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Validation of a questionnaire to detect emotions of students

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ABSTRACT: *In this paper we use the methodology of validation by expert judgment to validate a questionnaire that was designed to determine the emotions experienced by high school students (17-18 years old) who take mathematics subjects. The questionnaire was evaluated by a group of experts from the Mathematics Education area. In this paper we use the methodology of validation by expert judgment to validate a questionnaire that was designed to determine the emotions experienced by high school students (17-18 years old) who take mathematics subjects. The questionnaire was evaluated by a group of experts from the Mathematics Education area. Online questionnaires were used because the experts are located in different educational institutions, and in different cities. After performing the corresponding analysis, it was found that the questionnaire has a Content Validity Coefficient of 0.9808, which makes it possible to ensure that the questionnaire is adequate to be applied, since it will allow the expected data to be collected.*

KEYWORDS: *Content validation, expert judgment, questionnaire, emotions, high school students, mathematics courses.*

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I. INTRODUCTION

In our professional experience (a total of 70 years dedicated to teaching mathematics) at different educational levels, both in public and private schools, we have noticed that many students face serious problems in different mathematics courses, obtain low or good passing grades. failing Among the many reasons we have heard are that it is difficult for them to understand the concepts and how to approach problem solving, requiring frequent accompaniment from the teacher; In addition, we have noticed that students' attitudes towards learning mathematics range from disinterest and uncooperative to complete disgust.

Among the emotions that we have been able to identify in the students through their facial, corporal and verbal expressions when answering questions in this regard are: boredom, annoyance, anxiety, anger, fear, overwhelm, guilt, joy, satisfaction, enthusiasm. On the other hand, we have seen the need to continue investigating about emotions and how they influence the attitudes that people have. We have also seen that positive emotions help enhance performance in certain areas (Corradino & Fogarty, s.f.) and that there are also negative emotions that make it difficult to carry out certain activities (Pekrun et al., in press), but that even negative emotions are useful under certain circumstances (Jerrim, 2022).

The emotions that students experience are important for the teaching-learning processes because they influence attitudes. For example, they determine the student's willingness to collaborate in the activities that are implemented in the classroom and to actively participate (Mustafina et al., 2020). The applications of the derivative, which in Mexico are usually addressed in the penultimate or last semester of high school (17-18 years), require the student to have previous knowledge and skills not only in the area of Mathematics, but also in Physics, Chemistry, Biology and Geography (Demography) inclusive; that is, students need to integrate all the learning they have accumulated over previous years in the different subjects, to achieve an effective application in solving problems involving the derivative, requiring the use of Mathematical Thinking.

The emotions that the students of the last courses of the high school level experience, can be decisive for their future, because it is the moment in which they must make the decision of which studies to carry out at the higher level (university, technological, etc.), including selecting the institution in which they will carry out said studies. In our experience we have heard cases of students who make the decision to study a certain degree, on the condition that it does not have much content related to Mathematics; even though they like areas such as engineering.

II. STATE OF THE ART

Importance of studying the emotions of students

Since 2006, Zan et al. They talk about the growing interest in affect in the area of Educational Mathematics, although only as something different from mathematical thinking. Aguilar et al. (2016) analyzed the emotions of 87 high school students (17-18 years old) when they solve math problems. Among their results, they found that the most frequent emotional experiences are pride, amazement, stress, and guilt for not studying. They also showed that the student does not have an adequate management of positive emotions, which is an important aspect since negative emotions such as stress and guilt predominate when solving mathematical problems, which is an implication in the teaching-learning process of the subject.

García (2017) presented a work based on OCC and with it he stated that the affective domain refers to a wide range of feelings, emotions, beliefs, attitudes, values and appreciations in the learning of Mathematics. According to their results, the emotions that they detected the most in the students were: satisfaction, disappointment, fear, boredom, interest, joy, anguish, pride, reproach, self-reproach, like and dislike. While among the feelings experienced by teachers, are: happiness, resentment, anguish, jubilation, pleasure, anger, pride, gratitude, disappointment, remorse, gratification, and self-reproach.

