Do You Know What It Means?  Words, Meaning and Infograms
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Abstract
The paper explores the relationships between the essential cognitive skills: memory, abstract thinking and imagination, in the context of Infogram learning. Infograms are the symbolic graphic summaries of the material that use pictograms, abbreviations and key words for encoding and multiple retrieval of information. They facilitate meaningful learning and provide a ‘big picture’ of the topic. Infograms are neither concept maps nor infographics but can use elements of both in the process of creating the overall graphic symbolic narrative that covers the curriculum. All cognition is based on symbols that include words, abbreviations and pictograms. All symbols are abstractions. Infogram learning helps in developing the abstract thinking skills. Typical cognitive problems and successes are discussed. One way of detecting the problems is conducting the regular one-minute interviews with students in the classroom. Our students have the language, imagination and memory that need to apply to the content of the course. doi: 10.21692/haps.2017.018

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Introduction
In the beginning of each semester, I tell my Anatomy and Physiology students that for them it is also a foreign language class. The language we are studying is the terminology of medicine and human biology. It is based on Latin and Greek and may sound strange and intimidating. Students may have heard some of these words before but there will be hundreds of completely new names, often hard to pronounce, understand, and use.

Obviously any unfamiliar subject or field of knowledge has its own language or terminology that the learners need to master, but Anatomy and Physiology may be the champion in this respect. In my rough estimation, our curriculum demands from students to learn dozens of new names every week. This linguistic load accumulates very quickly and soon can become overwhelming.

On the other hand, we are not at liberty to reduce the load. It is the human body, and instructors cannot or, at least, should not skip a few organs or functions for the sake of emphasizing the rest. At this point, I ask my students, “Would you like your loved ones or yourself to be in the hospital at the mercy of nurses and doctors who never learned their Anatomy and Physiology? Or maybe they learned the right side of the body but not the left? Who wants this kind of health care for your family?” No students ever said that they did. Therefore, the challenge is accepted, not only to learn the terminology but also to understand and use the names correctly.

Success or Failure?
However, this is easier said than done. Of course, good intentions are always there. In my many years of teaching, I am yet to meet students who come to class hoping that they would fail. Some expect failure, based on their previous experiences, but deep down they still hope for a miracle, a fresh start. Then differentiation begins. In a diverse classroom, there will be some students who never show up or come to school occasionally.

Other students will miss a few classes, but their physical presence does not mean that they are truly engaged. The body is there, while the mind is wandering. Even without the electronic distractions of cell phones, tablets and laptops, even with their eyes on the teacher, these students may think about completely unrelated subjects. For example they may be contemplating buying shoes, meeting their boyfriends-girlfriends, and anything of interest, either fleeting or obsessive. In their lives, there are jobs, family emergencies, health scares, mental issues, various addictions and, in some cases, even homelessness and violence. The combined pressures grow and can make effective learning nearly impossible.

Sometimes we can help, and sometimes we cannot. Most of the time, we do not even know what is going on. I would say that the numbers of students who drop or fail the class for reasons of this nature may go from zero to 10-20 percent, depending on the student population.

The majority of students actually listen, participate and do the work. Many succeed, getting high grades. Others do reasonably well. There is also a group of students who, admittedly, work hard but do poorly on the exams. “I studied so much,” they tell you, “How could I fail? Can I see my test paper?” Usually they explain this request by saying that they want to learn from their mistakes, but I suspect that many of

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them want to make sure the teacher graded the test correctly, so much are they surprised by their low grades. It has been well documented that most students, particularly those with lower grades, tend to overestimate their future exam results (Clayson 2005). They believe that they learned the material but in reality they did not. The exam questions sounded familiar to them but it does not mean that their answers to the questions were correct.

Another big surprise comes if our students take an independent cumulative final exam, similar to the HAPS comprehensive online examination (HAPS 2017). The national averages for this exam are usually around 50 percent, maybe somewhat higher. Keep in mind that these are the averages of the selected schools and instructors, willing to pay for the test and take the risk of getting relatively low scores. In a less ambitious classroom the results may be even lower.

