Chapter 3

EXPERIENTIAL LEARNING OF THE UNIFYING PRINCIPLES OF SCIENCE THROUGH PHYSICAL ACTIVITIES

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ABSTRACT

Do cosmologists, cell biologists and sociologists understand each other when they explain the basic principles of their respective fields? Over the last three decades, considerable progress has been made in explaining different levels of organized matter through universal dynamical concepts. This has led to the growth of a common language domain in science. Two important consequences of this new scientific framework are a better mutual understanding between disciplines and the development of synthetic knowledge. Physical activities are a rich source of phenomena that are underpinned by universal dynamical concepts, and as such they can provide a perceptually grounded, i.e. experiential, basis on which to learn these concepts.

This chapter has three main aims. First, to examine the changes occurring within the linguistic (i.e., conceptual) landscape profile of scientific fields in relation to the presence or absence of general explanatory principles derived from nonlinear dynamical systems theory and statistical physics; Second, to discuss recent empirical results that capture the growth of the domain from the context-dependent languages of separate disciplines towards unified general concepts forming an embedded explanatory framework which allows the creation of synthetic knowledge; Third, to show how the perceptual (proprioceptive, visual and introspective) experience of sports-related activities can enhance the comprehension of these unifying explanatory principles and promote the acquisition of synthetic knowledge.

Keywords: science, science education, experiential learning, unifying principles, synthetic knowledge, dynamical systems, sport-related activities

INTRODUCTION

Science is a system, a language system arising from conceptual interactions from which explanatory patterns emerge. The past two decades have witnessed a large-scale diffusion of explanatory concepts coming from dynamical systems theory (DS) and statistical physics (SP) (from now on, the DSSP explanatory complex), into the fields of exercise and sports science. Sound theoretical and experimental work has corroborated the early ideas that phenomena of exercise and sports are amenable to the explanatory framework of the DSSP complex [1]. The nuclei of this growing trend can be traced back to the research into basic human movement carried out in previous decades. In the late 1970s and early 1980s, novel explanatory patterns regarding the nature of biological movement emerged which were underpinned by DSSP ideas [2, 3, 4, 5]. The spread of explanatory concepts from the DSSP complex into exercise and sports science is just the tip of the iceberg of a much more widespread process in science which has gone on for centuries, driven by the tacit rationale of the search for minimum principles able to explain a maximum number of phenomena [6, 7].

Science is also a cooperative social endeavor and a social exchange conducted via language. Science communities explore and strive to explain the immense diversity of processes at different levels and time scales of substance organization. The explanations acquired are continuously shared within and between scientific communities through language which enhances the diffusion process described above, and sports science is no exception to this rule. On the other hand, the diversity of phenomena constrains the scientific language of each discipline to form a specific vocabulary for naming and explaining natural properties and processes as well as communicating knowledge among scientists. For example, do a cosmologist, a cell biologist, a sports scientist and a sociologist understand each other when they explain the basic processes within their fields? Not entirely, one might suppose. Cosmologists speak about inflationary and electroweak epoch and space-time metrics, cell biologists about cell membranes, enzymes and ribosomes, sports scientists about fatigue-induced task disengagement, motor balance and attention focus, and sociologists about group formation, cohesion and social attitudes.

Recently, the diversity of phenomena and properties of substance organization was ascribed to the existence of "mesoscopic protectorates" [8], i.e., emergent levels of substance organization whose key properties cannot be formally, i.e., mathematically, deduced from the laws that govern the behavior of the more microscopic components (for a detailed explanation of this issue in physics, see [9]). Therefore, each level is endowed with specific and novel structures and properties which need a specific language to explain them. These languages, thus, use context-dependent concepts to name and explain the processes under scrutiny. Context dependence is viewed essentially as a major cause of the fragmentation between the vocabularies of different scientific disciplines. That is, while within specific scientific fields and subfields the communication of knowledge is made possible by a common vocabulary, the more distant disciplines are, the more difficult communication becomes. As this language fragmentation is also translated into science education, this inevitably leads to the formation of a fragmented worldview in learners and limits the possibilities of a learning transfer between different scientific subjects. However, the tension arising from the coexistence of context-dependent vocabulary and unifying tendencies in science can be seen as an opportunity rather than a problem: resolving it may result in explanatory patterns that are characterized by both a coherent explanatory skeleton coming from unifying tendencies and flexibility due to its context-dependent vocabulary [10]. The DSSP complex increasingly shows the potential of assimilating the context-dependent vocabularies of different scientific fields into its unifying corpus, manifesting the strength of the approach which can be harnessed as a powerful educational tool.

