THE UTILISATION OF SHORT-TERM AND LONG-TERM MEMORY IN TEACHING PHYSICS

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Abstract:*In this paper we are going to present the notion of short-term memory and how it is used by college students in physics, in the geometrical optics and mechanics chapters. I examined the utilisation and the reproduction of geometrical figures that describe the physics phenomenon. The experimental observations were of an empirical type, in humanistic classes, for three cases, out of which two were made during the regular classes (teaching and feed-back lessons) and one during individual supplementary training for students who had to catch up with the others. The students had to represent the forces and acceleration in an abstract drawing in order to render what is going on from a physical point of view. It is a quite difficult process for the students who used the short-term memory; for instance, during the teaching lesson the students just rendered/copied the drawing on the projector, without paying attention to the stages of reasoning/the logics of drawing.While describing the facts we will point out the mistakes the students made when using just short-term memory. Besides, we will show also the incorrect drawings, explaining why we believe they used this type of memory instead of the long-term one.Eventually, we will suggest some solutions, e.g. a plan with the stages to be followed when making the respective drawing that the students have to follow when achieving their own demonstration, so that they should avoid making the same mistakes as at the beginning, determining them to use both short-term and long-term memory.*

Key Words: **despartite cu punct si virgula**

1. Introduction

The process of learning consists of several stages, and it much depends on the teaching style of the teacher as well as on the learning style of the high school students. Also, the students' manner of learning depends on the way in which they work and memorize the information received from the teacher. I have made these observations along my whole career as a physics teacher, but what attracted me most was to discover my students' mechanism of thinking as I was interested in adapting my teaching styles to their needs. Starting with the 1980s, the notions used to designate the learning and memorizing process continued to evolve. Such terms as visual, auditory, tactile and kinesthetic memory were used at the time. [2, 10, 11]

These types of memory are used more to characterize the students' learning styles, namely sensory senses used by them to capture new information and then to send them to the brain, to decode it. After that, the brain activates the senses and initiates the memorizing process. [3] But after the way in which the brain works could be studied better by means of MRI measurements for example (the acronym of *brain* magnetic resonance *imaging* is *MRI*) [1], other concepts started to be used in order to define the learning process, such as the short-term memory, working memory and long-term memory.[11] So, I started to make inquiries about how these memories work and to closely observe how my students learn, in order to adapt my teaching style to them. In Physics, to solve an exercise or a problem for example, we have often to make a drawing, a graph or a chart in order to visualize the phenomenon,

then to clarify the data that are given, and what the requirements are. Once the student has understood these two last phases, he can start solving the exercise. This solving process makes the brain pass through all three memories: short-term, working-term and long-term memory.

Therefore, in this paper, I will describe three cases that I have observed during the process of teaching-learning, regarding the carrying out of a drawing or a chart at physics class. Also, I will compare this phenomenon with that observed at English lessons by my English teacher colleague. These situations were randomly observed without the specific purpose of measuring some variables such as the time of reaction or the time of response to a requirement. These empirical observations were made at long intervals of time, noticing my and my students' mistakes with the purpose of not repeating them.

I called the first case "The case of accurate reproduction of charts/diagrams and abstract drawings", the second "The case of building a chart based on a known reasoning"and the third "The case of the inattentive beginner". After describing and interpreting them through the use of different types of memories, I had some discussions with my mate, teacher of English, in order to make some comparisons with the way in which the pictures in the English text-books help students understand and explain the texts. I found out that the process of understanding the information is more efficient during the English classes compared to the physics ones when the students have to learn and interpret a chart or a picture. Finally, I will give some solutions in order to make learning during the physics classes more efficient.

2. Clarification of the concepts of short-term memory, working memory and long-term memory

Reading different papers, I noticed that these three types of memory were studied more on people who are losing their memory.