Aragón (2017) used the OCC Theory in his research with the idea of finding the reasons that cause the students' attitude towards the math class; analyzed the responses of the interviews of 30 high school students developed through the focus group technique. In his results, he identified 13 different emotions: boredom, pleasure, appreciation, self-reproach, anguish, disappointment, displeasure, interest, fear, resentment, reproach, satisfaction, and confirmed fears. He also identified some triggering situations.

O'Dell (2018) stated that the questions that guided his study in elementary school students were: what are the emotions that students show when they engage in the exploration of unsolved math problems? And how are the emotions of frustration and joy related to the difficulties that students experience, while they are engaged in the exploration of unsolved mathematical problems?

Use of questionnaires in studies of emotions

Ramírez (2018) used a questionnaire as an instrument to collect data. Among the results obtained are that what triggers them is understanding math topics, the insecurity of their knowledge, accrediting the subject, understanding math topics, solving mathematical problems, the use of mathematics, solving mathematical problems, the lack of knowledge, interest in mathematics, and difficulty of mathematics.

Daza and Garza (2018) carried out a study at the Upper Secondary Level, where the relationship between the attitudes of 740 students towards Mathematics and their development in this subject was problematized, through the characterization of the attitudes towards the differential and integral calculus of a group of high school students from the Mexican public education system. They used a Likert questionnaire on attitudes towards differential and integral calculus and a semi-structured interview. In this process of analysis, both positive and negative meanings of the students' attitude towards the different topics consulted related to calculus were identified.

Mato and De la Torre (2009) assessed the attitudes towards mathematics and the academic performance of 1220 high school students (12-15 years old). The authors used a 19-item questionnaire. They found that the acquisition of certain basic mathematical skills and the understanding of certain concepts are essential for effective functioning in today's society.

Căprioară (2017) collected data based on a type of opinion survey, applied to a total of 350 eighth grade students. The information extracted from the responses of the respondents was completed with the conclusions drawn from two focus groups. Affirms that emotions accompanied by hormonal and autonomic responses can be pleasant or unpleasant and used as adaptive reactions that affect our way of thinking, they are a reality within the school climate

Johns (2017) highlighted the use of the Motivated Learning Strategies Questionnaire (MLSQ) to measure motivation and learning strategies.

Riling et al. (2018) through an online survey studied factors that influence students' mathematical dispositions and presented the results of an exploratory study of students' disposition towards mathematics. They surveyed 275 students and asked them about their feelings toward math over the years, as well as what aspects of the class they liked or disliked.

Importance of questionnaire validation

In the questionnaire literature, you can see works that seek validation of the instrument used to collect information. For example, Arribas (2004) comments on the ease of using a questionnaire to collect information, in addition to offering a methodology to generate one that is validated by what he mentions "how to proceed when considering the design and validation of a questionnaire" (p. 24). Farias Mata (2015) spoke about the

importance of a validated questionnaire, for which he presents the methodology he followed to design and validate a questionnaire of attitudes towards mathematics.

Ursini et al. (2015) designed and validated a scale to collect information about students' attitudes towards mathematics. To establish the reliability and validity of their scale, they carried out the reliability analysis by calculating Cronbach's alpha coefficient; and for validity they used a factorial analysis.

A widely used methodology to validate data collection instruments is to use judges or experts from the area in which the instrument will be used. The validation and reliability of the instrument to be used rests on the experience of these judges. Escurra (1988) presented three ways to verify the validity of the content of an instrument applying the criteria of judges, in psychology.

Escobar-Pérez and Cuervo-Martínez (2008) generated an 8-step guide to carry out an expert judgment, in order to facilitate and make the application of this methodology more efficient.

In Robles and Rojas (2015) the design and validation of two cases of application of Validation by Expert Judgment are detailed, both in applied linguistics. In which the authors highlight the advantages of this methodology.

Hernández and Juárez (2020) designed and validated an instrument that allows them to evaluate tutoring in higher education schools. The instrument was validated with a group of experts selected for their significant experience in the area, among other elements.

Rodriguez et al. (2021) designed and validated a checklist to assess evidence of conceptual learning about the concept of synthesis of a topic. They also used validation by expert judgment.

