

*Full Length Research Paper*

# Preparation techniques for multiple-choice possibility measurement tools (MCPMT) in education

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**This study draws on the understanding that when the correlation between variables is not known yet the non-linear expectation in the correlation between the variables is present, non-linear measurement tools can be used. In education, possibility measurement tools can be used for non-linear measurement. Multiple-choice possibility measurement tools (MCPMT) can be prepared similarly to conventional multiple-choice measurement tools (CMCMT) utilized in quantitative measurements. In comparison with CMCMT, both more qualified measurements and more qualified evaluations can be carried out via possibility measurement tools; therefore, the preparation techniques of MCPMT, which is one possibility measurement tool, which can be used in information-centered and learner-centered measurements, are set forth in this study. MCPMT can resolve the problem of CMCMT in terms of the measurement of different variables with multiple options in one item. Additionally, the correlation between the variables can be determined by evaluating data obtained via MCPMT by means of two different new methods.**

**Key word:** Multiple-choice measurement tool (MCMT), multiple-choice possibility measurement tool (MCPMT), item techniques (IT), option technique (OT).

## INTRODUCTION

The brain is a complex system. The learning style of a complex system can be non-linear as well. The probability of learning to be linear can be as high as the probability of its being possible or functional. Learning can be correlated with a number of dependent and independent variables. The exact correlation of dependent variables of learning with independent variables has not been proven. Until today, it has not been proven that learning is linear, either. In education, the separation of learner-centered or the information-centered measurements can accelerate the determination of the correlation

between learning variables. Additionally, in the evaluations carried out with this separation, the improvement of the learning methods in these separation types can contribute to future studies.

When measurement tools are prepared without value sorting in answer options of their items/questions, they will be termed as MCMT. The measurement tools to be prepared by means of the possibility measurement tool techniques will be termed as MCPMT. The MCMT whose answer options have value sorting can be classified either as optional from a lower limit ( $0 \leq$  lower limit) to an

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upper limit, or as optional from a negative limit to a positive limit.

By breaking the information into its “significant smallest piece (SSP)” “anlamli en küçük parça (AKP)” as suggested in the study carried out by Yılmaz (2011), it can be compared and evaluated quantitatively by means of secondary information and correlated with the dependent variables (for example success) of learning, as well. A linear correlation, as well as a non-linear correlation, can be utilized between the information and the dependent variables of learning. To cite an example, success can be considered as the dependent variable of learning. When there are ten items, five options for each item, and there is one correct answer among these five options in a test, the success can be measured linearly as  $2/10$  ( $1/5$ ) for two correct answers,  $5/10$  ( $1/2$ ) for five correct answers or  $8/10$  ( $1/1,25$ ) for eight correct answers. It is uncertain to settle the incorrect answers within the purpose of this measurement

When the incorrect options do not have a second meaning in the same measurement tool, it can be evaluated by means of the binary basis independent possibility. In a binary basis independent possibility evaluation, the correlation between information and success can be established via the sum of the symmetric possibilities by a combination equation, until (including the symmetric possibility whose symmetric situation number is equal to the number of correct answers) the symmetric situation number (when the symmetrical situation number is used as the number of correct answers) as symmetric from the zero symmetrical situation number becomes equal to the number of correct answers. When such a correlation is established, in the above given multiple-choice test, it is evaluated via the binary basis independent possibility by dividing the sum of the symmetrical possibilities by the possibility distribution number; the success for two correct answers is obtained as  $56/1024$  ( $1/18,29$ ), the success for five correct answers is obtained as  $638/1024$  ( $1/1,60$ ), and the success for eight correct answers is obtained as  $1013/1024$  ( $1/1,01$ ). The change in the success rate based on the number of correct answers is non-linear. This renders the binary-basis independent possibility as non-linear. As the evaluations can be carried out from a symmetrical possibility measurement and the symmetrical possibility can be altered non-linearly based on symmetrical situation numbers, based on this example, the measurement tools by which the possibility will be measured are rendered as non-linear. The measurement tool by which uncertainty can be eliminated should be prepared in the evaluation of the multiple-choice test given in this study, as the questions that are answered incorrectly are uncertain. However, in the binary-basis independent possibility measurement, whether the questions are being answered correctly or incorrectly is irrelevant. The evaluation can be carried out via the symmetrical possibilities of binary-basis

independent possibility distributions, and the information content can be evaluated via the Shannon equation. When the possibility measurement tool is prepared in accordance with the sole internal variable option technique (OT) or internal variable OT it is irrelevant whether the questions are being answered correctly or incorrectly. The evaluation of the example given in this study can be carried out by means of independent possibility distribution of five situations to ten events. In a multiple-choice measurement, carrying out possibility evaluations may be more suitable via an independent possibility measurement tool instead of linear measurement and evaluation.

