ORIGINAL ARTICLE

THE NOMINAL GROUP TECHNIQUE AND THE QUESTIONNAIRE: THE DIAGNOSIS METHOD FOR THE OBSTACLES IN LEARNING MECHANICS IN HIGH SCHOOL

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ABSTRACT

Background: This work is rooted in observations and findings on the teaching and learning of mechanics in high school. Indeed, in different educational systems, researchers have shown that the mechanics is an educational content perceived by learners as arduous and difficult. **Objectives:** this research aims to locate the sources of the difficulties encountered by some students of second year Baccalaureate physical sciences. **Methods:** we used two methods: a method of ideas generation, to know the Nominal Group Technique and the questionnaire pencil / paper based on the former. **Results:** The data obtained revealed that the prerequisites are overestimated although students have already learnt the course of mechanics in the programs during common core and first year baccalaureate, they still have difficulties in the assimilation of basic concepts on this topic. **Conclusions:** the findings of the questionnaire and the NGT are similar and complementary .It becomes clear that using NGT and the questionnaire are efficient tools to diagnose high school students 'difficulties and obstacles in mechanics. So, NGT can be used not only in identifying students' problems with scientific notions, but also in other subjects.

Keywords: *Nominal Group Technique (NGT), classical mechanics, physics, nominal question.*

1. INTRODUCTION

At the level of high and middle school, the discipline of classical mechanics constitutes a conceptual pillar upon which several scientific domains rest: oscillation phenomena, the electrodynamics, the hydrodynamics, the physics of plasmas and the astrophysics. In fact, articulating around the movement and its causes, classical mechanics turns out to be fundamental in classical physical sciences and an indispensible bridge towards the quantum mechanics.

However, the research in the didactics of physics has clearly shown that the multiple concepts of mechanics seem to be complex and often induce learning difficulties for students [1,2]. In fact, these studies have shown that the sources of the obstacles that are likely to impede the learning of physics are various: the nature of the discipline itself, alternative conceptions, and shared knowledge learnt outside the class by students, etc [3-7].

An efficient teaching/learning depends highly on the identification of the obstacles for the learner. In fact, diagnosing the difficulties makes it possible to approach the conceptual universe of the students and grasp their level of acquisition and integration of the concepts of a discipline, and thus act accordingly.

The methods used in order to identify the difficulties are diverse: questionnaires, interviews, tests, etc. In this work, having as an objective the diagnosis of the difficulties encountered in the teaching and learning of mechanics at the final grade of high school, we resorted to an original method commonly used in the science of management which is the Nominal Group Technique (NGT). In the second phase, the diagnosis of the difficulties is done through the questionnaire, which supported and consolidated the data of the NGT.

1.1 The Nominal Group Technique (NGT)

1.1.2 Description of the NGT Technique: The Nominal Group Technique is a technique that had its origins in the psychosocial studies of the functioning of small groups (10 to 15 people). Set in 1968-1975 by Delbercq and Van de Venet Gustafson, its first applications were in the domain of management.
It quickly extended to different practices of social sciences [8] in order to become the optimal research technique for an objective, systematic, and quantitative description of the content showing communications [9]. Indeed, this is a more structured brainstorming method which is very useful for auto-evaluation and auto-diagnosis that makes it possible to highlight the choice of priorities within a group of persons gathered at the same place around the same problematic. The strong point of this technique results in the fact that it combines and alternates individual work and

the group's discussion. In this way, the group responds first individually to the nominal question but the moderator works to get out the collective reflection by following six steps [10] Step1: Each participant writes down the responses that he/she considers a solution to the nominal question.

Step 2: Collection of the ideas produced by the participants and their presentation in front of the group. We write them on the board.

Step 3: The moderator makes sure to clarify the meaning of the different proposals stated. He may cancel some if they are found to be redundant or irrelevant to the problem.

Step 4: Presentation of the retained responses and discussion.

Step 5: The participants are invited to choose 9 proposals among those presented and rank them according to priority. Knowing that the response proposals cited first are the most significant, we assigned a weighting mark pi to each response that goes down from the first response to the last.

Step 6: The moderator should lay out a chart presenting the responses and their corresponding pi.

2. MATERIALS AND RESULTS

In one class, we put together a group of fifteen students of the physical science baccalaureate stream chosen at random and we asked them the following nominal question:

What are the difficulties and the problems that you encounter while learning of mechanics?