In my school, the passing grade for the course is 60 percent. The majority of the students get a passing final exam score. Most other schools do not fail the majority of their students either. How can we explain this discrepancy? If the independent exams are objective and fair (and there are no reasons to doubt this), then there is one plausible explanation, that our own exam grades are significantly inflated overestimating what the students actually learned.

How is it possible? Probably we are subconsciously teaching to the test, our test. When the exam questions cover what we did not emphasize in class or the questions are simply rephrased, the students get confused and discouraged.

Words and Meaning

This brings us back to the question of knowledge and understanding. There are also application, analysis, synthesis and evaluation popularized by the Bloom’s Taxonomy (Bloom et al. 1956). They all reinforce each other and cannot be easily separated. However, it is hard to emphasize the analysis or evaluation skills when the students do not know the basic language of the subject. How can we prevent them from simply memorizing a bunch of words without clear understanding of the meaning?

Richard Feynman, the Nobel laureate in physics, summarized his teaching experience in a Brazilian university the following way: “After a lot of investigation, I finally figured out that the students had memorized everything, but they didn’t know what anything meant.” (Feynman 1985)

This is typical for the failing students who are convinced they studied hard. It may be true that they learned a lot but they barely know what it all means. And what about our A-plus students that get a B or a C grade on the independent exam? They know much more, nearly everything, but the meaning of that ‘everything’ often escapes them as well.

For some students the problem is the inability to connect the dots. Like in the story of blind people touching the elephant, there is no basic understanding of what the elephant is; instead, there are many isolated bits and pieces of seemingly unrelated information. After learning their independent exam grades, these student in this category are usually humbled and embarrassed, and so are their instructors.

But what can be done? First it is important to learn more about the problem, a step at a time:

Step One: How can the instructors find out who has the problem and to what extent? In theory, there may be some very capable, motivated and hard-working students that could figure out all the complexities of the topic by using a good textbook with the minimal help from the teacher. Unfortunately, there are not that many ideal learners in our classrooms. As for others, our understanding of their cognitive problems is usually based on the exam and assignment grades. There is no time to interview every student on a regular basis.

Step Two: What is going on in the minds of the students as they study and take exams? Maybe even more importantly, what is NOT happening but should be happening? Again, it is hard to learn without questioning the students individually.

Step Three: What cognitive tools can help? My answer to this question was the instructional materials called Infograms, first described in this journal (Kolchenko 2015). As I explained in the paper, Infograms helped me approach the first two questions as well.

Meaning and Infograms

Infograms are the visual snapshots of the topic (Figure 1). To design them effectively, I had to use graphic symbols: pictograms, abbreviations and key words, supplemented by the explanatory text, side notes, slides, term list and homework assignment. (The text is particularly helpful if students missed the explanation in class and study the Infogram on their own.) The resulting one-page graphic symbolic summary appears to be an invaluable tool both for learning new information and for recalling what was learned.
Infogram-based recalling, or retrieval of information, becomes a creative process as soon as the graphic details are significantly reduced and there is a need to fill the information void using memory and imagination. The value of retrieval practice for meaningful learning has been demonstrated repeatedly (Karpicke and Blunt 2011), but this practice is usually limited to using quizzes and exams for testing and self-testing. Using Infograms provides a new way for the cued retrieval; they are designed for fast and efficient reviewing of the material based on the graphic symbols. Infograms also provide a ‘big picture’ of the topic at a glance, emphasizing the relationships among the concepts and helping ‘to connect the dots.’

Infograms are not concept maps. Concept maps (Fig. 3) are usually limited to the names of concepts, in boxes, connected by the arrows-relationships (Novak and Gowin 1984). This feature is present in many types of graphic representation and it was used long before the term ‘concept mapping’ was coined.

In my experience, concept maps were of special interest to the instructors and students who knew the subject well. For the new learners, they were quite helpful illustrating simple topics with a small number of concepts and connections. As the number of boxed names and arrows between the boxes was increased, the concept maps were gradually became complicated graphic webs of limited educational value. For most students, they were rather confusing and off-putting.