In the cases where it is important to know the questions that are answered or in which order questions are answered, the measurement can be interpreted better by carrying out the evaluation via the equations of regular symmetric, irregular symmetric, event-based symmetric, symmetrical contiguous and symmetrical discrimination possibilities instead of symmetrical possibilities in the possibility distributions. The MCMT can be prepared similarly to CMCMT, which includes one correct answer (internal variable) in their item options, and it can also be prepared by referring to a meaning (internal variables) of the options of each item. The items of the measurement tool can be prepared without obligation to standardize the number of correct answers as well as with multiple correct answers. It can be prepared by referring meaning (external variable) to the items of the-MCPMT, as well.

The importance of possibility has shown an increase within the latest measurements and evaluations, and the possibility measurement tools are used in various disciplines. The possibility theories are utilized for explaining various measurements results (Mauris, 2013; Ryguła et al., 2018). The possibility measurement tools are used for identifying the lipid markers in medicine (Sumino et al., 2016). However, there are certain challenges and uncertainties in the use of possibility theories within the scope of measurement and evaluation. Ferrero et al. (2014) suggested the following with regards to use of possibility theories in measurement and evaluation within the study they carried out:

“The evaluation and expression of uncertainty in measurement is one of the fundamental issues in measurement science and challenges measurement experts especially when the combined uncertainty has to be evaluated. Recently, a new approach, within the framework of possibility theory, has been proposed to generalize the currently followed probabilistic approach. When possibility distributions are employed to represent random contribution to measurement uncertainty, their combination is still an open problem. This combination is directly related to the construction of the joint possibility distribution, generally performed by means of t-norms.”

It is of vital importance for the measurement tool to be suitable for using the possibility theories within the scope

of carrying out evaluations with possibility theories. In this study, the rules for preparation of possibility measurement tools will be developed as in compliance with the use of possibility theories within the scope of multiple-choice measurement tool (MCMT)s used in measurement and evaluation in education.

In this study, the MCPMT preparation techniques which can be used in order to determine the non-linear correlations that can be established in one external variable, in the interaction between the external variables, in one internal variable, in the interaction between the internal variables or between the pieces of the information will be given. Similarly to all the measurement tools, in the evaluations of the MCPMT, both the evaluation method through symmetrical possibilities and probabilities and the evaluation method in which the information contents can be determined through Shannon equations can be used.

### **Preparation techniques for MCPMT**

MCPMT can be prepared by means of item and OT. The MCPMT can be prepared in order to determine the possibility structures of variables and the non-linear correlations between the variables. In item techniques (IT), the variables to be measured by means of multiple items can be termed as external variables. The options of evaluation of the MCPMT, the evaluation can be carried out by means of symmetric, regular symmetric, irregular symmetric, symmetric with regard to the situation at which the distribution begins, event-based symmetric, symmetrical contiguous and symmetrical discrimination possibilities. The measurement tools can be evaluated more qualitatively by means of, above all, regular symmetric, irregular symmetric, symmetric with regard to the situation at which the distribution begins, for event-based symmetric, symmetrical contiguous and symmetrical discrimination possibilities.

#### ***Item techniques (IT) (External Variable Technique)***

The measurement tool can be prepared by defining the different learning fields, different discipline information, different information types, different information content or different epistemological levels to the items of the measurement tools as external variables. Additionally, different epistemological levels or different information content of the different discipline information and different information types can be defined as external variables. The possibility measurement tool can be prepared by means of these definitions. In a measurement tool, the items are separated into external variables in order to determine the effect of the other variable(s) (of the other group(s)) to an external variable (to a group of items) via simultaneous measurement. The preparation principles

for an external variable MCPMT are used in order to prepare such a measurement tool. The measurement tool preparation technique with external variables, and by means of preparation principles for an external variable MCPMT, will be termed as IT or external variable technique. The measurement tools prepared via this technique will be termed as MCPMT with IT. In the IT, all of the items or each item separately of external variables can be evaluated. Also in the IT, as to the preparation technique of the options, the evaluation method respective to that technique is used.