Galicia et al. (2017) generated a virtual tool that allows them to validate research instruments through expert judgment. Its tool facilitates the evaluation work of the judges in specific categories such as clarity, coherence, relevance, and sufficiency.

III. QUESTIONNAIRE DESIGN

The questionnaire that we validated is a modification of the one presented by Martínez & García (2014), in addition, questions of a rating scale type were added that allowed ordinal quantification of the intensity of emotions (using the Likert scale) experienced by the students (Aragón, 2017). and questions related to academic goals according to the research by Miranda and Santillana (2019). In Mexico, grades generally range from 0 to 10, and the grades to pass the course are 6, 7, 8, 9, and 10.

1. Indicate the option that best describes your situation.
Generally, your grades in the math subject are:
[ ] Excellent (9.0 to 10)
[ ] Good (8.0 to 8.9)
[ ] Poor (7.0 to 7.9)
[ ] Low (6.0 to 6.9)
[ ] Very low (has failed math on more than one occasion)

About Student Goals
2. Why are you attending high school?
3. If you will continue your studies at a higher level, what career will you study? why?
4. If you will not continue studying, explain your reasons.
5. What would you like to work on in the future?

About the math subject
6. Do you like math? Why?
7. Is it important to study mathematics? Why?
8. What emotions do you experience during math class? If you don't know the name of the emotion or you're not sure what emotion you're experiencing, explain what you're feeling. For example: I am very impatient during the class because I want it to be over, I don't want the class to end because it is so interesting, etc.
9. What do you consider to be the causes of the emotions you experience?

About emotional experiences in Mathematics class
10. Describe two pleasant experiences you have had in math class.
11. Describe two unpleasant experiences you have had in math class.

About Motivation in Mathematics Class
12. Describe two or more experiences where you have felt motivated or encouraged in math class.

13. Considering the maximum feeling of motivation that you have experienced in your school life during middle and high school as 5 (in any subject). Tell me the score that corresponds to the level of motivation you experienced in the situations you described in the previous question. Consider that: 1 = very little motivated, 2 = little motivated, 3 = regularly motivated, 4 = very motivated, 5 = highly motivated.
14. Describe two or more experiences in which you felt unmotivated or discouraged in math class.

15. Considering the maximum feeling of demotivation that you have experienced in your school life during middle and high school as 5 (in any subject). Tell me the score that corresponds to the level of amotivation you experienced in the situations you described in the previous question. Consider that: 1 = very little unmotivated, 2 = little unmotivated, 3 = regularly unmotivated, 4 = very unmotivated, 5 = extremely unmotivated.

About experiences of interest in math class
16. Describe two or more experiences in which you have felt interested in math class.
17. Considering the maximum interest you have experienced in your school life during middle and high school as 5 (in any subject). Tell me the rating that corresponds to the level of interest you experienced in the situations you described in the previous question. Consider that: 1 = very little interested, 2 = little interested, 3 = regularly interested, 4 = very interested, 5 = extremely interested.
18. Describe two or more experiences where you felt bored in math class.
19. Considering the most boredom you have experienced in your school life during middle and high school as 5 (in any subject). Tell me the score that corresponds to the level of boredom you experienced in the situations you described in the previous question. Consider that: 1 = very little boring, 2 = little boring, 3 = regularly boring, 4 = very boring, 5 = extremely boring.

About students' attitude towards mathematics
20. In general, what is your attitude towards mathematics?
[ ] Rejection. I prefer to avoid any subject related to mathematics.
[ ] Acceptance. I do not like them, but it is necessary to study them.
[ ] Attraction. I like mathematics and I am attracted to subjects related to it.

21. Any other experiences you would like to share related to math class?
Thank you for your participation.

The digital questionnaire was generated using Google Form® with the intention that the 20 volunteer high school students could receive it in their institutional workspaces of G-Suite® (currently Google Workspace), in order to guarantee that the participants are students of the institution in which the research is carried out. To apply the questionnaire, it was considered that two days in asynchronous format would be enough to answer the questionnaire, each question was configured to receive a text response in paragraph format or a selection in the case of multiple-choice questions.

