Professional Learning Indicator®

A summary of the theory behind, the development of, and the practical applicability of The Professional Learning Indicator®.
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Theoretical Background

Cognitive Abilities

Cognitive abilities are involved in completing any task, caused by mental activity that an individual engages in. Any task can be broken down into the different cognitive skills or functions needed to complete the task successfully, such as; the ability to perceive, be attentive, solve problems, absorb, process, and comprehend information. Cognitive abilities are an integral part of any task an individual conducts (from the simplest to the most complex) and a fundamental basis from which we learn, interact, communicate, comprehend, absorb, and process information. For instance; answering the telephone is presumably a simple act, but involves at least:

- Perception skills (linking sound to meaning)
- Decision-making skills (answering or not)
- Planning skills (initiating movement to answer the call)
- Verbal skills (talking and understanding language)
- Attention skills (paying and maintaining attention)

In order to illuminate the fundamentality of cognitive abilities a parallel is drawn to cognitive imparities. An individual diagnosed with cognitive impairment is likely to see the act of answering the telephone as an insurmountable task. Because s/he has problems focusing and maintaining attention, initiating, remembering, completing, and finishing activities, the imparities will affect any given act the person intends to conduct, even the most simple acts that are aspects of our everyday lives.

Another example is moving a barrel from one place to another. This task involves not only cognitive abilities (e.g. planning skills) but also physical strength. To define a strictly cognitive task (and measure the individual’s cognitive ability to complete the task successfully) will therefore require focusing only on the cognitive aspects of the task. A cognitive task can therefore be defined as a task that centrally involves cognitive functions not only in the understanding of the intended results, but also in the performance of the task, most particularly in the processing of mental information (Carroll, 1993).

To sum up: cognitive abilities represent a very general mental capability. This capability involves the ability to reason, plan, solve problems, absorb, process and implement complex information. Cognitive abilities are not to be understood as possessing knowledge in itself, which is supported by the fact that cognitive abilities do not increase with age nor education. Rather, they reflect a broader and deeper capability for comprehending our surroundings - ‘catching on,’ or ‘making sense,’ of things.
The General Cognitive Ability

The Professional Learning Indicator® (PLI™) measures the individual’s general cognitive ability, which can be derived from the multiple cognitive abilities. The general cognitive ability \((g)\) indicates the individual’s ability to adapt, solve problems, absorb, comprehend and process complex information, and is thus of great interest in any recruitment process. The general cognitive ability will indicate; how well the candidate will adapt in a given position; acquire knowledge on the job and; performance in job training programs.

John B. Carroll (1993) has conducted an extensive survey of more than 460 studies of cognitive abilities. Based on this he has developed a three-stratum hierarchical factor model of cognitive abilities in which he incorporates the different narrow and broad cognitive abilities or intelligence (in scientific discourse intelligence, mental abilities and cognitive abilities are often used interchangeably) and ultimately the general cognitive ability. This model can be regarded as an expansion and elaboration of other factor models proposed by acknowledged scientists like C. Spearman, K.J. Holzinger, L.L. Thurstone, P.E. Vernon, R.B. Cattell, J.L. Horn, and others. Carroll’s three-stratum model of cognitive abilities is derived through factor analysis and proposes a hierarchical model to describe cognitive abilities:

- **Stratum I** represents the narrow abilities
- **Stratum II** represents the broad abilities
- **Stratum III** represents the general cognitive ability

The essence of the model is that from the multiple cognitive abilities a joint factor can be derived. This factor is called \(g\) and refers to the general cognitive ability. \(g\) cannot be measured directly but is derived through factor analysis. The purpose of factor analysis is reducing complex information (several cognitive abilities -stratum I) into more manageable information (stratum III). The existence of a derived factor means that if a person scores high on fluid intelligence the possibility of high spatial intelligence is increased as well.
Developing a Highly $g$-loaded Assessment

Designing the PLI Assessment Tool

As referred to above $g$ cannot be measured directly, so in order to measure the general cognitive ability one must instead construct a highly $g$-loaded test, with elements from which $g$ can be derived.