2. The growing coherence of explanatory patterns in science – but not in science education textbooks

Recently, a preliminary research study examined the differences within the linguistic, i.e., conceptual, profile of contemporary scientific fields and science education textbooks [10, 11]. Specifically, the research aimed to examine possible hallmarks of enhanced conceptual coherence within the scientific language used in these areas, as represented by dimension reduction and information compression [12] emphasizing the position of sports sciences within it.

In the study, characteristic concepts of 10 widely separate scientific fields (according to the classical paradigm) were treated as linguistic degrees of freedom. Scientific fields were: elementary particle physics (EP), cosmology (CL), molecular physics (MP), chemical reactions (CR), cell biology (CB), neurobiology (NB), psychological processes (PP), motor behavior (MB), collective sports research (CS) and sociology of groups (SG). In the first phase, 35 generic explanatory and empirical concepts taken from contemporary university and high school textbooks were used for each scientific discipline. The concepts which defined the chapters, headings and subheadings were extracted first and then the rest of the most frequent generic concepts from different parts of the textbooks. The experimental apparatus, data extraction concepts and purely mathematico-technical terms were not taken into account. The following general explanatory concepts from the DSSP conceptual complex were used: self-organization (self-assembly or soft-assembly), collective modes (order parameter, collective coordinate or variable, reaction coordinate), control parameter or variable, phase transition, bifurcation, symmetry-symmetry breaking, stability, instability (loss of stability), metastability, criticality (critical point or manifold), gradients, scalar field, vector field, attractor, repeller, entropy-information, and network.

The second phase of the data collection consisted of an Internet search for scientific papers published in the fields mentioned above and archived in relevant databases, such as Scopus (Science Direct), Web of Science, Google Scholar, ArXiv. The sample papers from each of these fields were taken from pertinent impact factor journals. In total, 1276 papers were collected over a period of one year (May 2011 – April 2012). Since the research focused on the qualitative aspects of diffusion of concepts within scientific fields (not the quantitative ones, i.e., the degree of diffusion), a co-word analysis was performed: that is, we searched for combined expressions consisting of previously extracted scientific concepts and concepts from DSSP in each scientific discipline. Each paper was analyzed separately to minimize the possibility of spurious conceptual links. Only papers in which a genuine link between DSSP and fundamental processes researched in scientific fields was found were taken into further consideration. Under this procedure the loss was negligible. In each of the scientific fields analyzed more than 100 papers using DSSP explanatory principles of fundamental processes were found – with the notable exception of collective sports research, in which fewer than 50 papers were found.

Each conceptual space of scientific fields was represented by a binary vector of length n = 367 (10 scientific fields x 35 generic concepts + 17 DSSP concepts). A value of 1 was assigned to concepts that were found to exist in the scientific discipline and a value of 0 otherwise. Salton's cosine similarities were first calculated for each pair of the 10 scientific discipline binary vectors and for each of the two conditions separately (science education textbooks vs scientific research papers). Dimension reduction of the initial cosine similarity matrix under both conditions was conducted using tree clustering (single linkage) analysis and hierarchical principal component analysis (HPCA). Distances *d* between scientific fields were calculated as $d = 1 - q$; where *q* is Salton's cosine similarity (the overlap order parameter) between the vectors which defined the conceptual spaces of scientific fields. The population entropy of each principal component (PC) was calculated as $I_i = \ln \lambda_i + 0.5 \ln \pi + 0.5$, where λ_i represents its eigenvalue.

The results of the tree clustering analysis revealed significant differences between the conceptual content of the science education textbooks on the one hand and of contemporary science research papers on the other. The left-hand panel in Figure 1 shows that the absence of general explanatory concepts typical of secondary school and university textbooks generates a growing fragmentation of scientific fields (looking from right to left). On the other hand, the conceptual fragmentation has stabilized under the presence of general explanatory concepts typical of current scientific research.