After they were put into confidence, we incited and encouraged them to express themselves freely and without constraints on one of the two sheets we handed out to them. The collected data gave the sixteen responses that we transcribed on the chart. Conforming to step 3, we eliminated the redundant proposals and those that seemed irrelevant to us such as the responses that made no sense other than in the respondents' logic. In this way, the numbers of responses retained were reduced to thirteen. The step that followed consisted of asking the students to choose nine responses among this set and ranks them according to priority and assigning the weight 9 to the response at the top of the list, 8 to the second and so on down to the last one. Once the data were collected, they were displayed on the following chart where they are ranked according to a decreasing **pi.**

Students' Responses	pi	Rank
Forgetting the notions and concepts of mechanics taught during the preceding years (middle school, common core and first year baccalaureate)	110	1
Problems resolution	107	2
Mechanics concepts which are difficult to understand	104	3
Lack of reinforcement exercises	100	4
The courses of physical science remain theoretical (lack of practical work)	85	5
Lack of equipment in practical work classrooms	80	6
High number of students per practical work group	73	7
Overloaded Course and schedule and limited time	71	8
The teachers' explanation style lacks clarity and promptness	60	9
Teaching methods encouraging learners' passivity	52	10
Difficult exams, questions of memorization, absence of practical work quizzes	36	11
Lack of motivation of students	33	12
Lack of communication between teachers and the students	27	13

Delving into the chart shows that the students attribute their difficulties in mechanics mainly to the fact of having forgotten notions and concepts seen in middle school, common core and the first year of baccalaureate, to the resolution of problems, and to the complexity and difficulty of concepts. Indeed, the response that tops the list with the highest weight makes reference to having forgotten the notions and concepts seen in middle school, in common core and in the first year baccalaureate

The second source of the obstacle is the difficulty of resolving problems, with a weight (107) that is very close to the first point, which is about forgetting. The weight (104) corresponds to the third point, in which the students blame the complexity of the basic concepts in mechanics, is equally very close to the preceding two points. These responses go towards the same direction with the results of the bibliographic research confirming that the acquisition of scientific notions is not easy, that the concepts of physics are difficult to grasp, and that scientific knowledge in general is little integrated or rapidly forgotten [10-12]. The response 2 that refers to the resolution of problems is perfectly consistent with the bibliographic synthesis that has well underlined the difficulty students face to solve problems in physical sciences, which is a fact admitted unanimously by researchers in the didactics of physics. According to those researchers, the obstacle comes from the fact that the ability to solve problems depends not only on the learning of procedures but also on the ability to call for appropriate ancillary knowledge [13-16]. This result is corroborated by response 4 where the students admit that they did not have enough reinforcement exercises.

Through responses 5, 6 and 7 corresponding respectively to the weights 85, 80 and 73, the students strongly criticize the fact that the classes of physics at high school institutions are theoretical. They are thus well aware of the experimental nature of the discipline and, in this way, draw our attention to the lack of equipments and the basic scientific tools and also to the very high number of students in secondary school classes (often over 40). This makes it necessary to create or come up with work methods, arrangements of facilities arrangements and experimental protocols that are adapted to this situation.
 The response 8 presenting a non-negligible weight of 71 shows that the students think that there is an inadequacy between the knowledge that is taught (Mechanics) and the hourly load which is devoted to learning. This reflects the students' discomfort and their inability to assimilate the notions scheduled during the time which is normally allotted by the pedagogic guidelines and orientations. In addition to the didactic obstacles related to the difficulties of contents, the pedagogic methods of teaching are equally implicated by the students. As a case in point, the response 9 with the considerable weight 60 reveals that the students do not appreciate the teachers' way of explaining.

Responses 10, 12 and 13 go equally towards the same direction. They show that the method of conveying knowledge is far from being approved. In fact, they imply that these methods incite passivity and lack of motivation, and they note the absence of communication between the student and the teacher. The assessment was also mentioned in response 11. Apparently, the students think that the assessment is based more on memorization than on practice.

The inquiry by questionnaire

As we have already made clear, in order to check the data obtained through the NGT in relation with the students' difficulties, we elaborated a pre-evaluation questionnaire (ANEXE) that is made up of two types of items. The aim of the items of the first category is to estimate the degree of forgetfulness of the basic concepts of mechanics that were seen in the common core and first year baccalaureate. The questions, thus, relate to prerequisites. On the other hand, the items of the second category consist of questions on the concepts of mechanics that were introduced during the second year of the physical science baccalaureate in order to estimate their degree of difficulty.

Category 1 questions (G1) : Q1, Q2, Q3, Q4, Q5, Q6 ,Q7 , Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19 and Q20.
Category 2 Questions (G2) : Q20, Q21, Q22, Q23 and Q24.

It should be noted that the questions were formulated in such a way that takes into consideration the objectives of the curriculum Ministry of National Education. and the questionnaires suggested previously by other teachers. Let us keep in mind that the sample is made up of 100 students chosen at random three weeks after the course.