They must re-learn to stimulate their memory in order to remember simple things. Scientists realized that the learning mechanisms and patterns we use, are formed in childhood, in order to learn easy or more difficult things that require a rational thinking process. Thus, the short-term memory which lasts for a very short time, about 10-15 seconds [3, 5, 6], helps us remember simple things such as phone numbers, names or short demonstrations grouped in short sequences.[10, 11] So, we use this memory to repeat and memorize short and simple things, while for a scientific reasoning such as in physics we use long-term memory.

Figure 1: The books in the library are not yet put in order and they call out "Arrange me" [4] This image shows us that the order in which the knowledges are put in memory resembles to the order in which the books are placed in a library.

In my opinion according with reference [3], this means that in a teaching situation, it is very important to know and take into account the characteristics of memory. The teacher can thus present and expose the information (or the knowledge) to the students in a manner that allows them understand, organize and develop it in an efficient way in order to acquire the knowledge.

Long-term memory stocks more complicated information and such,

when using it, it is like accessing a library from which we take only the necessary information [4] that we repeat, identify, analyze and compare with the new and unknown information and we process it in order to reach a conclusion or a result.

This process of thinking also uses the working-memory, which points out to the pre-existent information and knowledge that already exists in the long-term memory and gives to the new knowledge a new meaning.

In order to be able to retain more complex information in the long-term memory, we have to go through a longer and much complicated process, like for example, divide the information into short sequences and memorise them, decode and understand them (the comprehending process), and then assemble the sequences (linking and assembling), interpret them, and make comparisons (clarification and analyzing). Eventually, they have to extract the idea which best explains the new complex information which shows that the new information has been understood and apprehended. This means that the synthesizing process has been accomplished. Only after that, the new information will be stocked in the long-term memory. In my opinion as a physics teacher, the information is first used by the working-memory which works in two ways, connecting the two types of memory: the long-term and short-term ones.

The following definition back up my point:

> *"La mémoire à long terme est un lieu mental, où l'information est entreposée et préservée. L'information est entreposée dans la mémoire à long terme selon le ou les codes qu'on lui a donnés dans la mémoire de travail. C'est donc le lieu où sont emmagasinés, parfois pour très longtemps, les faits, les habiletés et les connaissances diverses – sociales, affectives, motrices, intellectuelles – que nous avons acquis depuis notre naissance pour un usage ultérieur.* [3].
>
> *C'est dans la mémoire de travail que se structurent les réponses aux défis (exposé du professeur, question d'examen, exercices, laboratoire à réaliser, techniques à accomplir, etc.) auxquels l'élève est confronté* [idem 3]."

Interpreting the text from French reference [3], long-term memory is a mental place, where information is stored and preserved. The information is stored in the long-term memory according to the code or codes given to it in the working memory by the student. It is therefore the place where the facts, the skills and the various knowledge - social, emotional, motor, intellectual - that we have acquired since our birth are stored, for a very long time and used later. Also, theanswers to a question or a teacher's presentation, to which the student is confronted, are structured in working memory.

Additionally, *"Because of the work of Baddeley et al. (1975), working memory is generally viewed"* also*, "as the combination of multiple components working together. Some even include in that bundle the heavy contribution of long-term memory, which reduces the working memory load by organizing and grouping information in working memory into a smaller number of units (Miller, 1956; Ericsson and Kintsch, 1995)". [7]*

So, in this paper I will give three examples in which I will explain both my and my students' failures due to the inadequate use of these memories, examples which I noticed during the physics classes. The purpose is to observe how the students understand, memorize, interpret and reproduce a type of very abstract chart encountered in the physics classes. Then we will compare these processes of memorizing, learning and interpreting a picture in the physics classes with the interpretation of pictures in the English classes.

3. The Description of the three observations and the explanation of the observed mistakes and reactions

Further on, I will analyze each case. First of all, I am going to describe the drawing which had to be reproduced and interpreted by the students and finally, I will present the mistakes they made, showing that these mistakes derive from the fact that the students use short-term memory more and very little of the long-term one.

