A MULTIDIMENSIONAL SCALING TO ASSESSMENT INNOVATION COMPETENCY

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Abstract

Currently, one of the prerequisites required by companies is that professionals improve their qualifications in soft skills. The innovation competency appears as a source of competitive advantage in the business world. Innovation has become a relevant factor for the achievement of a competitive suitable advantage of companies in the market. However, it is not easy to define innovation, since it implies the acquisition of different capabilities and skills, such as, creativity, critical thinking, initiative, independent thinking, teamwork, networking, etc. The main purpose of this paper is to apply a Nonmetric Multidimensional Scaling (MDS) (PROXSCAL) to identify key dimensions underlying respondents’ students, to detect the most relevant skills to be included in assessment innovation competency as an alternative method to validate questionnaires. We used the INCODE-ICB-v6 questionnaire as the measurement instrument of innovation which measures the innovation construct with a series of 25 items, grouped into three categories: individual, teamwork and network. Responses were given a score of between 1 and 5 (1= major improvement needed; 5= excellent). The items included in the INCODE-ICB-v6 questionnaire to measure each of the competencies was defined in previous studies. The different items were presented in a random ordered list, not with the structure expected in each category. We applied a MDS, as a kind of concept mapping analysis with a sample of 918 students of a Massive Online Open Courses (MOOC) from a Spanish public university in the academic year 2014-2015, to perform a perceptual. This process consists of two stages. First, the participants, working individually, group the items in the category they think are best, to infer the underlying dimensions of the questionnaire according to a series of similarity or dissimilarity provided by students about the items. Then, we represent items in a perceptual map to appreciate the spatial representation of data to clarify underlying relationships. MDS analyses were carried out with two databases, one for four categories model and second for up to ten categories model. The results of multidimensional scaling confirm the structure of these three components in both models. Results shown that the internal consistency of theorist components of innovation is high in both models, for four and up to ten categories. In order to make calculations easier and faster, a routine in Visual Basic for Applications (VBA) was programmed.

Keywords: Innovation competency, Multivariate analysis, non-metric multidimensional scaling, INCODE questionnaire.

1 INTRODUCTION

Currently, one of the prerequisites required by companies is that professionals improve their qualifications in transversal skills. During the last few years developing students skills by incorporating better academic education processes to allow them a greatest success in labour market has become a main aim of the European Higher Education Area (EHEA). The innovation competency appears as a source of competitive advantage in the business world. Innovation capability is the most important determinant of a firm performance [11]. To build innovation competency, companies must include innovation in their competency models. A competency is a persistent pattern of behavior resulting from different knowledges, skills, abilities, and motivations. Innovation is important both at the personal and at the organizational level. Innovation represents the strategic process for competitiveness.

However, it is not easy to define innovation, since it implies the acquisition of different capabilities and capacities among which the following are noteworthy: creativity, creative problem-solving, problem identification, independent thinking, be open to new ideas, focus on research, team work, forward-looking approach, among others and which have been discussed in different papers ([4], [6], [7], [13]).

There is a lot of bibliography written about innovation skills. For example, Marin-Garcia, et al., 2016 show a summer of 44 papers collected from different reviews. They found 12 innovations models that
present a different degree of specified development and validation. Therefore, there is not one exclusive classification to group the different capabilities or characteristics that make up innovation ([1], [2], [6]) and there is much debate on the instruments used in order to identify and validate the acquisition of innovation skills.

A model specifically focuses on innovation competencies will be followed in this project ([5], [12], [13], [15]) and which has been reproduced in one of the more widely used instruments during the last few years to measure that competence: the Innovation Competencies Barometer (INCODE-ICv6 (IBC Barometer) ([6], [13], [15]) which measures innovation through three dimensions of capacity and talent recommended by the European Qualifications Framework for Learning, following the model proposed by Penttilä et al., (2011; 2012): individual, interpersonal and network (Figure 1).

