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Questionnaires with the 'bar' in social sciences

Thomas Vougiouklis[1], Penelope Vougiouklis[2]

[1] Emeritus Professor, Democritus University of Thrace
Alexandroupolis, Greece
tvougiou@eled.duth.gr

[2] Professor, Democritus University of Thrace
Komotini, Greece

pekavou@helit.duth.gr

Abstract

Vougiouklis & Vougiouklis have proposed the replacement of Likert scales, usually used in questionnaires, with a bar. With this proposal a discrete situation is replaced by a fuzzy one. There are identified certain advantages concerning the use of the bar as compared to that of a scale during both the stages of filling-in as well as processing a questionnaire. The main advantage is the fact that it is much quicker to fill in and much easier to explain to participants. The bar provides the potential for different types of processing Likert scales cannot offer. Therefore the researchers are allowed to ascertain that the given answers follow the Gauss or a parabola distribution, and they have the opportunity to 'correct' this tendency. In this research it is offered a possibility of choosing amongst a number of alternatives by utilizing fuzzy logic in the same way as it has already been done in industry and combining mathematical models with multivalued operations. Finally, the suggested method is applied in a *Course and Teaching Evaluation* process by the students of Democritus University of Thrace.

Keywords*:* Bar, Likert scale, fuzzy logic, questionnaire, mathematical models, hyperstructures.

1 Introduction

Mathematical models are used in almost every field of empirical research in order to reinforce the reliability of each research. Mathematicalisation of a problem could make its results recognizable and comparable with others. This is

because representing a research object or a phenomenon with numbers, figures or graphs might be simplest and in a recognizable way of reading the results.

During last decades hyperstructures seem to have a variety of applications not only in other branches of mathematics but also in many other sciences including the social ones. In papers and books, such as (Chvalina, Hoskova 2007; Cohen, Manion 1994; Maturo, Sciarra, Tofan 2008; Vougiouklis, Kambaki 2008; Vougiouklis, Kambakis-Vougiouklis 2007; Kambakis-Vougiouklis, Vougiouklis 2010; Kambakis-Vougiouklis 2011; Corsini, Leoreanu 2003; Davvaz, Leoreanu 2007), one can find numerous applications. An application, which combines hyperstructure and fuzzy theory, is to replace in questionnaires the scale of Likert by the bar of Vougiouklis & Vougiouklis.

In every empirical research three main stages could be normally identified: *design, implementation* and *processing of the results.* Main tools in an empirical research include *the questionnaire* where Likert scales are normally and widely used. Likert scales are often used to measure respondents' attitudes by asking the extent to which they agree or disagree with a particular question or statement. Likert scales may seem easy to analyze but there are important issues a data analyst should consider. More specifically, there are certain shortcomings usually identified in this type of scales and they include the range of the scale which each time is upon the researcher to decide as it is not standard how many different subdivisions, or grades, should be used. Moreover, this is not an easy job to accomplish as it is quite different to have 3 or 4 or 5 subdivisions since there are certain problems to overcome in each case. Such problems include lack of a medium choice in a 4-grade scale. Another shortcoming of typical Lickert scales is the difficulty of verbally refining the difference between different subdivisions and make them clear to the participants. This is not an easy process, as many researchers report that it takes their subjects more time to comprehend what each subdivision represents on their scale rather than accomplish the actual test. Such a problem is of course not purely linguistic but it involves a number of different factors such as social and psychological. Finally, in the stage of processing the results, the researchers will have only one possibility of working them out, the one they decided to establish when initially designing the experiment. Such a decision might deprive the researchers of the possibility to explore other parameters which might crop up in the process, or even try different subdivisions for either a more accurate calculation or in order to make the results comparable with else's who has used different scale.

In order to eliminate such shortcomings, we propose the substitution of Likert scales with the *bar*, as suggested by Vougiouklis & Vougiouklis (see Kambaki-Vougioukli, Vougiouklis 2008; Vougiouklis, Kambaki-Vougioukli 2011; Vougiouklis, Kambakis-Vougiouklis, 2013). This substitution makes things simpler and easier for both the subjects of an empirical research and the researcher, either at the stage of designing or that of results processing, because

it is really flexible. Moreover, the application of *the bar* opens a window towards the use of fuzzy sets in the whole procedure of empirical research, activating in this way more recent findings from different sciences, as well.