**PLI as a $g$-loaded Assessment**

The essential part in constructing what is considered a $g$-loaded assessment is to construct an assessment with questions that are carefully anchored in the narrow abilities (cf. stratum I) that collectively lead to general intelligence (cf. Stratum III). Accordingly, the question types used to measure $g$ in PLI are anchored in 9 narrow abilities (subcategories) underlying 3 broad abilities (categories). The categories in PLI are categories of reasoning; verbal, numeric and abstract.

<table>
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<tr>
<th>Sub-Category</th>
<th>Category</th>
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The chosen categories are the most commonly used for measuring $g$, and are hence thoroughly explored in the scientific field of intelligence research. In order to maximise the validity of the PLI, all questions are 100% related to one of the 9 subcategories. Examples of each of the 9 subcategories are presented in Appendix 1.

**PLI Format**

The PLI-assessment format is simple; the assessment taker has 12 minutes to answer 50 questions (within the 9 subcategories) of varying difficulty level. The assessment is
created, issued, and administered online, saving time and making the assessment very easy to send to a large proportion of applicants for a given position. A unique characteristic of PLI is that second (and third) testing is possible, based on the dynamic structure of the assessment tool.

**PLI as a Dynamic Test Tool**

PLI is dynamic in the sense that, when an assessment is created, a unique combination of 50 questions within the 9 subcategories (with varying level of difficulty) is generated. This combination is drawn from a large database of questions ensuring that every test is in fact unique. During the development of the questions, varying difficulty levels were established based on a significant sized population and the corresponding percentage of correct answers on any one question in the database. The system that generates the assessment is constructed to ensure that the difficulty level of the assessment is approximately the same for each assessment. To ensure that the items represent the difficulty level they were assigned, the percentage of correct answers to any one question in the database is monitored closely. As the number of completed assessments rises this ongoing process assures that the difficulty level of the generated assessments are approximately the same.

Due to this dynamic aspect, it is possible to assess a candidate more than once if there is any doubt about the correctness of the result. The candidate may have been interrupted, may have misunderstood the format etc. and a 2nd assessment is therefore required. With the 2nd assessment option memory bias is never an issue, and the result will therefore be comparable to the established norm.

Furthermore, when constructing g-loaded questions one must ensure that the ability to answer the questions depends on the specific areas of reasoning and NOT on pre-learned knowledge of a more general nature. According to this protocol for constructing g-loaded questions, PLI includes only common words, expressions etc. that will NOT confuse or bias the assessment taker when answering the actual question.

The careful selection and combination of the questions in every generated assessment ensure that PLI is a highly g-loaded assessment tool and thus may be used as an assessment of cognitive abilities in recruitment or internal selection of people.

**Cross-Cultural Validity**

In order to ensure that PLI results can be compared across language versions, we have been through a very thorough process eliminating cultural bias. During the development of the assessment the entire database of questions was reviewed by multiple individuals with different cultural backgrounds (ex. European, African American, Asian etc.). The individuals were asked to address any issues that might be offensive or unequally familiar to individuals from different cultural backgrounds; illustrations that might not be understood in the same manner etc. Any items that could not be changed to sufficiently address the cultural reviewer’s concerns were deleted.
Translation Process

PLI has been translated into 60+ languages by following a thorough standard for the translation process. The process used in translation is described below. Prior to the commencement of the translation work, a primary bilingual translator (native speaker of the target language and fluent in written English) is asked to complete a linguistic review of the content (in the English version) to detect any obvious cultural issues, translation issues, ambiguity etc. that may be encountered during translation.

1. The PLI questions are translated by the primary translator.
2. The translation process is closely monitored and verified by a second native translator.
3. The translated questions are forwarded to a linguist who checks the document for accuracy and correctness.
4. The questions subsequently undergo an in-country review, where one or more individuals living in the country in question, are asked to review the items for any cultural issues.
5. The in-country reviewer’s concerns are then reviewed by the primary translator and edits are made where appropriate.