Although some prior studies have been develop to validated the measuring tool with traditional analysis there is no formal research to validate it. The objective of this paper is twofold. Firstly, to apply a hybrid method, based on non-metric multidimensional scaling to detect the most relevant behaviors and skills that assessment innovation competency of higher education students to advocate that qualitative research tools can replace and merge with quantitative ones, in order to simplify the task of gathering and processing information, according with Santos, 2006. Second, build up, VBA subroutine in order to make calculations easier and faster.

This paper presents a contribution for researchers on the topics of innovation, business administration or human resource management, as it fulfills the lack of a formal quantitative system to validate questionnaires' surveys, not only to validate innovation competency. It can be probably apply to other generic competences that are included in current new degree programs. The rest of the paper is structured as follows. First, we present the research methodology. Second, the results obtained. Finally, this paper concludes with the main reflection of findings achieved in our analysis, their limitations and recommendations for further research.

2 METHODOLOGY

2.1 Instrument and Sample

To measure the construct of innovation, we use the questionnaire INCODE-ICB-v6 that comprises 25 items related to innovation competencies. The personal dimension is measured with 12 items, the interpersonal (teamwork) dimension with eight items and the networking dimension with five items. Responses are coded between 1 and 5 (1= I need to improve a lot; 5= Excellent). Due to limitations of space, we are unable to list the items of the INCOD-ICB-v6 questionnaire in this paper, but requests can be made via email to the corresponding author for a copy of the questionnaire in either Spanish or English.

The total sample was constituted by 918 students of a Massive Online Open Courses (MOOC) from a Spanish public university in the academic year 2014-2015, who will complete one version of the questionnaire (INCODE-ICB-v6) classifying the 25 items related to innovation competencies. The questionnaire and sample are the same that have been used in prior studies [10]. The items on this version of the questionnaire INCODE-ICB-v6 are in a different order with respect to the original questionnaire, where they are ordered in blocks: individual, interpersonal and network. Thus, a random organization of the items in the questionnaire prevents the bias of a certain cluster. The respondents were then divided in two groups. The first group, made up of 458 students, was required to freely classify the 25 items of the questionnaire into four categories, which had to be labelled by them. The second group was constituted by 460 respondents, which were required to classify the same 25 items, but in this case they had to do it freely in a maximum of 10 categories, which they also had to label.
Thus, in principle, there are not any categories in which to classify the items and the respondents are completely free to express their criteria of association and similarity among the items on the questionnaire related to their perception about the concept of innovation.

2.2 Method

In order to analyse the internal structure of the data collected from the questionnaire, we have used the Nonmetric Multidimensional Scaling (PROXSCAL). Non-metric Multidimensional Scaling is a technique used to externalize, make sense of, and organize large amounts of unstructured and dissimilar data. In this study a hybrid approach analysis is used as an optional tool to quantitative techniques for validating questionnaires. We develop both a composite or aggregate perceptual map and the measures of differences between respondents in their perception [3]. The aim is to understand the respondents' perceptions on the attributes of the study objects and plot the results on a perceptual map, transforming the similarity assessment among objects perceived by the respondents in distances between objects, being the researcher's art and science to interpret the dimensions of said perceptual map and assign it the relevant attributes [3].

In our case, the objects match up with items in the questionnaire and the purpose is to identify the respondents' judgment on the concept of innovation by searching the perceived attributes in the dimensions of the perceptual map obtained by correspondence analysis. In order to do this, the similarity comparisons among the items on the questionnaire carried out by the respondents shall be transformed in distances among said items which will be represented in the perceptual map.

Finally, a VBA was created to order to make calculations easier and faster. The routine reads an answer table and returns the matrix. The affinity matrix shows the degree of relationship between each pair of questions in the questionnaire, according to the assessment of students. More precisely, the VBA routine reads the results of the arrangement of the questions in the questionnaire into groups made by each student, and counts the number of times that each pair of questions have been considered to be in the same group.