In this case, a ‘big picture’ obscured the meaning of the topic. The use of Infograms, is supposed to clarify the meaning at a glance. This is achieved by drastically reducing graphic noise and, inevitably, increasing graphic abstraction.
For example, Figure 1 and Figure three cover the same topic, *Body Directional Terms and Planes*, but in a very different way. Figure 1 shows the Infogram (top) and the term list (bottom). Figure 3 shows the concept map.

Figure 2 presents the pictograms used in the Figure 1 Infogram. They are abstracted views of the human body: frontal, lateral and superior. The dotted vertical line is the body midline.

The Infogram also uses the term abbreviations. Capital C and P are used twice: C for cranial and caudal and P for proximal and posterior. The names are not confused because the position of the initials relative to the human body pictograms has additional meaning that eliminates ambiguity e.g. form the infogram, it is clear that cranial is closer to the head, etc.

As you compare Figure 1 and Figure 3, which one is more abstract? The full names in the concept map are less abstract than the initials in the Infogram. But the initials help you recall full names, while there is nothing to recall when the names are already given. In this sense, the greater abstraction of the Infogram is useful for learning.

Furthermore, the position of the initials relative to the pictograms of the human body help you recall the meaning of each name (superior means above, inferior means below, etc.), while the concept map has little meaning in this respect, unless you already know what the terms mean. In this sense, the concept map is more abstract and less useful for a student.

Finally, the visual impression: for a new learner, the concept map seems crowded and complicated in comparison to the compact and simple Infogram. Here, the visual meaning is more unique, memorable and intuitive.

Infograms are not infographics. The emerging field of *infographics* has one central goal and that is to improve graphic design of data representation. In other words, this is an effort to make data graphs and tables more readable and less misleading (Tufte 1997). It applies to all media e.g. video, online, slide presentations, print and others.

As important as it is, *infographics* are mostly limited to data representation and focus on any consumer of data, for example, designing the most effective infomercials. Infograms, on the other hand, are focused on the student and the content of learning. They can use some elements of infographics and concept mapping such as simple data graphs and tables; a few boxes connected by arrows, but they are not limited to them. Here, the goal is different. This is an attempt to create an overall graphic symbolic narrative that covers the curriculum, including all needed data and concepts, in a comprehensive, easy-to-use and intuitive manner.

**Symbols and Cognition**

The key is the role of symbols in human cognition. My main idea is this: all cognition, including school learning, is based on symbols. Any thinking is symbolic; it cannot be otherwise.

What does it mean? Symbols, for our purposes, are any sensory or mental signals that represent something else – anything else – in the mind of the learner. For example, all words are symbols, either auditory in oral speech or visual in writing, because any word represents something else, either in the world of reality or in the world of ideas. Abbreviations, popular since ancient times, are the symbols of the symbols (Kolchenko 2016). Graphics like pictograms are non-verbal visual symbols that may have multiple meanings, for example, an arrow or a cross (Kolchenko 2015).

Symbols are always abstractions of the meaning; they abstract the meaning by substituting it with something else. A little can represent a lot. A lot can represent a little. In the process, details are necessarily lost and an abstraction is born. The extent of abstracting can differ. As it grows, there may be a problem with comprehension (‘connecting the dots’).
Then learning is not just memorizing the symbols, for example, anatomy terms. It is also creating associations between the symbols and their meaning in a complex and ever-changing multi-symbolic matrix.

How does it happen in the learner’s mind? We do not have a magic window to see it happening, but it is possible to collect a lot of circumstantial evidence. Using Infograms, I developed a technique of briefly interviewing every student in my class once a week. The objective is to check the knowledge and understanding of the Infogram material we are studying.

**One-minute Interviews**

One-minute interviews are done in the Anatomy and Physiology lab where we have about 20 students. The lab runs for two and a half hours. As the students are busy taking a weekly quiz for about twenty minutes, I call them to my desk, one by one, and ask a few pointed questions about the Infogram material. Students usually respond very fast because most of them know and understand the Infogram, and if they do not, it is obvious almost immediately.

Clearly, there is no way I could do these one-minute interviews without the Infograms. But even with them it took me a few semesters to gradually learn how to do it right. The first question was simple: Do you know what the Infogram means? Originally I was able to talk to a few students during the quiz (they did not mind), but eventually I improved my technique enough to have more and more of these diagnostic conversations.