#### ***Option techniques (OT)***

The option preparation techniques by means of possibilities of selection among the options of an item are termed as OT. OT comprises a sole internal variable OT, internal variable OT, significant internal variable OT and internal variable ordering technique. The OT determines the evaluation method which can be applied to the measurement tool.

***Sole internal variable OT:*** The measurement tool preparation technique which is performed by using the preparation principles for sole internal variable option MCPMT without referring to a second meaning for the options apart from a correct one will be termed as the sole internal variable OT. The measurement tool to be prepared via this technique will be termed as the sole internal variable option technique multiple-choice possibility measurement tool OTMCPMT. The variable which is measured via this technique is termed as the sole internal variable. The two different techniques can be used in the evaluation method of the measurement performed by the sole internal variable OT. In the first technique to be used in evaluations, the number of correct options is correlated with the evaluation method. In the second technique to be used in evaluations, the possibility distributions of the correct options are correlated with the possibility evaluation method used. In the evaluations carried out by correlating the number of correct options with the evaluation method, binary basis independent possibility evaluation method can be used. In the evaluations carried out by correlating the correct options with possibility evaluation method, the other possibility evaluation methods apart from binary basis independent possibility evaluation method (when there are multiple options) can be used. If the incorrect options are to be evaluated in this technique, each option is evaluated separately.

***Internal variable OT:*** The measurement tool preparation technique which is performed by using the preparation principles for internal variable option MCPMT in the simultaneous measurement of the multiple internal variables' or singular internal variable's effect to each

other will be termed as the internal variable OT. The measurement tool to be prepared via this technique will be termed as the internal variable OTMCPMT. The variables which are measured via this technique are termed as internal variables. The evaluation methods of the sole internal variable OT can be used in the evaluation carried out via an internal variable OT.

**Significant internal variable OT:** The measurement tool preparation technique which is performed by using preparation principles for significant internal variable option MCPMT in the simultaneous measurement of the different internal variables, and which is prepared by defining an interval variable as relevant to the option's item to each option in accordance with the measurement purpose, will be termed as the significant internal variable OT. The measurement tool to be prepared via this technique will be termed as the significant internal variable OTMCPMT. All of the options are termed as internal variables in this technique. Via the measurement tool prepared in accordance with the evaluation method set forth in the study carried out by Yılmaz and Yalçın (2011), the given evaluation method can be used in the evaluations of the measurement performed by means of significant internal variable OT.

**Internal variable ordering technique:** The measurement tool preparation technique which is performed by using the preparation principles for internal variable ordering MCPMT in the simultaneous measurement of the different internal variables, and with which ordering of each item's internal variables (each item's options) can be carried out in accordance with the measurement purpose, will be termed as the internal variable ordering technique or option ordering technique. The measurement tool to be prepared via this technique will be termed as the internal variable ordering technique MCPMT. All of the options are termed as internal variables in this technique. The options of this measurement tool can comprise the information pieces given in the item. In the measurement evaluations carried out via an internal variable ordering technique, a binary basis independent possibility evaluation method can be used.

### Preparation principles for MCPMT

#### **Preparation Principles for the Sole Internal Variable Option MCPMT**

- 1) An internal variable should be found.
- 2) A second meaning should be referred to as the options apart from the internal variable.
- 3) Each item may not have the same option number.
- 4) When each item does not have the same number of options, the evaluation of the options, apart from the internal variable, should not be carried out.
- 5) Where all the options are to be evaluated, the

measurement analysis of the options should be carried out without referring to a different meaning than the options, apart from the internal variable.

- 6) If all the options are to be evaluated, each item should have the same option number.
- 7) The other options of an item should not comprise a particular part of the internal variable.
- 8) A different meaning for the internal variable in the same discipline should not be found.