3.1. "The case of accurate reproduction of diagrams and abstract drawings "

3.1.1. Initial condition

The first case is the one I named "The Case of Faithful Reproduction of Charts and Drawings". It was the one in which the reproduction of some drawings in the chapter of optics was observed during a physics class with a humanistic 9th grade. The task during was to "represent/draw the image of an object seen through a convex lens." These abstract drawings were already made and illustrated on the board, by means of a video projector. I chose the projection method, because the abstract drawing was very clear, without any ambiguities. This drawing was supposed to be reproduced by the students, without the teacher's help. The teacher did not have to give explanations about how to do it and in which order the lines should be drawn or which the elements of the drawing are (see figure 2).

3.1.2. Previously known knowledge

The theory on which the drawing technique is based (figure 2), was explained in a previous lesson. The students had to trace/draw the three rays of light which start at the top of the object, pass through the lens, suffering the refraction phenomenon and meet in the same point, to finally form the top of image.

3.1.3. Description of the abstract drawing

1)The first ray is the green one. It follows a straight line from the object, from point A to the center C of the lens.

2)The second ray, is the blue one. It starts from the object, also from point A, propa-gates parallel to the optical axis (the black horizontal line) and is refracted on the lens, passing through the second focal-point F2. The intersection of the two rays is point A' which is the image of A.

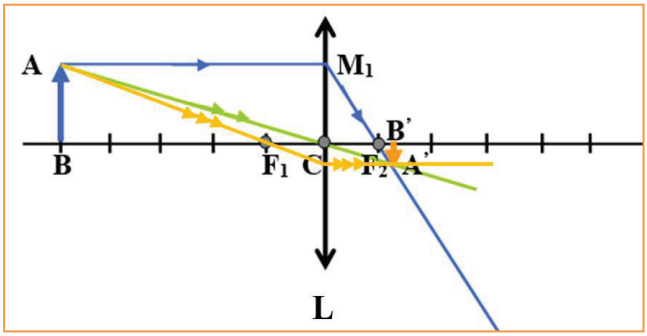

Fig. 2 An image formed through a convex lens when the object is situated at a long distance (5·f) Inspired by [8].

3)The third ray is the orange one. It goes from the object, from point A and passes through the first focal point F1; then it is refracted through the lens, and follows a line parallel to the main optical axis, meeting the other two rays also in point A'.

The students saw that drawing for the first time, but they had done similar drawings to obtain an image of an object in a mirror. If in the case of the mirror we speak about reflection, in the case of the lens it is about refraction, but the theoretical principles are similar.

3.1.4. Operations and steps that needed to be followed

1) Draw the lens;

2) Drawing the principal optical axis minding all the points: focal F1 and F2 and the center-C;

3) Mark the distances and values;
4) Sketch the object AB placing it at the required distance of 5u in front of the lens, to the left of the observer respectively; mark the points A and B that set the position of the object;
5)Trace the 3 rays, blue, green and orange which refract through the lens, according to the above rules. The students must trace the three rays from left to right because this is the direction in which the light propagates in the above drawing.
6) Get the intersection of the 3 rays and mark the intersection point with A'.
7) Construct the perpendicular line to the main optical axis which starts from A' and falls in B', thus obtaining the desired image.

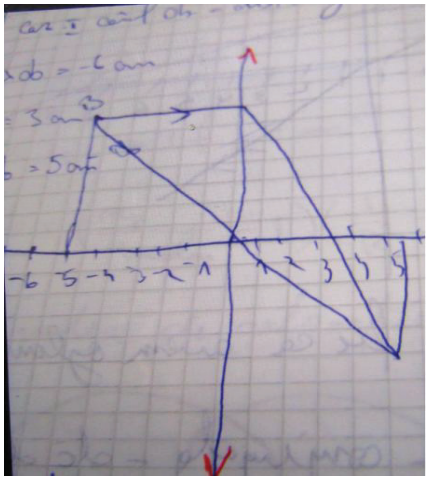

Figure3: The first student's drawing shows the formation of the image in a convex lens (distance between object and lens is 5u) – the drawing is made with more accuracy - photo captured by the physics teacher.

