimonious way to describe the relation between an item response and an underlying dimension and is thus preferred in some cases. Also called one-parameter model.

***Two-parameter model***

In item response theory, a model that specifies two parameters affecting an individual's response to a particular test item: (a) the difficulty level of the item and (b) the item discriminability.

***Three-parameter model***

In item response theory, a model that specifies three parameters affecting an individual's response to a particular test item: (a) the difficulty level of the item; (b) the discriminating power of the item; and (c) in multiple-choice items, the effect of guessing. The probability of a correct response to the item is held to be a mathematical function of these parameters.

***Anchor test***

A set of test items used as a reference point in comparing alternate forms of a test. One alternate form is administered to one group of participants, another is administered to a different group, and the items comprising the anchor test are administered to both groups. Scores on each alternate form are then compared with scores on the anchor test.

# Annex 4

## *Scheme Validation Process Flow Chart*

***Scheme analysis***
Scheme Technical Committee (STC) with the support of specialized experts/consultants proceed in a competence analysis. Scheme competences are documented. STC experts 18

**5.2** ***Evaluation of academic/training requirements***
STC members evaluate any applicable academic/training requirements of the certification scheme according to all applicable (market/legal/statutory/normative) scheme requirements.

**5.3** ***Evaluation of experience requirements***
STC members evaluate any applicable experience requirements of the certification scheme according to all applicable (market/legal/statutory/normative) scheme requirements.

**5.4** ***Evaluation of certification maintenance/recertification requirements***
STC members evaluate any applicable certification maintenance/recertification requirements of the certification scheme according to all applicable (market/legal/statutory/normative) scheme requirements.

**5.5** ***Selection and development of tests***
Specialized experts/consultants evaluate the scheme analysis information (competencies requirements) and determine the knowledge, skills and abilities and the methods for their measurement.

**5.6 S*et cutting scores and review final test***
STC experts review the test item-by-item. They select the correct answer, they are told the keyed answer, and they are asked what percent of qualified candidates would pass each item. The STC experts judge which, if any, of the knowledge, skills, or abilities is measured by the tests. This is also their final review of the total test before it is printed. The detailed *Scheme Validation Procedure (modified Angoff model)* is provided at the end of this document.

**5.7** ***Edit, compose and print tests***
Examination Department edits, composes, and prints (if required) the tests.

**5.8** ***Writing of content validation report***
Quality Assurance Manager writes a content-related validation report. The STC reviews a draft and the final report detailing the activities undertaken is then is provided to Certification Manager for approval and back to Quality Assurance Manager for inclusion to the Management Review agenda.

# Annex 4

## *References*

The following list of reference material provides sources of information on specific topics and issues relating to personnel testing and assessment. The main text has referred and quoted to many of the publications listed below:


- *Gathering, analyzing, and using data on test items, 1971, Henryson, S. in R. L. Thorndike;*
- *How to Set Cutoff Scores for Knowledge Tests Used in Promotion, Training, Certification, and Licensing, 1993, Richard E. Biddle;*
- *Testing and Assessment: An Employer's Guide to Good Practices, 1999, U.S. Department of Labor Employment and Training Administration;*
- *Validating Your Certification Exam, 2000, Association of Boards of Certification;*
- *Comparison of Several Popular Discrimination Indices Based on Different Criteria and Their Application in Item Analysis, 2008, Fu Liu;*
- *Setting the Passing Score of an Exam, 2018, Dr. George J. Anastasopoulos;*
- *Distractor Analysis Based on Item Difficulty Index and Item Discrimination Index, 2019, Burcu Hasançebi, Yüksel Terzi, Zafer Küçük;*
- *Test Quality, Professional Testing Inc.;*
- *StatisticsHowTo.com;*
- *ISO/IEC 17024:2012 Conformity assessment — General requirements for bodies operating certification of persons;*
- *ISO/IEC TS 17024:2014 Conformity assessment – Vocabulary related to competence of persons used for certification of persons;*
- *AERA/APA/NCME The standards for educational and psychological testing, 2014.*