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# Reusing Patterns for Indexing and Communicating Knowledge and Insight

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***Abstract*: Analogies can be used in most areas of human communication to highlight points of special interest. The creation of specific, specialised patterns, examples, or analogies for facilitating communication is resource-consuming. We therefore hypothesize that there are universal patterns that can be used and reused more economically, compared to specialised patterns, for indexing and communicating knowledge. We have conducted empirical tests with altogether 204 students, each one of whom was given 20 minutes to solve problems from six different scientific areas. The results of our tests show clearly an improvement of their problem solving skill when universal patterns were employed as cognitive aids. The average result of the test group that used universal patterns was 81 per cent higher than that of the control group.**

***Keywords***: Analogies, Problem-solving, Indexing knowledge, Patterns**.**

## I. Introduction

In learning and problem solving, a variety of human cognitive faculties are engaged. One very important cognitive tool is the ability to recognize patterns and use them for heuristic purposes. These patterns are contingent on the culture we grow up in, but, regardless of cultural influences, analogies can be used in most modes of human communication to illustrate what is important in a complex or abstract message [1].

Already the old Greeks Aristotle and Plato had given the subject some thought. They arrived at a rather broad conception of what an analogy is, defining it as a shared abstraction of some form, for example, regarding ideas, structures, functions, or some other similarity of some sort. They also viewed it as a tool of argumentation. If we look to more modern conceptions of the idea of analogy, Francis Bacon and John Stuart Mill pointed out that the use of analogy, unlike deduction, induction, and abduction is a form of argumentation that relates one particular to another. It does not necessarily involve a general rule in either the premises or the conclusions. In more recent, and cognitive, terms Chalmers contends that high-level perceptions are analogies. He also points to essential characteristics such as abstraction of commonalities and the influence of purpose of use [2]. Holyoak and Thagard also show in their work that purpose is a defining property in the formation of good analogies. They need to be perceived as well-correspondent or considered as good representations [3].

Analogies can be systematically used to focus on structural similarities of two pieces of knowledge, thereby facilitating learning. Research on the cognitive aspects of learning has shown that the situation in which the learning occurs is very important. People usually need a specific description of a context to be able to identify the essence of the knowledge that is conveyed [4]. It is, however, often the case that the context in itself is difficult to understand. In such cases analogies can be utilised to create a pre-understanding that is similar to the type of support that is usually provided by an understanding of the context.

A librarian learns to index new books by extracting the most relevant information from the books. This information can then be used to form a metadata pattern that is compared with analogous and already classified patterns in books. Such a use of metadata illustrates how previously understood knowledge can be reused for understanding new knowledge [5].

There are several indications that the cognitive mechanisms for storing and retrieving memories utilise similar classifications. The procedural memory outperforms the declarative memory and the matching of procedures is dominated by the logical relationship between the activity pattern and their effects [6]. It seems as if analogous patterns of disparate phenomena lend these very same phenomena: structure and credibility [7][8]. Theories similar to that of the procedural memory being more efficient than the declarative memory can be seen in 1) the episodic memory being more efficient than the semantic memory [9]. 2) the differentiation between how human beings utilise implicit versus explicit knowledge [10].

There are many examples of work done in the computer information systems field where different ways to obtain metadata for efficient communication, referencing, and indexing are used and investigated. Just to pick a couple of these, in [11] useful indexing properties of ontology reasoning (based on logical consequence) and ontology matching (based on relations and properties of concepts) are sought, as part of their investigation. Likewise, in [12] a general ontology-based model for landscapes is used for sharing, creating, and reusing ontologies for efficient communication with shared meanings of concepts, creating a platform of common ontologies.

What differentiates our work from the above and similar work is that we are seeking general structures of ontologies of universal applicability. Rather than studying a specific domain, extracting a general ontology and traits of the domain, we aim at finding domain-independent reusable patterns for a variety of domains.

Although it is well known that analogies are suited to convey a complex knowledge structure, they are sparsely utilised in university teaching. In the scientific world reasoning by analogy has a lower status than deductive reasoning, but reasoning by analogy does not have a low status when it is restricted to demonstrating examples of theories. Indeed, most theories in the natural sciences are examples of analogies, mapping the perceived reality. The use of analogies abounds, with the rare exception of the epistemological versions of quantum mechanics that are regarded as empiricist rather than realist theories. Theories, models, and simulations are all, usually, analogical mappings, highlighting different aspects of phenomena that for our purposes seem relevant.

