The Integrated Learning Process, Metacognition and Collaborative Learning

Nia Alexandrov , Raul V. Ramirez-Velarde
ACET Centre, The University of Reading; Tecnologico de Monterrey, Campus Monterrey

Key words: *Collaborative activities, learning cycle, metacognition*

Abstract:

The Integrated Learning Process is a model for learning that is based on XXI century science. It established a framework for the design of learning activities which could aim to develop different levels of cognition from concepts, to procedures, to creativity. It also establishes, when joined with the Integrated Metacognitive Processes model, a framework for the acquisition of metacognitive skills, soft skills, attitudes and values. By examining Collaborative learning under the light of the Integrated Processes models we can create new and innovative learning activities that will allows student to develop knowledge, skill and metacognition, and improve motivation.

1 Introduction

Modern interactive computer learning environments are based on certain assumptions about how people learn that derive in different types of learning activities and technology support. Usually, this translates into Learning Management systems as technology support and constructivist based learning activities. But as effective as this and other combinations have proven, there is still room for improvement. Constructivist approaches have been accuses of favoring endless reflection and not enough analysis, synthesis and planning. Examined under the light of the models we propose in this paper, we can clearly see the loop holes and improve collaborative learning as well as make it adapt to different situations and environments. The rest of the paper is organized as follows: Section two describes the Integrated Learning Processes model that determines the stages a collaborative learning activity must follow. Section three describes the need for and defines the concept of active learning and learning balance. Section for explains collaborative learning and its involved elements. Section five describes how to design new learning activities whereas section six describes the Integrated Metacognitive Processes model, which associates through metacognitive skills a learning activity to the traditional collaborative context. In section seven we present our conclusions.

2 The Natural Learning Cycle

2.1 Natural Learning

Neuroscience has made many advances in recent years that can be applied to improve teaching and learning. One of the most promising applications of neuroscience to learning is James Zulls “Natural Learning” [1]. Natural Leaning links functional parts of the brain to David Kolbs [2] learning cycle (See Figure 1). Table 1 explains the relation ships between the cerebral cortex and the learning cycle.

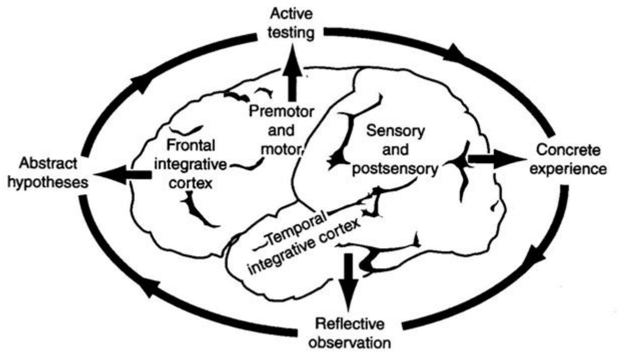

Figure 1. Kolb's Natural Leaning Cycle and the Human Brain

As Fig. 1 shows, the natural learning cycle is dead-on in complete concurrence with the structure and function of the brain. When we learn, we usually first perceive the information. This information is integrated to previous knowledge acquired by past experience. We later use the newly acquired knowledge to solve problems, create plans for action to finally act upon such plans and knowledge in such a way that a test of our skills is created. The result of such tests (that is, we either solved or did not solve the problem; and the plan did or did not work) is perceived by our senses and the cycle begins again.

2.2 Cycles Do Not Have a Beginning

Until now, we have been discussing about an experience-abstract-act cycle for learning. But if it is truly a cycle, a cycle with the sequence act-experience-abstract [3] or even abstract-act-experience can also be valuable [4]. Thus students can be asked to start their learning experience by exploring the environment, such as a laboratory, a repository of digital materials, a web page, a factory, etc. Then they can process their experience, ask questions, hypothesize and debate the function of different components, areas and mechanisms, etc. This will excite their curiosity and motivate them to learn. How many people have chosen maritime or aviation careers just by looking and wondering about planes and boats? Imagine the effect of actually getting on a plane or a ship and trying out different controls and gadgets. We encounter new information by ourselves only by exploring our environment.

But also, learning can also begin by hypothesizing how certain structures or concepts work, or how certain problems can be solved. Students find great satisfaction to learn that without prior knowledge, their answers where not far form the real solutions they were shown at the end.