More specifically, the following was proposed:

In every question, substitute the Likert scale with the 'bar' whose poles are defined with '0' on the left and '1' on the right:

0 ——————————— 1

The subjects/participants are asked, instead of deciding and checking a specific grade on the scale, to cut the bar at any point they feel best expresses their answer to the specific question.

In Vougiouklis, Kambakis-Vougiouklis (2011), it was suggested that the appropriate length of the bar is approximately 6.18cm, or 6.2cm, following the golden ration on the well known length of 10cm. More precisely it is considered that the average participant is over-familiarized with the 10cm length and an original suggestion might be the use of the *golden ratio,* suggested by the ancient Greeks. The golden ratio has not been used in language research and it might have the potential to be a useful tool in empirical research.

2 Scales and bar

Grading a variant depends both on its actual nature as well as on the researcher's judgment. Apparently, there are certain scales which are very often used, for example the 5/grade one with choices such as:

'I totally disagree', 'I disagree', 'I am between', 'I agree', 'I absolutely agree'.

This type of scale is characterized by necessary elements-rules which normally identify such scales. They usually start from the absolutely negative and end to the absolutely positive, or vice-versa. However, the most serious problem constitutes the discrimination of the limits of the actual partition. This problem of discrimination of the different categories concerns both the researcher and the subjects/participants and many times may result in frustration, especially on the part of the latter. It is a common practice to spend a lot of time in order to clarify questions posed by the participants. Consequently, the participants have to adapt themselves to the specific type of categorization in every single question- a task not at all easy and pleasant, which might affect the reliability of the specific results or, even worse, it might yield misleading ones. Such a situation it might prove to be a real hazard if it concerns issues such as health or serious financial investments and important business projects heavily depending on market research. We would not exaggerate, if we suggested that researchers should include another parameter, that of the reliability of the answers, which is connected to the level of the subjects' familiarization to the actual type of evaluation of the questions. Researchers, trying to avoid some

undesirable side-effects such as the risk of coming up with a concentration of the majority of the answers in the middle of the scale, choose a scale with no medium choice such as a 4/point scale. Clearly the kind of research will always decide the type of scale to be used, however if the researchers want to investigate some other parameters they had not provided for well in advance, or if they want to view some aspects from a different point of view, they will have to re-apply the test with a different scale. In this case, though, they will have to begin the process of familiarization of subjects with the new categorization.

The important subject of the linguistic parameter of the scales and its correlation to the fuzzy theory has been widely investigated by Zadeh (1965; 1975), the founder of the fuzzy theory. Zadeh has characterized the related variable "linguistic variable" accepting it in this way as the generating cause of fuzzy sets, something extremely important for linguistics. Yet, the linguistic escalation of the question parameter is not an easy job to accomplish (see Kambaki-Vougioukli 2010), as it depends upon factors other than purely linguistic, including all psychological, educational, economic and social status, age, gender and/or even language of the subjects. Consequently, in the normally used questionnaires with Likert scales, it is rather risky to claim that the grades of the scale are clearly pinpointed so that to be completely comprehensible by all subjects. For example, in a scale where

0=completely unsure, 1=rather unsure, 2=almost sure and 3=absolutely sure,

we can never be sure whether everybody distinguishes between 3 and 2 or 0 and 1 in the same way. Even more so, some subjects would like something in the middle or, even, something between 1 and 2 or 2 and 3 etc, ie a more detailed escalation.