An interesting point is the qualitative difference between mappings and metaphors, both representing cases of analogical thinking. Holyoak and Thagard define a mapping as a close-knit reflection of what is depicted, featuring all the characteristics that depict or drive the processes that we would like to gain a better grasp of. At the opposite end of the spectrum, metaphors also give a reflection of what is depicted, but using analogies that superficially do not seem to have much, or sometimes anything, to do with what they depict. Metaphors are the types of analogies that human beings may easily understand, but that are hard to detect with the aid of computational models, models that require identical forms at some level or mode of abstraction [3]. Vivid evidence of this may be seen in the limitations of machine translation, where the software seeks analogous text in a different language. One can observe that the translation of prosaic text may be executed intelligibly while that of metaphoric poetry makes no sense at all, although most human interpreters would manage to get a rough idea of the meaning [13].

To us, the inadequacy of existent computational models of analogical thinking – incorporating the relevant mechanisms, as we understand them, attempting to mimic the human correspondent faculty – seems to show that our understanding of analogical thinking still has large blank areas. Even then, we have to form a relationship with this particular mode of thinking, as it seems to saturate all our thinking in one way or the other, formally more so in the sciences than elsewhere.

In the extreme case, a mapping would be an exact replica of the modelled system, which, if computationally possible, would be the naive ideal of micro-simulation. One would be able to get precise predictions of how things would turn out in the real world, as the model would be an exact copy of the real world. The problem with attempted replica models, which usually become very complex, is that they do not easily yield an understanding of the inner workings of the system under study beyond the partial understanding that was used to build it. (But, they do allow for extraction of behavioural knowledge about the system.) An underlying reason for this problem is that without a simplification, bringing out essential characteristics, one does not acquire a birds-eye-view of the inner mechanisms and their interrelatedness in a system [14]. One may predict the modelled reality, but not extract an understanding of how it functions [14].

An analogy may afford the sought for birds-eye-view if the mapping is not too close or identical to the mapped reality, extracting only the essential features, in which case it becomes a progressive heuristic qualitative tool. Knowledge (in the conventional objective sense) emerges only when one is not totally and exclusively submerged in a system and acquires a viewpoint from a mental distance. The point we are trying to make is that perfect replica models do not contribute to improved theoretical conceptions as much as conceptually simplifying theorizing due to the increased complexity of such a model.

Conversely, metaphors may lose touch with what they are intended to describe if the intuitive connection is flawed, but, potentially, they may also lend great insight into both the nature of the target of the analogy (that which is to be described), and sometimes also the source of the analogy. (To exemplify the use of 'source' and 'target' we may use the images of Gaia for earth as a system and the Selfish Gene for gene independence and survival. In these instances the sources are mythology and characteristics of personality, while earth and genes are the targets. Both analogies bring a new understanding to the target, while also, at the same time, qualifying the source a shade of a nuance. Similarly, mathematical models may be interpreted as 'myths', in a broader sense of the word, whereby the essence of systems may be perceived conceptually and understood.) The reason for this is that the metaphor creates the distance of a differing perspective, and in the process also presents a conception of the target. Thus, strangely enough, the metaphor affords intrinsically the possibility of good description when an overall view or essence is sought for, while the close-knit mapping is better for description of detail. An exemplification of the strength of a metaphoric approach can be seen in the hidden variable conception of elements in quantum mechanics. The representation of such an element in the theory may be viewed as an analogy leaning toward the metaphoric end of the spectrum of analogies, constituting a conceptual tool whereby the overall contextuality of physical conditions may be expressed. (A hidden variable is a variable that cannot be observed as it cannot be concretized or reduced to a one-dimensional physical parameter measurement. It is a variable that, so to speak, is spread out in the whole system or is derived there of, giving all events a fully contextual significance [15]. One may note that also in the conventional interpretation of quantum mechanics there is a hidden variable, which is the wave-function itself [16].)