The process is cumbersome but minimises cultural or language bias and ensures that comparisons can be made across borders and cultures.

Global Norm Statistics

Not only comparisons across borders but comparison against a norm is of great interest. Does the candidate score above or below a global average in regard to the ability to adapt, solve problems, absorb, comprehend, and process complex information? In order to make such comparisons, the results must follow a standard normal distribution.

Analyses have been conducted that establish that the PLI scores follow a normal distribution curve. The analysis of more than 100,000 results (completed in 61 languages by 107 different nationalities) reveals an average of approximately 20 and a standard deviation of approximately 7. Being normally distributed this means that 68% (34,13% + 34,13%) of all results are within 20 +/- 7 (13-26).

Furthermore, the standard error of measurement is 3.65. Another way of stating this is that 3.65 represent one standard deviation around an individual’s true score. Accordingly, with 68% likelihood the true score for any assessment taker is the actual score plus/minus 3.65.
It should be noted that the established norm (20) represents a global average of multiple job functions and education levels, and that we have conducted norm studies on more homogenous groups of people to further elaborate the applicability of PLI.

By selecting a homogenous group of people you get a very precise indication of where a candidate should be placed in order to be above or below average, not just compared to a global norm but to a norm of similar others. The studied norm groups so far are university students in the US and Denmark, respectively. Because the global average includes people at all educational levels it was anticipated that this group of people (university students) would score above the global average, due to their higher educational level. *(It is important to note that education has no influence on cognitive abilities, but there is a high correlation between the two variables. This simply means that more intelligent people tend to attain higher educational level).*

Adherently, the norm studies revealed an average score around 22 and a standard deviation of around 6.5, stressing the statistical and cross-cultural validity of PLI. This means that the norm for university students is slightly higher because the global average reflects the entire spectrum of education levels and job functions. This has been confirmed by in-depth analyses on education level.

*Individual Norm Study documents are available on request.*
Scientific Validation of PLI

Scientific Measures of PLI

In cases of cognitive assessment tools like the PLI, validity and reliability are important aspects which indicate if the assessment tool has any value when applied to real world situations. Validity of an assessment tool like PLI is the degree to which it measures what it purports to measure. Validity answers the question: "Are we actually measuring (are these means a valid form of measuring) what (the construct) we think we are measuring?" Reliability refers to the extent to which the PLI result for a given individual is consistent over time. Reliability answers the question: “Is the result reliable and stable?” The following is an illustration of how results might turn out in terms of validity and reliability when results are analysed.

Left Illustration

These observations (dots) indicate reliable results (the observations are closely grouped, meaning that they are approximately the same over time). However, the results are not valid because they are not measuring what they are purport to measure (the observations are NOT grouped close to the target bull’s eye).

Right Illustration

These observations indicate both valid and reliable results (the observations are closely grouped and in the bull’s eye) and are the ideal outcome of scientific analyses in respect to PLI.
Validity of the Professional Learning Indicator

**PLI as a Measure of the General Cognitive Ability**

A concurrent validity study (of the results of a significantly sized population) has been conducted to scientifically establish that PLI does in fact measure what it purports to measure: the general cognitive ability. The way to establish whether two assessments measure the same construct, is to compare results from the two similar tools, to see if the results are approximately the same (a linear relationship is evident). Validity is determined by the correlation coefficient of the results of two assessments (Test tool A and B) completed by the same person. Each test result constitutes a variable. The correlation coefficient is a measure of linear relationship between two variables. The correlation coefficient can take any numerical value between -1 and +1, as illustrated graphically below.

This means that if all assessment takers would get the exact same result on two different assessment tools the correlation coefficient would be +/-1 (highly unlikely since all tests have measurement error). When conducting validity analyses, a correlation between .6 and .8 was targeted.

A concurrent validity study has been conducted, which compares results attained on PLI and the Wonderlic Classic Cognitive Ability Test tool. Wonderlic measures the general cognitive ability (g), and has been scientifically validated and shown to be a reliable and valid assessment tool (Wonderlic User's Manual, ©2002, Inc., 1795 N. Butterfield Rd., Libertyville, IL 60048-1238 800.323.3742).