Questionnaire Content Validation
As part of this research and trying to have valid instruments to collect data, the questionnaire presented above was subjected to a content validation process by expert judgment; this with the aim of providing and evaluating its stability and internal consistency. Content validity is essential to measure to what extent the instrument (in this case, questionnaire) represents the emotions experienced by students as faithfully as possible and, based on this, make pertinent inferences.
For this purpose, the Content Validity Coefficient (CVC) of Hernández-Nieto (2011) was used, where the opinion of 3 experts who carry out research at the Center for Research in Applied Science and Advanced Technology – Legaria Unit (CICATA) and 2 at the Universidad Veracruzana, 5 experts in total.

For content validation, each of the items that make up the questionnaire was considered and the following aspects were evaluated:
1. Relevance
2. Wording and terminology
3. Conceptual clarity
4. Scale
5. Sufficiency
Each of the aspects to be evaluated was defined as follows:
1. RELEVANCE
Degree of correspondence between the statement of the item and what it intends to measure

2. WORDING AND TERMINOLOGY
If the syntax and terminology used are appropriate for the recipients of the instrument (mathematics students of upper middle level of a private institution of upper middle class located in the city of Cuernavaca Morelos)
3. CONCEPTUAL CLARITY
If the statement of the item does not generate confusion or contradictions
4. SCALE (not evaluable in all the items), only in those that present a Likert scale.
Can the item be answered according to the scale presented by the instrument?
5. SUFFICIENCY (this criterion is only presented at the end of each section)
Referred to whether the items of the instrument are sufficient to measure what is to be measured.
Each of the items was evaluated using a Likert scale provided to the experts, and a space for comments was provided, as shown in the examples below:

Item 1
1. Indicate the option that best describes your situation.
Generally, your grades in the math subject are:
[ ] Excellent (9.0 to 10)
[ ] Good (8.0 to 8.9)
[ ] Poor (7.0 to 7.9)
[ ] Low (6.0 to 6.9)
[ ] Very low (has failed math on more than one occasion).

Instructions: mark with an X the score that you consider appropriate for each of the criteria.

	Remarks	**Punctuation**				
Features		**1**	**2**	**3**	**4**	**5**
Relevance						
Wording and terminology						
Conceptual clarity						
Scala						
Sufficiency of section 1						

Evaluation: 1 = unacceptable 2 = poor 3 = fair 4 = good 5 = excellent

Item 2
2. Why are you attending high school?
_____
_____

Instructions: mark with an X the score that you consider appropriate for each of the criteria.

	Remarks	**Punctuation**				
Characteristic		**1**	**2**	**3**	**4**	**5**
Relevance						
Wording and terminology						
Conceptual clarity						

Evaluation: 1 = unacceptable 2 = poor 3 = fair 4 = good 5 = excellent

The results obtained from the evaluation are set out below:

Table 1
Score assigned by expert judgment to each item of the questionnaire

Item	**Item key**	**E_1**	**E_2**	**E_3**	**E_4**	**E_5**
1	**1.9**	19	20	20	19	20
2	**S_1**	5	5	5	5	5
3	**2.1**	15	15	15	15	15
4	**2.2**	15	15	15	14	15
5	**2.3**	15	15	15	14	15
6	**2.4**	15	15	15	15	14
7	**S_2**	5	4	4	5	4

8	**3.1**	15	15	12	14	13
9	**3.2**	15	15	14	14	15
10	**3.3**	14	15	15	15	15
11	**3.4**	15	15	15	15	15
12	**S_3**	5	5	5	5	5
13	**4.1**	15	15	15	14	15
14	**4.2**	15	15	15	14	15
15	**S_4**	5	5	5	5	5
16	**5.1**	15	15	15	15	15
17	**5.2**	20	20	20	19	20
18	**5.3**	15	15	15	15	15
19	**5.4**	20	20	20	20	20
20	**S_5**	5	5	5	5	5
21	**6.1**	15	15	15	15	14
22	**6.2**	20	20	20	20	20
23	**6.3**	15	15	15	16	15
24	**6.4**	20	20	20	20	19
25	**S_6**	5	5	4	5	4
26	**7.1**	19	20	20	19	20
27	**S_7**	5	5	5	5	5