In Vougiouklis et al (2011) it is claimed that there is no need to demand from our subjects to try to distinguish the difference between the grades of a scale, an attempt which is tough anyway and might very well be in vain. Furthermore, we are sure that no special training will be necessary for our subjects so as to enable them to understand how to cut the bar proposed, as they can cut it intuitively, without any verbal processing. Such a process could be compared to somebody in a wheelchair trying to go up an inclined plane using a ramp rather than a flight of stairs. Consequently, the psychological factor could be easily controlled as the subject is asked to cut the bar 01 based only on pure intuition, which actually defines the most accurate point that specific moment the decision is made. The bar, in other words, gives access to a fuzzy attitude since it requires a mapping in the space 01 instead of a discreet answer 0 or 1.

Another issue that it is worth referring to is the following: If subjects are used to filling in questionnaires using Likert scales, then they are expected to have created in their mind an abstract scale of 3, 4, or 4 grades, or, even, of 10 or 100 grades or steps, by means of which they evaluate the questions posed. It is widely accepted that normally 10 is used for grading or marking while 100 is

used for percentages; then, obviously, the per cent answer is closer to that of the bar, since the 100-grade escalation of the short bar is closer to that of a continuum than the 10-grade one. However there is still one indication in the middle for which the least decisive or reluctant one are expected to go for! The suggestion that we should establish equal spaces along the bar using mill metric paper is inappropriate as it actually affects the subjects' answers guiding them towards certain points along the bar.

Lygeros (2009) points out that "the Vougiouklis & Vougiouklis innovation concerning the substitution of the scale with the bar is originated from the contention between continuous and discrete. The tool proposed is neither another one among the others suggested in the methodology of questionnaires nor some excuse in order that a theory should be artificially used and finally come up with the same results. By contrast, the Vougiouklis & Vougiouklis bar is trying to overcome, in a skilful mathematical way, methodological shortcomings of simplification created by a model such as the Likert scale. Every scale, using a discreet space for data analysis, creates by definition problems of orientation while trying to function in a space of finite dimensions. The specific choices offered by Likert scales in an absolute hierarchy, which appears to be some kind of simplification in statistics, yet it only consists a type of thought decay. If such a statement sounds rather provocative, consider the fact that thought should be limited within the elements of a finite set. Simplification results in naivety. The problem is oversimplification".

3 Advantages of the bar in the processing

Processing questionnaires using the bar gives the initiative to the researchers who have the chance to 'escalate' the answers without having to decide in advance how many grades they will need in order to identify the parameters and clarify the differences between the grades. More important, they are offered the flexibility of establishing balanced or imbalanced scales according to the needs of the specific research each time. In the filled collected questionnaires, the researchers need to be able to access and process them in more than one ways without having to repeat the test. In this way the subjects will be protected from going through a time consuming and rather unpleasant process but even more avoiding to risk the reliability of the results. This is because sitting the same test again, may involve the risk of the specific subjects' familiarization with the whole process and consequently affecting the reliability of the research itself. The use of the bar minimizes such risks and reinforces the objectivity of it as it gives more space to mathematical processing of the results.

One of the main characteristics of applied mathematics is the ability of different approaches, the ability of simplification of the form. That is why linear models are preferred and we tend to change continuum into discrete and vice-versa. Consequently the bar offers the possibility of accurate processing which is

the optimum for the researcher: from discrete into continuous and from single valued into fuzzy or multivalued, where the use of maps and the hyperstructure theory is closely related to fuzzy sets (Vougiouklis 1994; Corsini, Leoreanu 2003; Davvaz, Leoreanu 2007; Vougiouklis 2008; Vougiouklis, Kambaki 2008; Kambaki-Vougioukli, Karakos, Lygeros, Vougiouklis 2011; Nikolaidou, Vougiouklis 2012) could be of assistance to both data processing and, amongst others, language teaching (Vougiouklis, Kambaki 2008). It would be a very good idea to make an extra evaluation of our proposal by asking participants who have filled in questionnaires using Likert scales in the past, to specify whether the bar or the other type of scale makes things easier for them. Or even have a simultaneous use of both methods and ask for an immediate evaluation.