The correlation between PLI and Wonderlic demonstrate that there is a significant relationship between PLI and Wonderlic (.801) (**Overall average correlation of .795**). This coefficient level in a concurrent validity study is highly acceptable, and considering that the two assessments differ in regard to completion method, the analysis clearly underlines the validity of PLI as an assessment of the general cognitive ability.
A concurrent validity study has been conducted, which compares results attained on PLI and the Ravens Advanced Progressive Matrices Set II (APM). APM has has been in use for more than 60 years, and has been thoroughly validated over the past decades. There is a significant degree of overlap among the three categories in PLI (verbal, numeric and abstract) and Raven. The correlation between the PLI score and Raven APM demonstrates that there is a significant relationship between PLI and Raven (.611; overall average correlation of .616). This level in a concurrent validity study is highly acceptable, and considering that the two assessments differ in regard to administration, length and number of categories, the analyses clearly underline the validity of PLI as an assessment of the general cognitive ability.

PLI has been compared to an in-house product that measures the general cognitive ability and through structured use has demonstrated predictability for leadership performance over 40 years and has been used to test more than 1,000,000 people from more than 100 different countries. Analyses reveal a correlation of 0.75, confirming that PLI measures the general cognitive ability and is therefore a valid assessment tool with great applicability. Construct-validity study is available on request.

Reliability of the Professional Learning Indicator

**PLI as a Reliable Assessment Tool**

Analyses have been conducted to scientifically establish that PLI results are reliable, under the empirically validated assumption that the general cognitive ability is a stable construct. The reliability of PLI is determined by a test-retest correlation coefficient of the results of two PLI assessments completed by the same person. If all the assessment takers would get the exact same result in their 1st and 2nd assessment the correlation coefficient would be 1. When conducting reliability analyses a correlation of 0.70 between the two assessments was targeted. This correlation refers to a very strong relationship between two variables, and meeting or exceeding this correlation would mean that PLI is a reliable assessment tool.

Analyses reveal reliability correlations in the range of .71 - .84 (based on reliability studies on significantly sized populations) indicating a very strong (scientifically significant) relationship between the results of two assessments completed by the same person. Reliability analyses have been performed on individual languages; Danish and US English, revealing correlations of 0.71 and 0.74 respectively. These correlations stress the cultural neutrality and underline the fact that PLI is a reliable assessment tool. *Reliability study is available on request.*

*In terms of reliability it has been scientifically established that PLI is a reliable assessment tool for measuring the stable construct: the general cognitive ability. This means that you can actually trust the results, hereby emphasising the applicability of PLI.*
Practical Applicability of PLI

Practical Validity of g-loaded Assessment Tools

Having defined general cognitive abilities and having concluded that a higher stratum $g$ exists and can be measured is of course of scientific interest within research of intelligence, but the next step is to determine the practical application of this knowledge in relation to building a competitive organisation. What we are looking for is practical validity in terms of predictability and explaining useful correlations between measurements of the general cognitive ability and learning, job performance, etc. Highly $g$-loaded tests demonstrate a more far-reaching and universal practical validity than any other existing coherent psychological construct. $g$-loaded tests predict performance to some degree in every kind of behaviour that calls for learning, decision, and judgement, but the predictability increases with job complexity.

Complexity, $g$ and Predicting Job Performance

Over time, several analyses on the degree of $g$ and predictability of performance and training have been conducted. In general they show a corresponding increase in the validity of $g$ for predicting job performance and learning as jobs increase in complexity related to information-processing demands. The predictability increases with job complexity, but even when it comes to jobs that are only moderately complex you will find $g$-loaded tests to be by far the best predictor of successful job performance. All kinds of work involve some kind of cognitive processing, and all such processes reflect $g$.

"In the world of work, $g$ is the main cognitive correlate and best single predictor of success in job training and job performance. Its validity is not nullified or replaced by formal education (independent of $g$), nor is it decreased by increasing experience on the job" (Jensen, 1998).