In terms of 'source' and 'target', a mapping is an analogy where the distance between the source and the target of the analogy is short, and for metaphors the conceptual distance is long [17]. The metaphor may have qualities that are heuristically superior to those of the mapping, but, as it involves human intuition, it is difficult to formalize its functions. It is also hard for us to know how flawed our intuition may be.

Probably, the main reason for the limited use of analogies is that it is difficult to create suitable analogies. Indeed, it takes a poet to create a good and useful analogy.

We think that this search for good analogies could to some extent be made obsolete if we reused general patterns as contexts for knowledge. We suggest that general patterns can be reused for indexing and communicating a large number of diverse pieces of knowledge. The general patterns can be seen as archetypical instances of real world instances that can be used for the type of intuitive classification that Edinger and Elder describe [18].

In our empirical study, the experiments have been carried out in order to verify/falsify the hypothesis that general patterns can be reused for many different subjects. The idea is that knowledge of a simple set of universal cognitive patterns, related to theoretical learning, linked together in a hierarchy, facilitates learning and problem solving in all theoretical fields. If this would be the case, learning would be easier. Instead of having to spend so much time painstakingly remembering apparently unrelated facts pertaining to each specialized field, students could focus their learning on a simple set of general patterns and ideas that would increase their real understanding of all subjects that could be related to these general patterns. In this way they would learn to see relations rather than just sets of facts. We also hypothesize that the general patterns could speed up the whole process of acquiring knowledge in any subject of choice, as memory is enhanced when new pieces of knowledge can be linked to already existent coherent systems of thought [1]. (We also recognize that many times a sophisticated understanding of apparently atomic details of larger theoretical structures is key to a proper conception of the essential grand scale mechanisms of an entire system, but we will not deal with that here.)

Our hypothesis was difficult to test since the nature of general patterns and analogies is subjective and intuitive. It is easy to prove that analogies can be used for specific teaching purposes [19], but it is difficult to investigate to what extent analogies can be used to create the foundations or principles of how knowledge can be structured in large bodies of knowledge, or be taught at universities.

We investigate to what extent patterns are well suited for creating memory structures or knowledge structures. The famous "restaurant script" [20] shows clearly how patterns can guide the users' actions. It seems, however, as if nobody has succeeded in creating such structures of patterns that can be used on a larger scale. It seems that the major reason is that it is resource consuming to find good and useful patterns for supporting the communication of knowledge. If the range of a general set of patterns is too limited, one would have to develop specialised patterns for a large number of instances of knowledge, which would be a painstaking and probably unrealistic task. Obviously, this indicates the value of our hypothesis, since there is a need for a more economical way to use general patterns to communicate knowledge.

In order to test our hypothesis we decided to investigate the use of general patterns for problem solving. To see whether the students really understood the use of patterns for problem solving or not, we created test problems where a general pattern was the key to the solution of the problem.

If our hypothesis is proven to be true, it will indicate the relevance of the following hypotheses:

General patterns

- can be used for indexing specific, but analogous, instances of knowledge that embody the same general pattern.
- can provide a substitution for the context that is needed to understand the specific, specialised knowledge
- can support people in their endeavour, deeply, to understand specific, specialised pieces of knowledge, for example, by affording references to instances of knowledge in other areas, exhibiting the same general patterns
- can be used in teaching
- can be used in indexing knowledge on the web
- can facilitate search for knowledge
- can open up to more cross-fertilization between diverse theoretical fields of scientific study when theory-structure is generalized, looking beyond parametric details.
- can bring a synthesizing momentum to theory building, connecting different scientific fields and complementing the movement towards a division of a field into diverse fields of study.
- can create a platform for communication between the sciences and the humanities.

## II. Methodology and results

### *A. Methodology*

We selected subjects (topics) for our investigation that together would as much as possible reflect the full range of human intellectual and emotional abilities, and that we were acquainted with. The subjects we chose were mathematics, physics, aesthetics, literature, religion, psychology, and medicine, trying to diversify our choices as much as possible. We looked for simple, basic patterns or theorems, leaving more complex matters for future research. We did not want the patterns to be either too general, as that would make them less powerful tools for problem solving, or too detailed, as that would make the patterns applicable only to certain specialized cases. The ease with which we could find patterns in the different subjects varied. Religion and physics seem to abound with conceptual constructs, while, for example, medicine rather seems to be a set of facts connected to each other in a simple, concrete manner. A discussion concerning the theoretical disparity of physics and biology as disciplines in this regard is raised in [21]. A pattern we could apply to all subjects was that of two complementary qualities, for example, the wave and particle aspects of light in physics.