3. RESULTS

The results that were obtained are reported in the chart 2 below:

QUESTIONS	N°Q	PERCENTAGE OF RIGHT RESPONSES (%)	NUMBER OF FALSE RESPONSES (%)	NO RESPONSES (%)	TOTAL NUMBER OF UNSATISFACTORY RESPONSES (%)
Physical Scalar and Vectorial Quantities : position, movement, speed	Q_1	19	74	**7**	**81**
	Q_2	30	65	5	70
	Q_3	24	73	3	76
	Q_4	15	81	4	85
	Q_5	28	68	4	72
Universal Gravity	Q_6	26	71	3	74
	Q_7	27	55	8	63
Rotation of a rigid	Q_8	62	28	10	38

body around a fixed axis	Q$_9$	49	49	2	51
Work and power of a force	Q$_{10}$	17	70	13	83
	Q$_{11}$	80	19	1	20
	Q$_{12}$	43	47	10	57
Kinetic Energy and potential Energy of Gravity	Q$_{13}$	70	24	6	30
	Q$_{14}$	32	65	3	68
	Q$_{15}$	25	81	4	75
	Q$_{16}$	15	76	9	85
	Q$_{17}$	2	90	8	98
Mechanical Energy of a solid	Q$_{18}$	90	7	3	10
	Q$_{19}$	22	70	8	78
	Q$_{20}$	25	60	15	75
Newton's principles	Q$_{21}$	45	50	5	55
	Q$_{22}$	40	55	5	60
	Q$_{23}$	8	80	12	92
	Q$_{24}$	10	80	10	90

The analysis of the responses has made it possible to note that although the students in the survey were subject to an extensive teaching of mechanics (in the middle school curriculum, in the common core and the first year baccalaureate), they are far from mastering all the basic competencies relative to this theme. In fact, we can say that these students are not acquainted at all with the fundamental concepts of this content. They still exhibit some conceptual difficulties on the fundamentals of mechanics such as speed, energy, the notion of referential, etc. This questionnaire confirms the data in the literature corresponding to certain concepts such as that of energy [6,17]. This questionnaire also confirms that via the NGT students say that they find the concepts of physics difficult.

Reading the data in the chart also reveals that the percentages of correct responses are very low in the case of the questions of the two categories G1 and G2. This goes in the same direction as the bibliographic research [10,18]concerning the forget of concepts that were learnt. This forgetfulness points, on the one hand, to an ineffective assimilation and a surface learning [19] and, on another hand, to the non-mastery of the pre-requisites. This may constitute a real obstacle to an efficient learning and, thus, favor and reinforce surface learning [18,20,21]. It should be noted that the students raised this point during the NGT experiment.

The third research was also highlighted through the NGT and was reported by the literature didactic of the physics. This concerns the resolution of problems that was characterized by researchers as one of the major obstacles in physics.

Indeed, the percentages relative to the modes of responding to the question 24 : 10 % of correct responses, 80 % of false responses and 10 % of 'I don't know' clearly show that the surveyed students have difficulties in solving this problem. This fact is probably due to:
✓ The inaptitude for autonomy and adapting to new situations
✓ The inability to adjust concepts that they have learnt to new problem situations
✓ The inability to mobilize appropriate annex knowledge and involve transversal skills
✓ The non-acquisition of concepts relative to kinetic energy, potential energy of gravity, Newton's principles, universal gravity and speed
✓ The inability of analysis and synthesis
In fact, the questionnaire data processing made it possible to highlight that, in addition to these different conceptual difficulties relative to the discipline of physical sciences, the students who were tested seem to have shortcomings in the knowledge connected with physics such as algebra and geometry. Thus, we noted:
• the confusion between a vector and its norm
• the confusion between a movement and its trajectory
• the confusion between the notion of speed and the acceleration

4. CONCLUSION

At the end of this work that aims at diagnosing the difficulties and obstacles related to the learning of teaching sequences of Mechanics, and where we brought together two methods of analysis : the Nominal Group Technique and the pencil/paper questionnaire, we can say the following :

The NGT that consists of a method of generating ideas enabled us to give an overview over the difficulties and the obstacles of students related to this content. Thus, according to the data obtained through this technique, the students think that they are faced to three main problems common to two contents: the complexity of scientific

concepts, the rapid forgetfulness of notions learnt and the overload of the syllabus. They add another problem that they consider crucial to know, which the resolution of the problem is.

These facts were corroborated by the data obtained through the analysis of the questionnaire (Mechanics). Indeed, the students seem to have forgotten the notions previously learnt and exhibit apparent difficulties in the case of problem resolution. In fact, it seems that mechanics induces far more difficulties. It should be noted that the analysis through the questionnaire equally made it possible to highlight conceptual difficulties and notional confusions in the surveyed population. Thus, we may for example, cite the notions of the repository, the force, the energy, etc.