Where:
E1, E2,…, E5 = Scores assigned by each expert, respectively.
S1, S2,…, S7 = Evaluation of sufficiency of section
Based on the previous results and in order to assess the degree of agreement of the 5 experts with respect to each of the items, the mean obtained for each of the items was calculated using:

$$CVC_i = \frac{M_x}{V_{máx}}$$

Where:
CVCi = preliminary content validity coefficient for each item
Mx = mean of the score given by the experts for each item
Vmax = maximum score that item i could achieve
Subsequently, the error assigned to each item (Pei) was calculated in order to reduce possible biases introduced by some of the experts.

$$Pe_i = \left(\frac{1}{j}\right)^j$$

Where:
j = 5 (number of experts)
Finally, the CVC content validity coefficient was calculated for each item using:
$CVC = CVCi - Pe_i$
At the end, the CVC of the entire questionnaire was determined by calculating the arithmetic mean of the CVCi for each item.
The results obtained are shown in the following table:

Table 2
Calculation of the content validity coefficient (CVC) for each item and for the instrument.

Item	Item key	E_1	E_2	E_3	E_4	E_5	M_x	CVC_i	Pe_i	CVC
1	**1.9**	19	20	20	19	20	19.6	0.9800	0.00032	0.9797
2	**S_1**	5	5	5	5	5	5	1.0000	0.00032	0.9997
3	**2.1**	15	15	15	15	15	15	1.0000	0.00032	0.9997
4	**2.2**	15	15	15	14	15	14.8	0.9867	0.00032	0.9863
5	**2.3**	15	15	15	14	15	14.8	0.9867	0.00032	0.9863
6	**2.4**	15	15	15	15	14	14.8	0.9867	0.00032	0.9863
7	**S_2**	5	4	4	5	4	4.4	0.8800	0.00032	0.8797
8	**3.1**	15	15	12	14	13	13.8	0.9200	0.00032	0.9197
9	**3.2**	15	15	14	14	15	14.6	0.9733	0.00032	0.9730
10	**3.3**	14	15	15	15	15	14.8	0.9867	0.00032	0.9863
11	**3.4**	15	15	15	15	15	15	1.0000	0.00032	0.9997
12	**S_3**	5	5	5	5	5	5	1.0000	0.00032	0.9997
13	**4.1**	15	15	15	14	15	14.8	0.9867	0.00032	0.9863
14	**4.2**	15	15	15	14	15	14.8	0.9867	0.00032	0.9863
15	**S_4**	5	5	5	5	5	5	1.0000	0.00032	0.9997
16	**5.1**	15	15	15	15	15	15	1.0000	0.00032	0.9997
17	**5.2**	20	20	20	19	20	19.8	0.9900	0.00032	0.9897
18	**5.3**	15	15	15	15	15	15	1.0000	0.00032	0.9997
19	**5.4**	20	20	20	20	20	20	1.0000	0.00032	0.9997
20	**S_5**	5	5	5	5	5	5	1.0000	0.00032	0.9997
21	**6.1**	15	15	15	15	14	14.8	0.9867	0.00032	0.9863
22	**6.2**	20	20	20	20	20	20	1.0000	0.00032	0.9997
23	**6.3**	15	15	15	16	15	15.2	0.9500	0.00032	0.9497
24	**6.4**	20	20	20	20	19	19.8	0.9900	0.00032	0.9897
25	**S_6**	5	5	4	5	4	4.6	0.9200	0.00032	0.9197
26	**7.1**	19	20	20	19	20	19.6	0.9800	0.00032	0.9797
27	**S_7**	5	5	5	5	5	5	1.0000	0.00032	0.9997
									Instrument	0.9808

When analyzing the CVC values for each of the items, in general; it is observed that its value is higher than 0.8 (the value recommended by Hernández-Nieto to accept an item) so it is not considered necessary to replace any item; however, based on the comments of the experts, some of them were modified (specifically S2, 3.1 and S6).

Question 3.1
Do you like math? Why?
With this question you can identify emotions of like/dislike towards the object of mathematics with the consequent attitudes of acceptance, rejection or attraction.