We thought that such an exact and stable length gives it the advantage of an easy and accurate comparability among different researchers and researches anywhere in the world. Not to mention the burden of having to define and then explain to the participants all the fine differences between terms or phrases used. More specifically, if we need to choose from an escalation including *very good, good, fairly good, almost good, not really good, not good, not good enough, rather bad, not very bad,* etc, how can we be sure that we can explain the differences accurately and make each of them completely comprehensible and easily distinguished from the other relative choices to all our participants? In the case of the bar, however, we leave this decision upon the participants, even without having to explain it verbally.

A really difficult problem for researchers to solve is if they, for some reason, have to change a, say, 5/grade scale such as 'I totally disagree, I disagree, I am between, I agree, I absolutely agree', into a 6/grade one. The researchers then will have to find a new word or phrase to put into somewhere between the words or phrases in use and moreover to redefine the limits and the meanings of these.

A big problem in questionnaires is if the questions increased dramatically. For example, if a new parameter appeared as the 'confidence' which double the questions. In these cases we think that the bar is the only solution (Kambaki-Vougioukli 1992; Kambakis-Vougiouklis 2012; Kambakis-Vougiouklis 2013; Kambakis-Vougiouklis, Mamoukari 2014; Kambakis-Vougiouklis, Mamoukari 2015)

4 Gauss distribution and parabola case

Questionnaire procession using the bar gives the initiative to the researcher, who has the chance to 'escalate' the answers without having to decide in advance how many grades there will be finally needed so as to be able to identify the parameters and clarify the differences between the grades. Even more so, there is a good degree of flexibility in establishing balanced or imbalanced scales taking into consideration the needs of the specific research each time. More specifically, after the researcher has collected the filled-in questionnaires, he will be able to process and access them in numerous ways

without having to repeat the test putting the subjects in a new time consuming process and risking the reliability of results. Using the bar minimizes such risks and, more important, reinforces the objectivity of it as it gives more space to mathematical processing of the results.

The final stage is that of the processing the result. The procedure to be followed is exactly the same as with any Likert scale. Thus we can divide the bar in as many equal spaces as we wish. The bar gives a potential for different types of processing not provided by the Likert scales. For example, suppose that we find out that the given answers follow the Gauss distribution and we wish to 'correct' this tendency Vougiouklis, Kambaki-Vougioukli (2011).

We remind that we had analogous classes using the Gauss distribution which are as follows in mm:

for 3 classes with limit values 0 – 27 – 35 – 62
for 4 classes with limit values 0 – 25 – 31 – 37 – 62
for 5 classes with limit values 0 – 24 – 29 – 33 – 38 – 62
for 6 classes with limit values 0 – 22 – 27 – 31 – 35 – 40 – 62
for 7 classes with limit values 0 – 21.5 – 26 – 29.5 – 32.5 – 36 – 40.5 – 62

The case we set now is the following: We suppose that we consider that the answers are decreasing, say, for example, for psychological reasons, from the left to the right side of the segment [0,1]. One of the models to represent the situation is the decreasing parabola $x=1-y^2$. In order to correct (normalize) the results we can divide the continuum [01] into equal-area spaces according to the above decreasing parabola distribution. This can be done by dividing the segment [0, 6.2] in equal-area spaces as follows:

For the ***increasing low parabola***, in its canonical form: $x=y^2$, we have the following segments, in mm:

for 3 classes with limit values 0 – 43 – 54 – 62
for 4 classes with limit values 0 – 39 – 49 – 56 – 62
for 5 classes with limit values 0 – 36 – 46 – 52 – 58 – 62
for 6 classes with limit values 0 – 34 – 43 – 49 – 54 – 58 – 62
for 7 classes with limit values 0 – 32 – 41 – 47 – 51 – 55 – 59 – 62

A second case is the ***increasing upper parabola*** is represented by $1-y=(1-x)^2$, and it is symmetric to the above with respect to the point (0.5 , 0.5). Then we divide the segment [0, 6.2] in equal-area spaces as follows, in mm:

for 3 classes with limit values 0 – 32 – 48 – 62
for 4 classes with limit values 0 – 27 – 40 – 51 – 62
for 5 classes with limit values 0 – 24 – 35 – 45 – 54 – 62
for 6 classes with limit values 0 – 22 – 32 – 40 – 48 – 55 – 62
for 7 classes with limit values 0 – 20 – 30 – 37 – 44 – 50 – 56 – 62