Having obtained a set of patterns for each subject, we started to look for interdisciplinary similarities of these patterns, that is, universal patterns, and a unifying hierarchical structure that would link them together.

DUALISM

- *Has feature:*
  - **Complementary**. One part is a complement of the other
  - **Movement**. There is an oscillating movement in between two opposites
- *Has:*
  - **Examples**: The examples below are taken from different fields of human endeavour: 1) Physics 2) Psychology
- *Is controlled by:*
  - **Control system**. 1) Frictional forces and outer impulses 2) A languid attitude and psychic energy that looks for release and builds up until it breaks its stale state
- *Has parts:*
  - **Thesis.**
    - *Has instances:*
      - **Balance**. 1) In physics one could consider midrange weight atoms as being in balance. 2) In psychological terms a state of inner harmony is considered to be a state of balance
        - *Momentum:*
          - **Balance moving toward imbalance**. 1) If heavy or light atoms are to be constructed energy is needed 2) A harmonious state that deteriorates into a state of conflict locks up energy.
            - *consumes:*
              - **Energy**: 1) Energy as described in physics 2) Psychic energy
  - **Antithesis.**
    - *Has instances:*
      - **Imbalance**. 1) In physics heavy and light atoms can be considered as not being in balance. 2) In psychological terms a state of conflict can be equated with a state of imbalance
        - *Momentum:*
          - **Imbalance moving toward balance**. 1) When heavy atoms are split or light atoms are fused energy is released. 2) A state of inner psychological conflict that turns into a state of inner harmony releases psychological energy
            - *produces:*
              - **Energy**: 1) Energy as described in physics 2) Psychic energy

**Figure 1.** Example of hierarchical structure of patterns

In Figure 1 above we give an example of how a basic pattern may be conceived to branch into a hierarchical structure of patterns.

When we had found or constructed such a general hierarchy, we used its constituent patterns and primitives to work out problems for a survey. We created a number of problems from six theoretical fields. We first had a preliminary testing round with 60 students and then 144 students in the test proper that we asked to solve the problems within 20 minutes. We wanted to see to what extent the general patterns could affect the understanding needed to find a solution to a problem. The test was specifically designed to see whether a set of general patterns would significantly help the students in solving problems containing structures analogous to those patterns.

For the control group we had a questionnaire prepared with positive affirmations preceding the questions, suggesting that the whole test was very easy and that they would easily come up with good answers. The reason why positive suggestions were given to the control group was to make sure that both groups received the same amount and similar quality of instructions, thereby avoiding the Hawthorne effect [22]. This effect occurs when a group performs better just because they have been provided with more stimuli/information. The test group was given a set of patterns among which there were patterns that contained the structure or abstract idea of the solutions of the problems. The number of patterns outnumbered the number of problems to be solved three or four times. We started our fieldwork with two preliminary tests to see if the questions were suitable. We wanted the questions to be as difficult as possible, since that would show that the patterns had been used in a creative way. This would then show that the general patterns had given the students a real understanding of the problems, and that they really had been used as problem solving tools.

In our first preliminary test with 60 students we realised we had made our questions too difficult to solve. Thus, we had to make them easier. As the original questions were creatively too demanding, involving both analytical skills and artistic sensitivity, we had to make the analogies between the given general patterns and the structures of the questions and their answers more apparent.

We also realized that we had been too optimistic about being able to measure people's answers to the "softer" questions. It seemed, for example, in the case of a poem, that the patterns could even make it more difficult to solve a problem, as the subjects would have an understanding of the poem that would make our patterns contra-productive. We really would have liked to incorporate the "softer" questions into the questionnaire, as that would have made our results more general in nature.

After the second preliminary test, we also noticed that there were a couple of questions and answers that a large part of the subjects already knew. These questions were removed from the test.