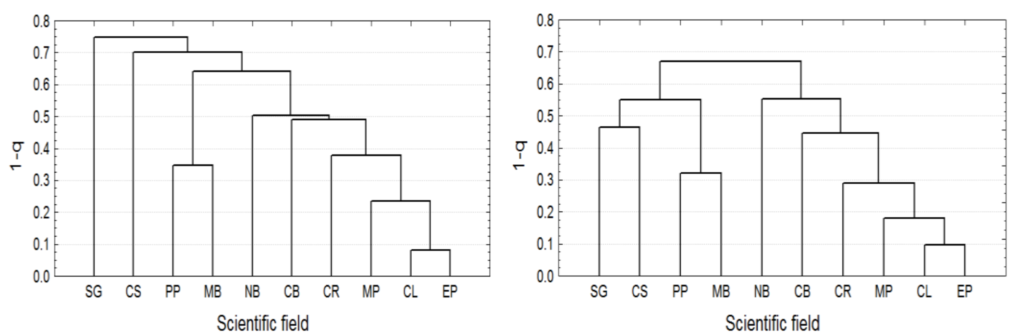

Figure1. Left-hand panel: A hierarchical structure showing conceptual fragmentation of scientific fields in the absence of the general explanatory concepts typical of science education textbooks. Right-hand panel: Reduced conceptual fragmentation between scientific fields as a consequence of the diffusion of unifying explanatory concepts typical of current scientific research. EP - physics of elementary particles; CL - cosmology; MP - molecular physics; CR - chemical reactions; CB - cell biology; NB - neurobiology; MB - motor behavior; PP - psychological processes; CS - collective sports research; SG - sociology of groups. The distance is calculated as d = 1 - q, where q is the cosine similarity between scientific areas.

Notice also that the change in the distance in physical sciences (EP, CL and MP) between the right-hand and the left-hand panel is negligible. This is because most of the general explanatory concepts are already present within the realm of these scientific fields in high school and especially in university textbooks, and they also spread into the contemporary scientific research literature in these fields. This is not so for the other scientific fields, in which the conceptual dimensions of textbooks and contemporary scientific research differ markedly.

For science education textbook data, HPCA led to a compression of the original 10 vectors to four PCs with eigenvalues λ_1 = 3.8; λ_2 = 2.46; λ_3 = 1.4; and λ_4 = 1.02 explaining 86% of the total variance. The entropy for this set of PCs was I = 6.88 nats. The correlation matrix of the principal components given in Table 1 (upper row, left panel) showed the fragmentation of scientific fields existing with respect to the conceptual similarity. Only PC_1 and PC_2 showed medium to low associations with PC_3. The first principal component comprised the scientific fields: physics of elementary particles (EP), cosmology (CL) and molecular physics (MP) among the physical sciences. The second one comprised neurobiology (NB), motor behavior (MB), collective sports (CS) and psychological processes (PP) forming the area of psychobiology. The third principal component was saturated by chemical reactions (CR) and cell biology (CB), but the principal component of this important projection also contained neurobiology (NB). This group was predominantly saturated by the scientific area of biochemistry, with neurobiology acting as a bridge between this area and psychobiology. The fourth principal component comprised psychological processes (PP) and sociology of groups (SG), forming the area of social psychology.

	PC_1	PC_2	PC_3	PC_4
PC_1	1.00			
PC_2	0.14	1.00		
PC_3	***0.43***	***0.38***	1.00	
PC_4	-0.01	0.08	0.03	1.00

	PC_{II}	PC_1	PC_2	PC_3	PC_4
EP	0.50	***0.84***	-0.04	-0.06	-0.02
CL	0.49	***0.84***	-0.05	-0.07	-0.01
MP	0.57	***0.75***	-0.12	0.12	0.01
CR	0.58	0.16	-0.24	***0.63***	0.07
CB	0.66	-0.04	0.11	***0.65***	-0.08
NB	0.62	-0.16	***0.56***	***0.41***	-0.07
MB	0.45	0.06	***0.83***	-0.08	-0.02
PP	0.34	-0.16	***0.80***	-0.03	***0.58***
CS	0.22	0.02	***0.50***	-0.12	0.19
SG	0.04	-0.03	0.02	0.01	***0.93***

	PC1	PC2	PC3
PC1	1.00		
PC2	***0.61***	1.00	
PC3	***0.52***	***0.67***	1.00

	PC_{II}	PC_1	PC_2	PC_3
EP	0.65	***0.67***	-0.11	0.06
CL	0.61	***0.68***	-0.13	0.05
MP	0.65	***0.70***	-0.04	-0.04
CR	0.64	***0.57***	0.12	-0.13
CB	0.69	***0.31***	***0.47***	-0.27
NB	0.75	-0.04	***0.60***	-0.07
MB	0.77	-0.08	***0.34***	***0.28***
PP	0.74	-0.24	***0.33***	***0.40***
CS	0.70	0.02	-0.03	***0.55***
SG	0.58	0.13	-0.21	***0.58***

Table 1. Left-hand panels: Correlations between primary principal components (PCs). Right-hand panels: PC structure by scientific fields and their projections on the secondary principal component PC_{II}. Upper row: science education textbooks. Lower row: Contemporary science research papers. EP - physics of

elementary particles; CL - cosmology; MP - molecular physics; CR - chemical reactions; CB - cell biology; NB - neurobiology; MB - motor behavior; PP - psychological processes; CS - collective sports research; SG - sociology of groups.