The corresponding decreasing cases are symmetric, to line x=0.5, therefore the results are symmetric. More precisely we have the cases:

For the ***decreasing low parabola***, in its canonical form: $y=(1-x)^2$, we have the following segments, in mm:

for 3 classes with limit values 0 – 8 – 19 – 62
for 4 classes with limit values 0 – 6 – 13 – 23 – 62
for 5 classes with limit values 0 – 4 – 10 – 16 – 26 – 62
for 6 classes with limit values 0 – 4 – 8 – 13 – 19 – 28 – 62
for 7 classes with limit values 0 – 3 – 7 – 11 – 15 – 21 – 30 – 62

A second case is the ***decreasing upper parabola*** is represented by $1-y=x^2$, we have the following segments, in mm:

for 3 classes with limit values 0 – 14 – 30 – 62
for 4 classes with limit values 0 – 11 – 22 – 35 – 62
for 5 classes with limit values 0 – 8 – 17 – 27 – 38 – 62
for 6 classes with limit values 0 – 7 – 14 – 22 – 30 – 40 – 62
for 7 classes with limit values 0 – 6 – 12 – 18 – 25 – 32 – 42 – 62

5 Application

Bearing in mind the lack of previous research concerning alternative methods of data processing in questionnaires rather than scales, the purpose of the present study was to determine whether the use of the bar instead of a scale, more specifically Likert scale, could be more effective and easily plausible. Our objective was also to test our subjects' reaction and their attitude towards the method suggested.

Within the frame of evaluation of the Department of Primary Education of Democritus University of Thrace, 1st year students were allocated questionnaires of subject evaluation concerning Geometry and Algebra where (a) the scale was substituted by the bar and (b) they were asked to specify whether they preferred the bar or scale (Kambaki-Vougioukli, Karakos, Lygeros, Vougiouklis 2011).

Method

5.1 Participants

There were two groups of students: Group 1 consisted of 143 students, who had just finished the first term of their first year of studies while Group 2 consisted of 109 (different) students, who had just accomplished the second term of their first year of studies.

5.2 Instrumentation

The questionnaires consisted of 65 questions in which we used the bar [01]. Finally, there was an extra question at the end of each questionnaire, asking the participants whether they preferred the bar or the Likert scale.

5.3 Procedure

Group 1: By the end of the first term, all the 143 students filled in the questionnaire consisting of 65 items concerning the taught subject of Algebra. In all questions there was used a bar instead of a 6-grade Likert scale used in any

other subject evaluation. Questions included the students' judgment of the instructors' effectiveness, the quality of the subject, the evaluation of the coursebooks, laboratories etc. Finally, they had to state whether they preferred the bar to a usual Likert scale.

Group 2: Similarly, by the end of the second term, 109 students filled in the questionnaire consisting of 65 items concerning the taught subject of Geometry. In all questions there was used a bar instead of a 6-grade Likert scale used in any other subject evaluation. Questions included the students' judgment of the instructors' effectiveness, the quality of the subject, the evaluation of the coursebooks, laboratories etc. Finally, they had to state whether they preferred the bar to a usual Likert scale.

5.4 Data analysis

In order to study the difference amongst various possible ways of codification of results, we chose the following three:

A. codification of the answers into 4 equal-length spaces (4 classes)

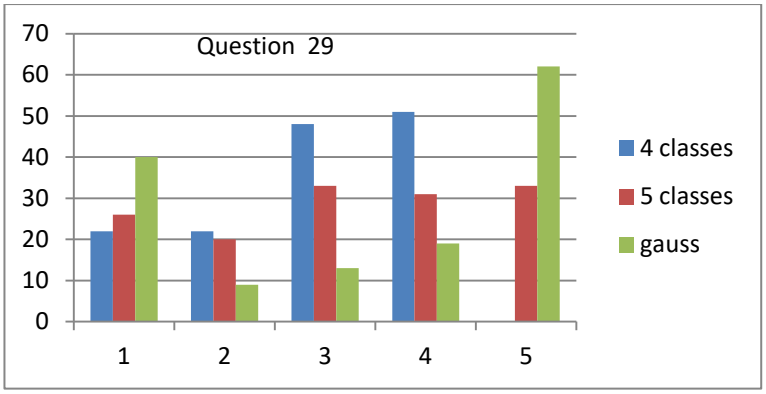
B. codification of the answers into 5 equal-length spaces (5 classes)