In both these trial tests we noticed that many subjects preferred not to answer a question rather than running the risk of submitting an erroneous answer, many times actually guessing the correct answer when asked afterwards. This made us change the instructions given, for example, clarifying that it was not a test testing their intelligence. In our actual test, testing for our hypothesis, 144 students were given about 20 minutes to answer the questions, which were four in number (out of which one had to be dropped from our survey later on). To give the reader an idea of the type of questions we used and the type of answers we expected, the first question with a satisfactory answer follows:

Question 1: In physics, the nature of light has been tested in different ways. In some experiments it has been **proven** that light has a particle nature, that is, the light we perceive with our eyes comes as a stream of particles. In yet other experiments, it has been **proven** that light propagates like waves, not unlike waves on lakes and oceans. At the same time, particle and wave natures are opposites, mutually exclusive natures. One cannot, so to speak, be a circle and a square at the same time. Our question is: What could one infer from these results regarding the relationship between the wave and particle natures of light?"

The four patterns presented to the students prior to question 1 were:

- Operating systems are used to maintain balance
- A pole and its anti-pole form an integrated whole
- If A is stronger than B and B is stronger than C, then C can overcome B by asking A to conquer B
- The vantage point from which a human being views the world creates the world she lives in

These patterns were presented together with analogous examples of the patterns. In the case of "A pole and its anti-pole form an integrated whole" the given examples were:

- Heat and cold constitute the reverse sides of a coin. Without the one, the other would not exist. Together they describe one aspect of our perception of the world
- In the arts, form and content is spoken of, whether it is in the context of music, literature, sculpture, or paintings. For example, in music, musical notes, harmony, counterpoint are different aspects of its form. In literature, it could be language, metrical form, etc. Content, on the other hand, is what is conveyed or the soul of the piece of art. These two, form and content, could not exist without each other. Literature would not exist without language, and as soon as there is language there is also content. Vapidity and emptiness could also be the content of a work of art; in the same way silence is a part of music.

Among the four patterns "A pole and its anti-pole form an integrated whole" was the correct one. As we asked the students to reformulate the general patterns or concepts, using the terminology of the specific questions, a good answer to the question above might have been: Together, the wave and particle natures of light form the one single, integral and indivisible phenomenon of light.

The other three questions of the test, including the one that too many knew the answer to, were:

Question 2: In physics it has been discovered that time moves slower with a person that is in motion relative to the time of a stationary observer. We do not expect you to understand this, but from a general perspective we would like to ask the following: If we would generalize this result to other areas, what would it say about the reality each one of us live in and the point of observation each one of us have?

Question 3: If a stick is illuminated from two opposing directions, two shadows form; one green shadow and one red shadow. The red shadow results from the red light illuminating the shaded area of the white light. All areas that are illumined by both red and white light throw back a rose coloured nuance. None of this is surprising. But, in the shadow of the red light the surface reflects the colour green, an area that actually is illumined by the white light. Also, the wavelength of the green light is not actually that of green light. The question is: Which general conclusion might be drawn from the above regarding the ability of human beings to see colour in the real world?

Question 4 (the excluded one): There are psychological tests where patients are shown a picture with a neutral content. In spite of this, the pictures make the patients disclose their unconscious feelings and fantasies. The question is: Could you describe, using simple words, a psychological process that could explain the above.

#### 1) *The Sample*

The theoretical population of our survey are all university students. For practical reasons we had to select our sample of students manually. We opted for a class of second year undergraduates, comprising 144 students, studying system sciences. These students should well reflect the theoretical population, as system sciences are interdisciplinary subjects. We wanted them to be acquainted with both the "harder" disciplines, such as mathematics, logic, computer programming, etc, and the "softer" disciplines, for example, social anthropology, design and psychology.

### B. *Results*

To be consistent in our judgement of the answers to the questions, we made a template of correct answers, like the suggested answer above. Each answer could be rewarded 0, 0.5, or 1 point. 1 point was awarded fully correct answers, 0 incorrect ones, and 0.5 for partially correct answers.