3.1.5. Observation of the phenomenon of tracing the drawing and the reactions of the students

The orderof the steps wasn't respected, and neither was the direction in which the rays were supposed to be drawn, which reveals that students did not appeal at all to the known rules stocked in the long-term memory and they didn't use even the working memory as they did not pay attention to the signs and colours on the drawing. They just put everything in the short-term memory, imitating what they saw, without considering the physics phenomenon.

This experience taught me that we cannot use ready-made drawings when teaching. The teacher must build the drawing and during the process he must speak and explain. This means that the teacher has to verbalize all his actions, explaining why he uses this order and direction of lines.

Here we have two drawings of two students from human class (figures 3 and 4). The pictures were captured by the physics teacher.

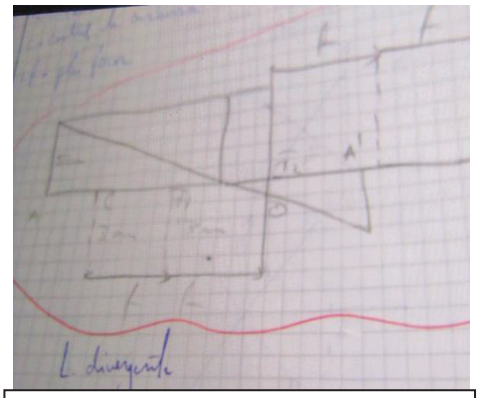

Figure 4: The second student's drawing shows the formation of the image in a convex lens – the drawing is done with much less accuracy than the first student – photo captured by the physics teacher

3.1.6. Comparison with the teaching of a foreign language such as English

We know very well that the English text-books are full of pictures. My English teacher colleague says that the photos are easier to interpret because they are closer to everyday life, they represent real situations and students can make correlations with what they live and know very well. In their minds, respectively in the long-term memory, they search for words that they already know and try to make sentences which describe the pictures. When the teacher talks about what is happening in the picture, or when students say what they think about the pictures (e.g. figure 5), the ones listening can not only understand, but also create analogies, and learn new words by just using active hearing, which means that they are using in the same time their working and long-term memory.

The only difference between English and physics is that students in English class have more ideas about life and moreover, these aspects represent their own experiences, while at physics class they cannot make similar analogies. So, what regards physics, in the 9th grade everything is still ambiguous, the students have little knowledge about physics and it is safer to say that the information in their long-term memory is still only partially structured (like the books in figure 1). Moreover, the students I observed are studying humanistic sciences, so they are not really inclined towards sciences. But, in the English class they have an inclination for humanistic sciences and they have all information stored in a much orderly manner in their long-term memory. Therefore, they have less inclination for mathematics and other sciences. Here we have a picture of Cirque du Soleil (figure 6) reproduced from an English book. (Who does not know what a show or circus is?)

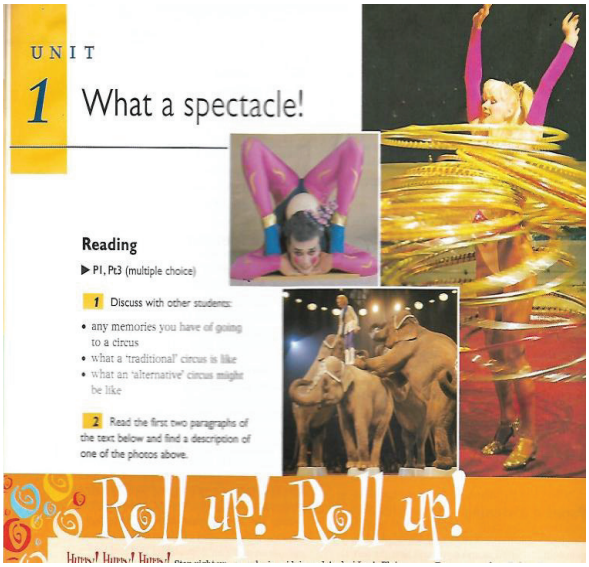

Figure 6: Cirque du Soleil [9]