C. codification of the answers into 5 equal-area spaces according to Gauss distribution, that is to say 5 classes with limit value 0.39, 0.47, 0.53, 0.61 and 1.

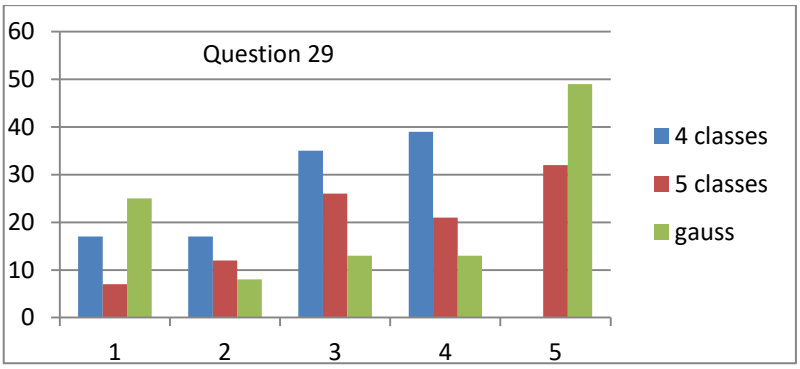
5.5 Results-discussion

Indicatively, in Bar-graphs 1 and 2, we present the processing results for question 29 "*Specify the degree of interest aroused by the teacher him/herself",* from the Algebra questionnaire, where the following is observed: when the answers are divided into equal-length spaces, no substantial difference is observed in classes 1 and 2 while in any other class the difference is obvious. This might be due to the fact that answers in high classes do not substantially differ amongst themselves concerning the limits defined and this fact has as a result these answers to shift from one class to the other depending on the limits defined each time. Similarly, when we choose the Gauss distribution, we can easily see the different distribution of the answers on the 5 classes, because all the answers seem to be crowded on the two extreme classes.

In bar-graphs 1 and 2 we have the processed results of question 29 of the Geometry questionnaire, where we can observe that when the answers are divided or codified into equal-length spaces, no substantial difference is observed while in every other class the difference is substantial and obvious.



Bar-graph 1



Bar-graph 2.

As far as the extra question about students' attitude towards the use of the bar as compared, or contrasted, to Likert scale, there was a massive preference of the bar: 236 out of 252 answered the specific question as follows: 197, or 83,47%, prefer the bar and 39, or 16,53% prefer Likert scale.

Conclusions

From the above discussion, the conclusion could be easily drawn that the use of the bar instead of a scale gives the researcher the chance to handle the questionnaire in a more flexible and dynamic way, taking into account the special difficulties and characteristics of each different research as well as the need of greater or smaller numbers of classes of the variables (questions). In every case, results derived by the use of a bar could be easily adapted to results derived by using a scale, making them comparable, while the opposite is impossible. This is because any answer given on a bar can be transferred on any scale, while answers given on a specific scale not only cannot be transferred on a bar but the opposite is impossible. Consequently, if the researcher wishes to compare results using different codifications in order to find out whether different conclusions could be derived, s/he has no other choice but repeat the

same test with all the above mentioned shortcomings of a repetition of the same experiment. To conclude, we hold that the suggested bar may offer solutions never thought of before and help researchers consider result processing from a different viewpoint.

Final conclusion: *Continuous vs Discrete*. From a philosophical point of view, we consider that a problem is better to be expressed on a 'continuous model', while transfer and processing of the problem is better to be done on a 'discrete model'.

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