3 RESULTS

Practically all the individuals responded to all 25 items on the questionnaire, so any missing values are not due to the characteristics of an item, nor do they present a problem for the data collected as a whole.

The non-metric multidimensional scaling was carried out with two databases, one for four categories model and second for up to ten categories model. Due to limitations of space, we are unable to show both categories models, and we focus on four categories, but complete results can be obtained via email to the corresponding author. In order to determine the similarity among items perceived by the respondents, the frequencies with which each item was classified into a category together with other item were calculated (affinity matrix) and then we applied a multidimensional scaling.

In table 1, we can see that stress and measurements for adjustment indicate the efficiency with which the distances of the solution get closer to the original distances.

<table>
<thead>
<tr>
<th>Table 1. Measures of stress for the model of four categories.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normalized raw stress</strong></td>
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<tr>
<td><strong>Stress-I</strong></td>
</tr>
<tr>
<td><strong>Stress-II</strong></td>
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<tr>
<td><strong>S-Stress</strong></td>
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<tr>
<td><strong>Told dispersion (D.A.F.)</strong></td>
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<tr>
<td><strong>Tucker consistency coefficient</strong></td>
</tr>
</tbody>
</table>

Note: PROXSCAL minimizes normalized stress raw.

<sup>a</sup> Optimal scaling factor = 1.020
<sup>b</sup> Optimal scaling factor = .996

Source: Author's own (2017).
In the four categories model, each of the stress statistics measure the mismatch of the data, so stress values are close to 0 (Normalized raw stress 0.01947). On the other side, the explained dispersion and Tucker’s consistency coefficient measure the adjustment of the model and, in our case, these measurements for adjustment get closer to value 1 (Tucker consistency coefficient 0.99022). All of this means we are before an excellent solution.

The perceptual map obtained for the first group of respondents of four categories is shown below in figure 2.

The chart on figure 2 shows the two first dimensions related to the 25 items of the questionnaire. The items have been coloured according to the three components supposed for innovation (individual, interpersonal and network). As we can observe in the map, the items corresponding to the individual component, in blue, are clearly grouped, except item 23. The items of the interpersonal component, in green, present a very compact grouping made up of items (4, 6, 7, 17) with a clear approach to items 14 and 19 which belong to the networking component. Similar results were obtained with the model with up to ten categories [10]

Finally, we develop a VBA in order to make calculations easier and faster. Visual Basic for Applications, is powerful built-in programming language, that permits researchers to easily incorporate user-written functions into a spreadsheet. We develop a subroutine to set up the perceptual map. Syntax of the subroutine is available can be obtained via email to the corresponding author.

4 CONCLUSIONS

The purpose this paper was twofold. Firstly, to apply a hybrid method, based on non-metric multidimensional scaling to detect the most relevant skills that assessment innovation competency. Second, to build up a VBA in order to make calculations easier and faster to researches. Results shown that the internal consistency of theorist components of innovation is high in both models, for four and up to ten categories. The empirical results of multidimensional scale confirms the structure of the three components (individual, interpersonal and networking) of the innovation competencies contemplated by TUAS follow the European Qualifications Framework, although some unsettled items were detected, in particular items C3, C8, C15 y C23 because they are away from their theorist related items. But in any case, the internal measurement of the innovation competency is maintained.

The paper, thus makes a significant contribution because a mixed analysis to validate questionnaires could be used in surveys in many areas, such as management, business and not only in higher education. Results shows a validation based on distances of INCODE questionnaire to assessment the innovation competency of university students that can be used as an alternative to the traditional ones. These findings are useful for researchers since they add the first sample in which the validation of a competency is developed with a qualitative technique based on distance and we develop a VBA in order to make programming easier to researches. Results over the technical characteristics of the instrument, suggest real application for the improvement of measurement innovative competency.
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REFERENCES