3.2. Making a Scheme Based on a Previously Known Reasoning

3.2.1. Initial condition

The observation is made also at a 9th grade humanistic profile, during a feed-back lesson meant to verify the acquired knowledge. The theme was the same: "drawing the image on an object in a convex lens", like in figure 2 above. In this case the notions of drawing were clearer in the mind of the student because he already knew the theory and the reasoning/the logics of drawing. The students already had some landmarks. This is why I called it "The case of building a chart based on a known reasoning".

3.2.2. Previous knowledge

The students already knew how the drawing looked like, what rules they needed to follow in order to build it as well as the theoretical part. Some of the students had learned at home and already knew pretty well how it had to be drawn while others had not worked at home.

3.2.3. The observation of the phenomenon

The student that was asked to answer was one of those who hadn't practised at home. Before coming to the board, he briefly looked over his notes for a few seconds. This means that the student used only the short-term memory and very little of the long-term memory because, not practicing at home, he didn't have many notions stored in the long-term memory (Figures 3 and 4). In such a short time the student couldn't process all the details of the drawing and his drawing was not a correct one, demonstrating me that he used only the short-time memory. He kept in mind that the drawing was a parallelogram, which he knew from the Maths class, information that was in his long-term memory. And this was not the only case in the class, which demonstrated me that the 50-minute class is not time enough, so, the student must repeat and fulfill the tasks at home. The teacher has to come with supplementary hand-outs to determine the students use their working memory.

3.3. "The case of the inattentive beginner"

3.3.1. Initial condition and previous knowledge

The third case was noticed during a supplementary class with a student in the 9th grade from the sciences profile that had to work more in order to catch up with the others. The student comes from a coinhabiting nationality with special places at the entrance in high-school. Generally, this category has less knowledge compared to the others, so, their long-term memory is very week. They do not even master simple notions of math. The task consisted of two problems of mechanics. At first, the student solved everything by himself. Then I checked and corrected his answers. In the next stage, the student had to do the problem again, in the corrected way, for him to understand everything better.

3.3.2. The observation of the phenomenon

Because the last drawing we discussed together was the one in the second problem, he drew this one for the first problem. This shows that he did not process the information again, namely he did not read the request of the first problem again and because he kept in mind what he had done a few minutes before, he drew the last thing the teacher explained to him. So, he used just the short-time memory. Moreover, he closed his eyes and drew again with many details, but the drawing was not according to the requests of the problem. People would say that it was "lack of attention".

4. Solutions in order to avoid a wrong understanding and reproduction of drawings:

After observing all these, I divided the process of drawing into smaller and simpler stages and I devised a plan which I called "A plan for solving a problem of mechanics" which I asked the students to put down on their portfolio and use any time they have to solve a problem from this chapter. I did the same for the chapter of optics.

Making a comparison with the teaching of the English language, we reached the conclusion that the methodology of teaching this language is more advanced than the one of teaching physics because they have been long using this separation in small requests and the repetition in loops with different types of exercises. But, even in these circumstances there is the danger of forming some automatisms for certain grammar problems and, students with very good results in CAE can get weaker results during different internal competitions where the structure of the tasks is more diverse.

5. Conclusions

In conclusion we can say that practicing hard (using work-memory) or a quick look over a drawing (short-term memory) are not enough. If the student does not use long-term memory, he makes mistakes which at first sight might seem of minimum importance but which practically show that the student did not get to the level in which to use all three types of memory efficiently and simultaneously. This problem can be solved by the students by working harder and fulfilling the tasks given as a home-work and by the teacher by means of hand-outs meant to separate the working stages until the students are able to decode them correctly. But, unfortunately, during the classes, due to the lack of time, we do not have enough time to close this loop of learning and let students practice enough to become more independent and get more self-confident and this is what they complain about.

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