Vectors that define scientific language areas showed heterogeneous projection values on the secondary principal component PC_{II}. While physical sciences and biochemistry components projected relatively homogeneously onto it with medium values, scientific fields forming the psychobiology and social psychology areas showed a significant decline. This is consistent with the tree cluster analysis results discussed above. We conclude that in science education textbooks, because of the absence of binding concepts and principles, explanatory language becomes increasingly fragmented in the areas that study the higher forms of organization of matter (MB-SG).

The HPCA of the contemporary scientific research papers in the principal components given in Table 1 (lower row) showed a different picture. The dimension reduction led to compression of the original 10 vectors to three PCs with eigenvalues λ_1 = 5.76; λ_2 = 1.62; and λ_3 = 1.04; explaining 85% of the total variance. The entropy calculated was I = 5.48 nats. This significant reduction of dimensionality and information suppression of ΔI = 1.4 nats or approximately 2 bits, compared with science education textbooks was a consequence of language similarities not only between neighboring scientific fields, but also because widely disparate sciences share common explanatory concepts from the DSSP complex. The primary PCs were moderately correlated and resulted in one secondary PC_{II} which was also moderately saturated in equal measure by all the scientific disciplines. The first principal component contained the following scientific fields: physics of elementary particles (EP), cosmology (CL), molecular physics (MP), chemical reactions (CR) and cell biology (CB) under natural sciences. The major projections on the second primary PC showed cell biology (CB), neurobiology (NB) and motor behavior (MB) under life sciences. The third primary principal component was saturated by motor behavior (MB), psychological processes (PP), collective sports research (CS) and sociology of groups (SG) under the social psychology clade. Cell biology (CB), motor behavior (MB), and psychological processes (PP) acted as bridges between the three main components. It is important to notice that, due to the medium-size correlations between primary PCs and the homogenous structure of the projections of scientific fields on PC_{II}, the flow of information within the conceptual space is not restricted to the most closely related science fields, but may be much more diverse and may be shared among vastly disparate areas such as EP, and PP and SG. This point to the possibility of circumventing, albeit not eliminating, the emergentism-reductionism duality – an interesting topic in its own right, which will be discussed elsewhere.

Generally speaking, there is a clear difference between the conceptual spaces of science education textbooks and contemporary scientific research papers. The latter have larger conceptual coherence as a consequence of the use of unifying explanatory concepts from the DSSP. Only three primary PCs were extracted in the analysis of the conceptual space of contemporary scientific papers, compared with four in the case of science education textbooks. This clearly shows the existence of a greater dimension reduction in the scientific research papers, as well as information compression as revealed by the difference of population entropies. Though separate scientific fields maintain their context-dependent language (inter-scientific conceptual distances d do not go to zero – see Fig. 1), the unifying DSSP concepts form an embedded explanatory framework within which stabilizing synthetic knowledge becomes a feasible perspective. Unifying explanatory concepts play the role of a correspondence principle which forms a stable link between the models of organized matter at different levels and time scales. In a sense, the recurent explanatory patterns if viewed ontologically, point to an existence of a structure which metaphorically may be called holographic. The change of the space-time scale resolution keeps some principles unchanged. Interestingly, the scientific fields cell biology, motor behavior and psychological processes act as bridges between wider science areas. This finding may have major science education repercussions; some preliminary consequences and ideas will be discussed in the next section.

3. Towards an experientially-grounded learning of DSSP concepts

Though it has been suggested, and experimentally corroborated, that concepts from the DSSP complex may have a major explanatory role in exercise and sports science, the possibility that these sciences may provide an educational underpinning to the learning of science through the DSSP conceptual system has not been proposed to date. In relation to this, it was the mathematician Henry Poincaré [13, 14] who noticed the fundamental fact that the concept of space in humans is built upon our basic capabilities to move. In his own words: "To localize an object simply means to represent to oneself the movements that would be necessary to reach it. I will explain myself. It is not a question of representing the movements themselves in space, but solely of representing to oneself the muscular sensations which accompany these movements and which do not presuppose the preexistence of the notion of space", and further on "I have shown in 'Science and Hypothesis' the preponderant role played by the movements of our body in the genesis of the notion of space. For a being completely immovable there would be neither space nor geometry." [13, p. 47-48].