Moreover, it should be noted that the results obtained through the NGT and the questionnaire proved to agree and be complementary.

Finally, we can also say that this method of generating ideas: NGT is a tool of "indicative" diagnosis of learners' difficulties and plays the role of a 'smoke detector'. The obstacles and the problems detected have to be verified and confirmed by classical diagnostic methods such as the questionnaire and the interview. It should be underlined that in the case of our study, all the data of the NGT, even those that we have not had the chance of verifying, were stated by the community of researchers in the didactic of sciences or educational sciences.

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ANEXE

Questionnaire mechanical difficulties Diagnosis

I) Answer with true or false to the following statements:

Q1 - The average velocity of a point of an object moving between two instants depends on the reference speed contrary to their instant speed   which does not depend on the repository.
o True
o False
o I do not know

Q2 - The shape of route from one point of a solid in motion depends on the repository.
o True
o False
o I do not know

Q3 - All points of a moving body have the same instantaneous speed at the same time.
o True
o False
o I do not know

Q4 - The velocity vector of a body in uniform motion changes.
o True
o False
o I do not know

Q5 - The instantaneous velocity vector of a body in uniform rotation varies.
o True
o False
o I do not know

II) Select the correct proposal from the following suggestions:

Q6 - When the moon is moving around the earth, he suffered gravitation applied:
o the earth and not the sun.
o the earth and the sun together.
o all the planets and the sun.
o I do not know

Q7 - Consider a mass m = 700 g ball situated at a distance d = 1m between the center of the ball and the surface of the earth. The value of the universal force of attraction between the ball and the earth is :

o $F = 6.8N$

o $F = 684N$

o $F = 6.84.10^{-3}N$

o I do not know

III) Select the correct proposal from the following suggestions:

Q8 - When a non-deformable solid body rotates around a fixed axis during the period of time dt:
o all the points belonging to this body rotate at the same angle.
o all the points belonging to this body turn at different angles.
o all points belonging to this body travel the same distances.
o I do not know.

Q9- The speed of a point belonging to a solid body during rotation around a fixed axis depends on:
o position of the point relative to the axis of rotation only.
o angular velocity only.
o position of the point relative to the axis of rotation and the angular velocity of the body.
o I do not know

IV) Choose the proposal from the following suggestions:

Q10 - The power of the work of a constant force decreases when :
o the rate of displacement of the point of interaction of the force increases.
o the moving speed of the force interaction point decreases.
o the rate of displacement of the point of interaction of the force remains constant.
o I do not know

Q11 - The work of a constant force is a magnitude:
o scalar
o Vector
o always positive

o I do not know

Q12 - The work of a constant force is motor during travel if their interaction point is:

o perpendicular to the displacement vector.

o parallel to the displacement vector and in the same direction.

o parallel to the motion vector and in the opposite direction.

o I do not know

V) Select the correct proposal from the following suggestions:

Q13 - The kinetic energy is a quantity:

o algebraic

o always positive scalar

o vector

o I do not know

Q14 - The gravitational potential energy is a quantity:

o positive

o negative

o algebraic

o I do not know

Q15 - The change in gravitational potential energy and the work of the weight of a body between two instants T1 and T2 being:

o different

o equal

o opposed

o I do not know

Q16 - Identify the necessary conditions to write the formula of the gravitational potential energy as follows:

o $$E_{pp} = mgz$$

o $$E_{pp} = mg(z - z_0)$$

o   I do not know

Q17 - Recall the steps to follow when you apply the theorem of kinetic energy.

V) Select the correct proposition:

Q18- The mechanical energy of a solid body is:

o $$E_m = E_c - E_{pp}$$

o $$E_m = E_c + E_{pp}$$

o I do not know

Q19- The mechanical energy of a solid body in interaction with the ground is equal to:

o the work of this body

o the sum of the works of the forces applied on the body with the exception of weight

o the sum of the works of the forces applied on the body.

o I do not know

Q20- The mechanical energy of a solid body in movement under the effect of the weight:

o increases

o decreases

o remains as it is

o I do not know

Q21- Arguably the vector sum of the forces applied to a solid is void if:

o The solid is immobile.

o The solid is animated by a uniform motion

o The velocity vector vg of the mobile center of mass is constant

o vg speed mobile center of mass is constant

o I do not know

Q22- List the three principles of Newton's laws of motion setting.

Q23- Recall the steps to follow when you apply Newton's 2nd law.

Q24-A ball of 200 g is launched from the soil vertically upward with an initial velocity of 10 m / s. What can we say?

o when the speed of the ball is canceled, its potential energy is 10 J.

o the balloon will rise of 10 m.

o the balloon will rise of 5 m.

o when the ball is 3 m from the ground, its kinetic energy will be 4 J.