Furthermore, Jensen points out that meta-analysis of hundreds of test validation studies has demonstrated that the validity of highly $g$-loaded tests for predicting job performance for a position in one organisation, is generalisable to all other jobs in the same broad range or family, in any given organisation.

Hunter & Hunter (1984) demonstrated the differences of correlations between $g$ and complexity in an analysis of 515 different occupations which were categorised in different complexity levels. The performance validity in highly complex jobs was 0.58, in medium complex jobs 0.51, and in insignificantly complex jobs 0.40. The way to understand these numbers are as follows.
If you have a group of 100 people in highly complex jobs with different performance levels, 34% of the difference in performance level (meaning: why do some people perform better than others?) can be explained solely by their difference in cognitive abilities. So, predictability is certainly correlated to job complexity, but even in jobs with low complexity you will find that $g$-loaded tests is an extremely valuable tool in predicting job performance and learning capabilities.

On the basis of meta-analytic findings of 85 years of research in personnel selection, Schmidt & Hunter (1998) investigated 19 different selection procedures for predicting job performance, training performance and the paired combinations of general mental ability and 18 other selection procedures. The study combines measures of different human factors with job performance, and generally points to $g$ as the best predictor of job performance. Furthermore, general cognitive ability is the single factor that has been measured for the longest period and by most researchers (ibid.). Thus the findings related to general cognitive ability tests are based on a more solid amount of research than structured interviews or assessment centres, etc. (ibid.).

Schmidt and Hunter (1998) have summed up the research and noted the following about measuring general cognitive abilities in personnel selection:

“... general cognitive ability has the highest validity and lowest application cost ... the research evidence for the validity of general cognitive ability measures for predicting job performance is stronger than for any other method ... General cognitive ability has been shown to be the best available predictor of job-related learning. It is the best predictor of acquisition of job knowledge on the job and of performance in job training programs ... the theoretical foundation for general cognitive ability is stronger than for any other personnel measure”.

All in all we can conclude that various meta-analyses of $g$ and job performance point to $g$ as the best single predictor of job performance across jobs, emphasising the applicability of PLI™ in creating a competitive organisation.
References:


Other relevant reading material


Appendix
Sample Items

1 Number Series
What is the next number in the sequence below?
3 5 9 17
A) 26
B) 27
C) 33
D) 35

2 Number Value
Which number has the lowest value?
A) \( \frac{1}{2} + \frac{1}{4} \) *
B) \(.51 + .3\)
C) \(3 + \frac{1}{3}\)
D) \(25 + .61\)

3 Math Word Problems
1. A recent survey of customers determined that 3/5 of them prefer to be contacted by email rather than by telephone. If 60 customers indicated they preferred to be contacted by telephone, how many customers in total were surveyed?
A) 24
B) 36
C) 100
D) 150

4 Antonyms
Which of the following is the opposite of the word Elated?
A) euphonic
B) dejected
C) furious
D) emaciated

5 Verbal Reasoning
Sally laughs every time the bell rings.
The bell rang twice yesterday.
Which of the following must be true?
A) Sally laughed only twice yesterday.*
B) Sally laughed at least two times yesterday.
C) Sally laughed fewer than two times yesterday.
D) The bell will ring twice today.

6 Analogies
Car is to Convertible as Artist is to:
A) Painter
B) Sculpture
C) Sedan
D) Oil
Sample Items

7 Visual Analogies

[Diagram of shapes]

is to as is to

A) [Shape A]
B) [Shape B]
C) [Shape C]
D) [Shape D]

8 Visual Series

[Diagram of arrows and shapes]

Which of the figures below comes next in the sequence of figures shown above?

A) [Arrow A]
B) [Arrow B]
C) [Arrow C]
D) [Arrow D]

9 Common Features

[Diagram of shapes]

Which of the figures below does not share a common feature with the two figures above?

A) [Shape A]
B) [Shape B]
C) [Shape C]
D) [Shape D]