#### **Preparation principles for the internal variable optional MCPMT**

- 1) There should be more than two options.
- 2) If there is a correlation between the internal variables, the other internal variables, apart from the first internal variable, should be used in the solution of the first internal variable.
- 3) The internal variables of an item can also be correlated with the item, without being correlated with each other.
- 4) There should be at least two internal variables in multiple items.
- 5) There should be at least one option whose internal variable is not defined in an item.
- 6) The internal variable number of each item may not be equal.
- 7) A second meaning should not refer to the options which are not defined as internal variables in an item.
- 8) The options which are not defined as internal variables in an item should not comprise a particular part of the internal variable.
- 9) Two internal variables of an item should not have the same values.
- 10) When the other internal variables, apart from the first internal variable, are not used in the solution of the first internal variable, or they are not correlated with the item, the item should be divided into at least two different items.

#### **Preparation principles for the significant internal variable option MCPMT**

The internal variables, based on both the measurement purpose and evaluation purpose, are defined in all options of the items. In preparation for such a measurement tool, the principles to take into consideration are as follows:

- 1) An internal variable is defined in all options of an item.
- 2) Each item should have the same internal variables.
- 3) All items of the measurement tool should have the same number of internal variables.
- 4) An internal variable should be present in an item once.
- 5) The correlation of an internal variable with the item should be established in an item.
- 6) For the purpose of the measurement, the correlation

between internal variables should be meaningful.

7) The evaluation correlation of the internal variables with each other should be established.

8) The same internal variables should be evaluated together.

10) The evaluation method with which the different internal variables can be evaluated. separately should be used.

In the study carried out by Yılmaz (2011), it is set forth that by comparing the data obtained via qualitative measurement tools with the right data, the obtained data can be classified as correct, incorrect, correct which is present in incorrect data, unrelated and zero (absent). In this classification, by breaking the data obtained by the measurement into their SSP and comparing these SSP to the SSP of the right data (the solution of the measurement tool), they are classified by means of assigning one positive score, one negative score and a zero score to the SSP which are not present in the data. When all the scores of a phase are positive, it is defined as a positive phase. When all the scores of a phase are negative, it is defined as an unrelated phase. When the scores of a phase are both negative and positive, it is defined as a negative phase. The positive scores in the negative phase are defined separately as positive scores in negatives. The SSPs which are not present in the data are defined as zero score. The evaluation methods of these phases and scores are given out, as well (Yılmaz and Yalçın, 2011). In this study, the principles given out for qualitative measurement tools can be set forth for a quantitative MCPMT with exemplary question and answer options.

An example of a proper question: What is the unit of force in the SI system?

- a) dyn (incorrect)
- b)  $\text{kg} \cdot \frac{\text{m}}{\text{s}^2}$  (positive in negatives)
- c)  $\text{kg} \cdot \frac{\text{m}}{\text{s}^2}$  (correct)
- d)  $\text{kg} \cdot \frac{\text{m}^2}{\text{s}^2}$  (unrelated)

1) One item should have one correct option. When there is  $\text{kg} \cdot \frac{\text{m}}{\text{s}^2}$  in the example, Newton, which is the unit of

force in SI system, should not be included in the options.

2) One item should have one incorrect option.

3) The correlation of the incorrect option with the correct option should be found in an item. Although the unit of force is dyn in the cgs system, as the unit of force in the SI system is asked in the example, the option is incorrect and the different meaning usage of dyn is not present in the same discipline or in the different disciplines.

4) When there is an incorrect answer within an item, the different meaning of the incorrect option situated in another option should be found with respect to the same discipline. A new meaning with regard to the item should

be referable to this option. In the example, the unrelated meaning was referred.

5) The option to which a meaning is referred should not have a different meaning in the same discipline. In the example, an incorrect option definition should not be made, as option “d” is the unit of the work and energy.

6) The option definition should be used for absence or lacking situation.

In the evaluations of the measurement tools which will be adapted via the principles of this technique, the binary basis independent possibility VDOİHI method can be used.

**Preparation principles for the internal variable ordering MCPMT**

- 1) The internal variables of an item should be in accordance with the ordering.
- 2) Numerical value should not be referred to the orderings.
- 3) One internal variable with the same order should be involved in the one item.
- 4) The measurement of each item should be carried out by two possibilities, such as correct and incorrect.
- 5) The scale, which is in accordance with the ordering, should be involved in the measurement tool.
- 6) The internal variable number of each item may not be equal.
- 7) The internal variables of the items should be in accordance with different ordering.
- 8) An item should not have an internal variable which is not in accordance with the ordering.
- 9) A second ordering should not be done by means of the internal variables of an item.
- 10) A binary basis independent possibility evaluation should be carried out.
- 11) In an evaluation, the analysis should be carried out via the possibility which is in accordance with the measurement purpose or via the Shannon equation.