During the last semester, Spring 2017, I interviewed everybody every week. Now all students expected me to talk to them, and if I missed someone, that person would remind me later saying, “You didn’t talk to me today!” Then I would find a minute (in the lab, it is not that hard) and ask my questions. I marked the outcome for every student every time. From the very beginning, it was clear that there might be different levels of comprehension, from ‘a student who knows nothing’ to ‘a student who understands everything.’ Those extremes rarely happen, but other levels are not uncommon. In a class of students the range of comprehension means that some students can:

1. Know the appropriate terms but not know the meaning of the terms.
2. Know the meaning of terms and give definitions, verbatim.
3. Know the meaning of terms and explain it in their own words.
4. Explain relationships between concepts, compare and contrast.
5. Give examples and describe applications.
6. Explain seemingly unrelated examples using the knowledge of the material.

**Cognitive Problems and Successes**

Using this questioning process, I was able to find out, in real time, who had a learning problem and what kind of problem it was. I gave students advice, individually, and monitored the progress of every student. That did not mean that all the problems were solved right away. However, I was able to observe how persistent the problems were, including the problems of the desperate attempts to memorize every word rather than understand and imagine the content.

One of the cognitive problems I have observed concerns the entrenched learning habits that a student develops during the first twelve years of schooling. Many students truly believe that memory is the most important learning skill. They say so in the surveys (unpublished results) and they practice this belief consistently, no matter what the instructor suggests. Changing a twelve-year old cognitive routine is not an easy one-semester task.

On the bright side, the one-minute interviews provided a tool that has allowed me to continue the investigation. It also shows that the majority of students are on the right track. This may explain a couple of recent messages from my former students, which were sent long time after they got their course grades.

One student requested:

“I am desperately asking you if you have Infograms for Anatomy and Physiology II. Please, please send (them) to me. I used to be an A student with your Infograms’ help. I feel I am getting lost during this semester.”

Another student wrote, one year after completing the course:

“I decided to go back to the Infograms to refresh my memory and so far, I remember most of it! Obviously, there are a few things that I have to look for in the text but a good portion of it I remember just from the Infogram pictures. I thought I should share that since it’s an ongoing project that you are still working on and I seriously think it’s great that I had the opportunity to be in your class and learn from the Infograms.”

**Conclusion: Memory or Imagination?**

Of course memory is important. It is the foundation, which is always implied. Weak memory can be a big problem for a student. There is also a condition called amnesia (no memory), but the patients with this condition are not likely to take our course. You can say that some of our students have a peculiar kind of selective amnesia, especially after the exams, with no retention of knowledge whatsoever. But the same people remember a lot of other information without much effort, for example, anything related to popular culture. It is hard to say that their memory is weak, except maybe for the science curriculum.

The reason, I think, is not even the lack of interest but the failure of imagination. Their imagination is bold in the movie...
theater but timid in the science lab. This is why the scientific symbols-abstractions are rarely connected to the reality in their minds. For this, you need your imagination free and strong. Einstein once said, “Imagination is more important than knowledge.” (Einstein 1929). Surely he did not mean that knowledge is not important. He just emphasized the priority. Imagination makes the abstract thinking possible, associating abstract symbols with the reality and each other.

Abstract thinking is the most wanted cognitive skill in sciences, but it is not limited to dwelling in complete abstractions. It is also the constant transition between the real and the abstract that we continuously practice with Infograms, and imagination makes it smooth and easy. Is abstraction difficult? All words are abstractions, and this means that anyone who mastered language is capable of abstract thinking. When I tell my students that imagination is more important than knowledge, they are genuinely surprised. The good news is they have everything they need to become good learners; they have language, imagination and memory. They just need to apply all of this to the subject matter of anatomy and physiology.

About the Author
Vasiliy Kolchenko is a Professor of Biology at New York City College of Technology, The City University of New York. Vasiliy teaches Anatomy and Physiology and Bioinformatics. His research includes biosensor development and graphic representation in science education. He also writes and performs music. This is his Teaching Science song: https://www.youtube.com/watch?v=CpeI5wHvKE4

Literature Cited