Occasionally, students would come up with several answers to a single question. In these instances we would give them a full mark if one of the answers was correct, and it answered the question independent of the other answers. We did this as we were mainly looking for the ability to come up with **one** good idea that could solve a problem. The students' ability to analyse different ideas and to choose one of them to solve a problem did not belong to the domain of our investigation.

Sometimes the answers were not entirely correct, but showed understanding of the spirit, or essence, of the problems. In such cases we awarded the answers 0.5 points, for example: "Light may manifest as either a wave or a particle as we do not know how to observe light". Similarly, we had to give ourselves the freedom to judge answers intuitively in some cases, as answers containing wordings that should have given them the same mark and meaning according to our template could have slightly different meanings, our main focus being the general understanding of the problems.

As some students paraphrased the patterns, using the terminology of the specific questions, and others did not, we decided to keep a separate count of those who did (shown later in Table 3), as they in a clearer way had shown an understanding of how analogies work. For example, answering the question above with "The wave and particle natures of light are two expressions of the integral event of light traversing space", instead of just restating the given pattern "A pole and its anti-pole form an integrated whole". Those who did not paraphrase the general patterns had of course also shown that they had understood the gist of it, but had not proven it to the same degree. Still, since both types produced correct solutions we decided to give both types of answers a full mark (count of results in Table 1 and 2).

In Table 1 below the main results of our survey are shown. One student in the test group did not fill in any answers. Therefore her test was taken out of the count. Furthermore, some of the students already knew the answers to some of the questions. The answers to these questions were also taken out of the survey. One of the questions had to be dropped altogether, as too many students stated in their test forms that they already knew the answer to that question. (At the end of the test form we asked the students whether they thought the questions were difficult or not, and whether they had previous exposure to the topics of the questions. For the test group, we also asked if they found the given general patterns helpful.)

In the last row of Table 1 the overall results are shown. As can be seen, the number of correct answers of students in the test group is almost twice that of those in the control group.

**Table 1.** Results of the test. In each category and for each question, the fraction of the answers that were correct is presented. The heading CONTROL refers to test results of the control group and the heading ANALOGIES refers to test results of the group that was given analogous patterns. M = Male and F = Female. The discrepancy between the total number of individuals tested and the sum of the number of individuals tested in each gender category is due to that 3 individuals did not submit their gender.

| | CONTROL | | ANALOGIES | |
|---|---|---|---|---|
| **Individuals tested** | 77 | | 67 | |
| **Gender** | **M** | **F** | **M** | **F** |
| **Number of individuals:** | **42** | **33** | **32** | **34** |
| **Question 1** | **40%** | **30%** | **69%** | **44%** |
| **Question 1,Both genders** | **35%** | | **56%** | |
| **Question 2** | **27%** | **32%** | **61%** | **29%** |
| **Question 2, Both genders** | **28%** | | **45%** | |
| **Question 3** | **19%** | **14%** | **47%** | **31%** |
| **Question 3, Both genders** | **16%** | | **38%** | |
| **Average of question 1-3** | **28%** | **25%** | **59%** | **35%** |
| **Average of the two tests** | **26 %** | | **47 %** | |

**Table 3.** Percentages of the correct answers that clearly showed an ability to adapt the given patterns to the given problems, showing a clear understanding of what an analogy is and how it can be used as a problem-solving tool.

| | Percentage of correct answers that showed creative use of patterns | Number of correct answers showing creative use of patterns | Total number of correct answers | Total number of answers |
|---|---|---|---|---|
| **Question1** | 44% | 16 | 36 | 64 |
| **Question2** | 51% | 15 | 29,5 | 65 |
| **Question3** | 56% | 14,5 | 26 | 66 |
| **Overall** | **50%** | **45,5** | **91,5** | **195** |

In Table 2, in the third column, the overall improvement is given in relative numbers.

**Table 2.** Improvement of performance when using analogous patterns.

| Male | Female | Overall |
|---|---|---|
| **111%** | **40%** | **81%** |

As can be seen we divided both the test group and the control group into gender categories. The overall result of that division can be seen in the last but one row of Table 1.