Proper question example 1: Order the equation of torque with the options given below.

- a = b) F c) x d)  $\mathcal{J}$  e) r

Correct answer ordering: d, a, e, c, b

Measurement tool example

Ordering No	1	2	3	4	5
	d	a	e	c	b

Correct answer ordering: 2, 5, 4, 1, 3

Measurement tool example

Scale option	a	b	c	d	e
	2	5	4	1	3

A wrong question example: Carry out the ordering of the force equation with the options given below:

a = b) F c) m d) a e)

Although the force formulas tend to be written as  $F = m \cdot a$ , the same result can also be obtained by the operation  $F = a \cdot m$  in scalar multiplication. In this situation, “a” and “m” have the same ordering. As two options with the same ordering (one internal variable with the same ordering should be involved in an item) are present, it is a wrong measurement item.

A wrong question example: Carry out the ordering of the force equation with the options given below:

a = b) F c) m d) a e) . f) V

In this question, option “f” is not related to the question.

As an option which is not in accordance with the ordering is present (one internal variable which is not in accordance with the ordering should not be involved in an item), it is a wrong measurement item.

A wrong question example: Carry out the ordering of the force equation with the options given below:

a = b) F c) m d) a e) . f) V g) t h) /

The two different orderings,  $F = m \cdot a$  and  $F = m \cdot V/t$ , can be carried out in the answer. Since the options are accordant with two different orderings (a second ordering should not be carried out with the internal variables of an item), it is a wrong measurement item.

### **Preparation principles for the external variable MCPMT**

- 1) Multiple external variables should be present.
- 2) Multiple options should be present by which each external variable can be measured.
- 3) The item numbers of the external variables may not be equal.
- 4) The external variables should have a meaningful measurement correlation between them for the purpose of measurement.
- 5) The order with which the external variables are present in the measurement tool should be determined by the purpose of measurement.
- 6) Options should be prepared in accordance with the OT.
- 7) The same OT should be used for all the external variables (one of the following techniques should be

used: the sole internal variable OT, internal variable OT, significant internal variable OT or internal variable ordering technique).

The same evaluation method should be used for external variables.

### **Conclusion**

The five different MCPMTs can be developed by defining the external and internal variables to the item and/or its options via the techniques set forth in this study. By means of MCPMT with the IT, the measurement of an external variable can be carried out, and also the correlation between the variables can be determined by measuring the different external variables simultaneously. The quantitative measurements can be deepened by using different OT. The correlations between internal variables can be determined simultaneously via internal variable OTMCPMT or significant internal variable OTMCPMT. The correlation, which can be established between the pieces of information, can be determined simultaneously via the internal variable ordering technique MCPMT. Non-linear correlations between the variables can be determined by performing information-based measurements via the measurement tool to be developed.

In comparison with the CMCMT, the more qualified measurement tools can be prepared by means of the preparation techniques for MCPMT. Possibility measurement tools can be evaluated more qualitatively than conventional quantitative measurement tools by means of regular symmetric, irregular symmetric, symmetric with regard to the situation at which the distribution begins, event-based symmetric, symmetrical contiguous and symmetrical discrimination possibilities. Additionally, in comparison with conventional quantitative measurement tools, both more qualified and more quantified evaluations can be carried out by preparing the options with different meanings and levels of information, especially for the options of the possibility measurement tools which can be prepared via OT.

### **Suggestions**

The MCPMT can be used when the correlation between variables is not known yet and the non-linear expectation in the correlation between the variables is present. In the possibility measurement tools, the evaluation method by which information content can be determined via Shannon equation can be used, as well as the evaluation method through symmetrical possibilities and probabilities.

Information-based and learner-centered measurements can be performed with possibility measurement tools. Information-centered new evaluation methods of the possibility measurement tools, which can be prepared via

the techniques given out in this study, can be developed. Additionally, learner-centered evaluation methods of the possibility measurement tools can be developed. The learner-centered evaluation methods can be developed via alteration of the symmetrical situation numbers, which are determined by means of different measurements.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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