Psychology went on a long voyage through the phases of Piagetian developmental stage theory [15] and classical cognitive science with it's amodal symbol systems [16] before returning to Poincaré's ideas on the perceptual action-groundedness of abstract mathematical constructs, this time in the form of the embodied and grounded cognition approach [17, 18]. The difference between these approaches is not of major importance here. Grounded cognition is clear on the importance of perception-action and introspection in the acquisition and further use of abstract concepts. In learning and education sciences, this approach has gained momentum in the past twenty years in a form in which the perceptual groundedness of the learning of science concepts has been realized through contemporary methods such as: computer simulations and animations [19, 20, 21]. On the other hand, the power of the DSSP conceptual complex for learning transfer between disparate science fields is becoming clear from the results and discussion under the previous subheading [10]. In particular, we saw that the conceptual space of psychological processes and motor behavior research already contains explanatory patterns from the DSST complex which bridge the explanatory gap between classically disparate scientific areas. Psychological processes and motor behavior are also perfectly suited in the sense that they are directly accessible to learners and observers in a form of introspection and/or perceptions of overt motor actions. Hence, the link between the educational consequences of grounded cognition and the unifying role of the DSSP language offers a unique opportunity to combine physical activities and general explanatory principles into a specific integrated framework of experiential learning [22]. In the following section we give a fuller example of how this integration can be applied and then briefly discuss a few more examples and their links with more distant science fields.

4. Experientally-grounded learning of DSSP concepts through physical activities

Kolb's system of experiential learning contains four phases linked in a circle. Inside the brackets, we expand briefly on the meaning of these phases for the examples that follow.

1. concrete experience (a physical activity: perception-action and/or introspection)
2. reflective observation on the experience (paying attention to key perceived phenomena and their phases)
3. abstract conceptualization based upon the reflective observation (conceptualization, estimation and/or plotting of relations)
4. experimenting with the new concepts (context-specific and context-free (i.e., unifying) concepts, applying to other science fields).

4.1. Learning the concepts. Metastability, criticality (instability), search for stability and qualitative change.

Balance task.

Teacher's introduction: Keeping balance in the upright position is a basic motor skill in humans. It needs a coordinated cooperation of the neuro-muscular system at many levels to negotiate the major environmental constraint – gravity. Gravity tends to collapse the body, i.e., its center of mass, to the minimum gravitational potential energy. When lying on our back or belly the center of mass reaches its gravitational potential minimum. For the human body this state is the global energy minimum (i.e., the ground state) which is reflected, for example, in the minimum metabolic rate under these constraints. All other positions and activities are excited and are therefore metastable states that need active control in order to be stabilized. The degree of stability can be tested by applying external perturbations to the body and observing how it behaves. Rapid recovery of its previous state signifies stability, slow recovery signifies approaching instability, and no recovery at all signifies instability, i.e., loss of stability.

Concrete experience: The learner stands with the feet parallel facing a target within reach/just out of reach. S/he is instructed to pay attention to a specific set of bodily sensations that will occur under different conditions. The distance from the target is divided into 10 equidistant intervals. The scaled target distance D is calculated as a ratio between the physical distance of the learner from the target to his/her arm length measured from the shoulder to the finger tips. The physical distance is measured from the tips of the toes to the vertical projection of the front part of the target on the floor. Starting from the closest scaled distance, the learner tries to reach and touch the target. Also, at each scaled distance, a partner applies a relatively constant mechanical perturbation to the learner's trunk in the direction of the target. As the scaled distance increases, typically close to $D = 1.4$, the learner loses balance and takes a step forward, i.e. transits to a more stable diagonal stance [23].

Reflective observation on the experience: The learner is asked to provide a number of self-reports on the sensations of stability perceived at different scaled distances D, especially with respect to the perturbations applied by the partner and the behavioral variability of the lower limbs and the center of mass.