In Table 2, the relative improvement for each gender has also been given. The gender differences should not be taken too seriously, as the survey was not designed to measure them. We could think of a few plausible reasons for this gender difference. First, as the "softer" questions, questions that culturally, and maybe otherwise, suit women better, had to be excluded from the test, due to that they did not lend themselves to measurement the same way the "harder" questions did, the remaining questions had a gender bias in favour of the men. Second, we cannot disregard the fact that two men drew up and evaluated the whole test.

In Table 3 above, the statistics of the aforementioned clearly imaginative use of analogous patterns is shown. As can be seen in the last row of this table, about 50 per cent of the correct answers indicated this understanding clearly. Here we must emphasize that the other correct answers did so too, but not as evidently.

The results of table 3 show that the users can adapt the given patterns to the given problems; in other words, they indicate that general patterns can be used as problem solving tools.

## III. Discussion

The results of our test show that analogies are useful cognitive tools when trying to understand or when assimilating new knowledge. As we looked for general cognitive patterns in our preliminary work, aiming at creating, or finding, a single hierarchy containing all these patterns, we found that two subjects (physics and religion) already in themselves contain quite general hierarchies applicable to other subjects, the patterns of religion being of a more general nature, for example, with the monotheistic idea of God being an all inclusive pattern, and the patterns of physics more going into intricate details. Combining these two domains of knowledge and extracting the essence of their structures or contents would go very far in creating a general hierarchy.

If we use Bohm's and Hiley's perspective to qualify the distinction between a mapping and a metaphor in the sciences, and their range of use, a scientific theory functions primarily as a means to an insight into the nature of things, besides that of representing knowledge about those things. That is to say, the metaphoric qualities of the scientific theoretical mapping seem to be an important aspect in our use of the theories. The insights that we derive from the scientific process are of metaphoric quality as well as detailed mappings. The perceived contents of theories are of dual nature [15].

Furthermore, from an analogy-interpretive point of view, the imaginative qualitative concepts that initiate scientific projects are many times of metaphoric nature initially, when they are not empirically proven yet and their contents are still metaphysical. What we want to suggest here is the importance of the use of metaphors in science and, if used intentionally as such, would yield a wealth of further means to discovery and theoretical description. An intentional and more conscious use of analogies, ranging from the mapping to the metaphor with the appreciation of their strengths and weaknesses, seems laid before us.

A possible further use of analogies in the sciences is that when a detail-focused reductive approach produces a situation of fragmentary partial mappings of reality, mappings that do not cohere, one could also look into the possibility of using a metaphoric approach, for example, in the form of hidden variables. A metaphor may have the potential to synthesize a straggly set of mappings into one coherent mapping. Some of the many theoretically unwieldy complex systems that have come under scientific study recently may yield to a metaphorically inspired approach. It might even be so that it is not in principle possible to reason in analytical consecutive steps or make empirical measurements/observations in a piecemeal fashion when studying phenomena that do not yield to a reductive theoretical approach. For example, the straggly impression of the whole body of observations in the case of influenza epidemiology [23] may stem from fragmentary empiricism that has its roots in theoretical reductionism. In extension, a metaphoric methodology of analogy might possibly suggest to us improved observational strategies, as observational methods would be directed toward observations of qualitatively different contents.

*A. Comments on the questionnaire*

The way students managed the test varied widely. Some students could easily find the appropriate pattern while others opted for the ones that, as far as we could see, had nothing to do with the questions. As in the case of mathematics and music, some have a knack for it and others not.

Looking at the test results, it also seems the use of analogies is gender related. In the control group the performances of males and females were about the same, but with the aid of general patterns, the males improved their performance with 111 per cent, while the females improved their performance with 40 per cent only. As our test was not specifically designed to measure gender differences, we do not want to draw any conclusions regarding gender. Still, it is noteworthy, and may be fertile ground for future work.

*B. Conclusions*

With the average performance of the test group being 81 per cent higher than that of the control group, the results of the test are markedly interesting. The results have affirmed that general patterns are powerful tools in problem solving, thus proving part of our hypothesis highly plausible. We have not proven the existence of a universal hierarchy of patterns and notions, as our search was tentative. Still, we incorporated this idea in our hypothesis, as it constitutes an indispensable part of the efficient use of analogies in learning.

Hopefully, continued research will throw some further light on general patterns as cognitive aids.

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