Table 3
Emotions identified according to the answers to question 3.1

Students	Answers	Emotions
1	Yes, although sometimes I don't understand them, but I do like them	Attraction (love)
2	No, it's a subject that stresses me a lot about topics I don't understand.	Repulsion (hatred)
3	Yes, they are easy if you understand them.	Attraction (love)

A	No, because I find them tedious.	Repulsion (hatred)
B	Yes, I like to solve problems with numbers.	Attraction (love)
C	Yes, I understand them and they are easy for me	Attraction (love)
D	Lately I've lost a bit of taste for them because at this level they're difficult for me, but in general I do like them, since elementary school.	Attraction (love)
E	Normal. (He doesn't like them much, clarification in interview)	Attraction (love)
F	Yes, they are complex and entertaining	Attraction (love)
G	Yes, I like them a lot, I believe that mathematics is part of our daily life, although many times or some people do not realize it, we need it, from the simplest to the most complicated.	Attraction (love)
I	Yes, because they are entertaining and they will serve me for what I want to be when I grow up.	Attraction (love)
II	I do like them because they distract me and I forget about the things that happen, but they make me desperate in the end.	Attraction (love)
III	I don't like them, I don't know why; but they are very important.	Repulsion (hatred)
IV	A little, because they get complicated.	Attraction (love)
V	Yes, because they are interesting and at the same time not because I get very stressed (he doesn't like them very much, clarified in an interview).	Attraction (love)
VI	Yes. They are easy to understand.	Attraction (love)
VII	Not so much, they are very complicated. (He doesn't really like them, clarified in an interview).	Repulsion (hatred)
VIII	I don't like them, but they are interesting when you understand them.	Repulsion (hatred)
IX	I do like them, because I feel that they are extremely useful on a day-to-day basis and it is very satisfying when you just understand 100%.	Attraction (love)
X	I couldn't say I don't like them, they just make it very difficult for me. (He doesn't like them much, clarification in interview).	Attraction (love)

There are 15 students (75%) who do show a taste for mathematics, which implies a sense of attraction towards it, while 5 of them indicate that they do not like it (25%). Of 3 students with excellent performance, 2 like mathematics (67%), of 7 students with good performance, 6 like mathematics (85%), of 9 students with average performance, 6 like mathematics (67%).), the only student with low performance, mentions that she does not dislike them at all. Due to the answers provided by the students; even different intensities are identified in the taste or attraction; some participants like mathematics a lot, others like it a little.
As can be seen, the identified emotions correspond to the aspect of the objects (mathematics in this case) caused by a perception of whether they are difficult or easy, whether they are entertaining, whether they are interesting, whether they are complex.

Question 5.1
Describe two or more experiences where you felt motivated or encouraged in math class.

Table 4
Answers of students with average performance in mathematics to question 5.1

Students	**Answers**
I	When my teachers explained to me and I understood or when my friends asked me for help.
II	When I understand the exercises.
III	When my colleagues help me and when I do everything well.
IV	When I entered high school, I realized that they explain a topic in detail and the information they provide is very understandable and you have no doubts.
V	When the teachers gave me motivation and when they gave me recognition for participating in a math contest in front of everyone.
VI	When my teacher taught me arithmetic and motivated me with a phrase from Rocky. One day I studied for an exam and was encouraged to know that everything I studied was coming.
VII	When I managed to understand something in the first year of high school and they put me on the blackboard and I managed to do it by myself. When I managed to do all my jobs by myself.
VIII	I feel motivated when I understand problems and can solve them quickly.
IX	The first 2 years of high school were my favorite years of math class. Because I understood everything, the teachers were very nice, mathematics was not difficult for me (clarified in interview).

In the case of students with average performance, the main causes are seen: the teacher's explanation, the support they receive from their classmates, that the teachers motivate them, that the content of their exams coincide with what they studied in class, receive public recognition, be able to solve their exercises by themselves, understand the problems and exercises.

IV. CONCLUSION

The final version of the questionnaire is the one we presented earlier. In general, a CVC value of 0.9808 is appreciated for the questionnaire, which is why it is considered acceptable and adequate for its application

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