Abstract conceptualization based upon the reflective observation. This phase may involve the following set of tasks:

- Conceptualizing the scaled distance as a control parameter and the center of mass as a collective variable, and plotting the stability profile of the center of mass vs the scaled distance D.
- Emphasizing the discussion of the qualitative structural change occurring at the instability (i.e., critical) point at D =1.4, i.e., the abrupt transition of the center of mass to a new value and the transition from the parallel to the newly adopted diagonal stance (the concept of a phase transition or bifurcation).
- Plotting of the stability change experienced due to the partner's perturbations as a function of the scaled distance D from the target.
- Plotting of the perceived variability of the center of mass and the lower limbs at scaled distances far from, and at, the point of instability when not perturbed by the partner (critical enhancement of fluctuations). Discussing the increase in the perturbations to form the new stable state of the diagonal stance.
- Comparing the degree of stability of the parallel stance to the diagonal stance and to the lying position.
- Plotting of these stability profiles on an energy landscape plot.

Notice that the concept of stability may be studied in a perceptually grounded fashion with inanimate mechanical bodies as well, with learners acting and observing the effects produced on the body. However, important phenomena like the enhancement of fluctuations close to the critical point will not be obtained in this case. In more formal learning settings, the whole procedure may be videotaped and essential variables may be estimated, such as the center of mass displacement and the leg displacement, and then put to further use.

Experimenting with the new concepts. This learning phase is the one in which the unifying power of the DSSP concepts should be used. After reviewing the final conceptual and explanatory outcome of the analysis in the previous phase, the teacher may connect concepts and explanations used in the balance task with concepts from other science fields. For example, according to the teacher's preferences and background, the energy landscape plotted to demonstrate the experienced stability profile of the body during the balance task may be compared to a similar landscape from transition state theory in chemical kinetics [24] or to the Jeans instability of star formation in astrophysics [25]. Alternatively, teachers may compare it to the potential energy landscape of the inflationary scenario of cosmology or to the phase transitions in condensed matter and elementary particle physics [26, 27]. At this level, distinguishing between context-dependent and context-free (i.e., unifying) concepts and explanations is clearly one of the aims. For example, a context-dependent concept like the center of mass may be associated with the reaction coordinate in chemical reactions or with the gas density in the star formation scenario, all playing the role of a unifying concept of collective variable. The increase in fluctuation (or in the initial perturbation) as a unifying concept may be associated with the following context-dependent concepts: in the balance task it may be associated with the formation of a new (diagonal) stance, in chemical reactions with the activation and formation of new chemical bonds, and in the star formation process with the increase in gas density or with the exponential stretching of primordial fluctuations and the seeds of galaxy formation. The context-dependent concept of stable parallel or diagonal stance in the balance task may be associated with the general concept of stability and contextualized again in examples of stability in neurosciences and psychology [28, 29] or stable collective attitudes and frozen conflicts in social groups [30]. In the balance task, the teacher may pay attention to the fact that forces generated within the body (the neuro-musculo-skeletal system) are basically of electromagnetic type and emphasize that what learners witness is the competition between the only two long-range (macroscopic) forces in the universe: the biologically highly organized electromagnetic force, and gravity. This may be linked to the competition between these two forces (or their derivatives) in creating stability or instability in stars.

We have shown how a simple balance task can be a fruitful source of experiential learning of a plethora of unifying explanatory concepts from the DSSP conceptual space and how they can be linked them with phenomena relevant to traditionally distant science fields. Similar physical activity tasks may enrich the set of examples and start the new cycle of the four learning phases mentioned above. The task disengagement induced by fatigue [31], the instability of the focus of attention and the spontaneous switch to task-related thoughts close to fatigue-induced exhaustion [32] are only a few examples. Phenomena from collective sports may also prove fruitful for the experiential grounding of general concepts such as networks, interactions and self-interactions, symmetry and asymmetry, and metastability.

5. Conclusion

The application of systems science and its perspectives from the viewpoint of science education were analyzed and discussed. In its current form, the science education material belonging dominantly to fields other than physico-chemical sciences increases the fragmentation of scientific language. This is not the case in the domain of science research, which is characterized by increasing degrees of language coherence. This tension between science education and science research may be bridged by introducing the contemporary explanatory patterns already existing in the science research area. These explanatory patterns belong predominantly to the DSSP conceptual space. The experiential learning modules based on the formation of perceptually-grounded concepts by use of physical activities represent a viable way of introducing the DSSP explanatory patterns and creating a more integrated system of science education. The benefits we envision are particularly relevant to the enhancement of learning transfer and the synthetic world view formation in learners. Additionally, concepts grounded in physical activities may underpin and reinforce intuitive aspects. Based in part on previous research on this topic, the best way to link different science fields for educational purposes seems to be to design separate subject and teacher profiles specialized in creating learning environments with the main aim of integrating the explanatory patterns of science using the DSSP explanatory language.

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