2.3 The Integrated Learning Processes Model

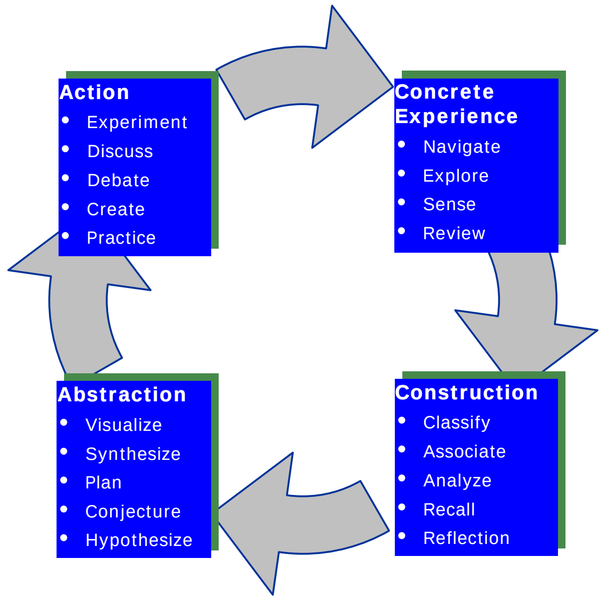

Figure 2. Integrated Learning Processes Educational Model

By analyzing the biological information just presented and a collection of successful educational models, we have developed the Integrated Learning Process model which allows for the design of effective learning activities, digital materials and tutoring strategies [5]. It consists of following the activities indicated in the learning cycle of Fig. 2. In this model, the beginning and ending of Kolb's and Zull's natural learning cycle are linked together in the conceptualization phase of the model. This allows for traditional teaching as much as exploration and action based learning.

3 Active Learning

3.1 Active Learning and the Joy of Learning

There is also biological evidence that regions of the human brain that are related to pleasure are also related to movement. As Zull points out, this is not surprising since movement is needed to achieve happiness and pleasure. This implies that **active learning** must be an integral part of any modern educational model, as much as it should respect the natural learning cycle. But it also implies that convincing students of their achievements we will gain better motivation. Thus education should motivate students using three strategies:

1. Focus on student background, interests, responsibilities, culture and environment. This will make learning an experience about life, and thus more meaningful.
2. Provide active learning. If the activity is significant enough and varied enough it will keep students interested
3. Provide achievement based evaluation and feedback. This will not only enhance the sensation of movement but will help students overcome their fears and concerns which can severely damage learning.

As we have learned from the natural learning cycle, action closes this cycle. It allows students to test their ideas and plans. It also allows students to store procedures and algorithms in long-term memory by repetition. This cycle, experience-abstract-act is the reason the nervous system evolved. Every learning technique, philosophy and strategy must follow the cycle: see-mimic-practice, see-discuss-communicate, see-plan-test, think-structure-test, etc. and then repeat. Strategies that emphasize only one o some parts of the cycle, for example when we value speed in mathematical computations and other types of problem solving, immediately start problem solving without analysis or discuss subjects endlessly, will produce much less impressive results. And teachers and instructors must understand that not all can happen fast. Explicitly, there is no time limit for good reflection, which is done in the back-cortex, or good planning which is a front-cortex activity. Emphasis in speed can also be a looser.

Action is not only movement. For the front-cortex action means discussion, argument, debate. When students acquire or raise awareness, take a course of action, commit to ideas, they take action and thus complete the natural learning cycle.

Nevertheless, although active and constant practice will help construct effective knowledge storage and acquisition mechanisms, in order to truly complete the natural learning cycle, students must test their own ideas. A didactical approach based on the natural learning cycle must be an inside-outside, past-future experience. That is to say that advanced didactical approaches should help students learn, reflect, process and integrate knowledge. After that, we proceed from outside-past knowledge managed by the back cortex to inside-future knowledge by making plans, proposing strategies, acting to reach goals, testing in physical or physical-like environments and completing by sensing a complete experience. Either by actually constructing or simulating to construct something, or by sharing, discussing arguing and debate, however we test our ideas the physical nature is always a clarifying process.

3.2 The Need of Social Interaction

Speech and technology are integral parts of being human. Almost surely, each one is a cause of the other. And both are direct causes of the most important genetic changes that define human kind. In the dawn of our species, humans depended on understanding and changing the environment in order to survive. This translated into the use of tools to enhance the limits of the physical body, hitherto the origin of technology in its most simple definition. This is actually not an exclusively human behavior. Elephants, chimps, otters and some other animals have been observed using tools. Technology is not part of our genetic makeup, it must be learned. Soon, the use of tools and the passing of important information about the environment and the use of it became so vast that the power of observation as a means of preserving such knowledge began to reach its limit. At the same time, approximately one hundred thousand years ago, a biological development began to have a heavy effect on the future of the human specie. The sound producing parts located near the trachea moved a little bit further down the neck, allowing more flexibility in the vocal chords which enabled the development of speech (this is why humans tend to asphyxiate while eating). Speech vastly improved the transfer of knowledge. Although it might seem at first that technology caused speech, the picture might be more complicated than it seems and the final answer as whether which caused which has not been fully resolved. This is because humans came into existence with both a certain ability to communicate and a certain ability to use tools. It seems perfectly natural that speech enabled the development of technology through teaching and collaboration; as it is perfectly logical that the need to transmit more complex knowledge demanded more complex speech. It is more probable that a virtuous cycle was formed between speech and technology that constantly drove the development of more complicated human brains. It is not an exaggeration to postulate that technology and speech are integral parts of our biology, since both had direct influence in our genetic makeup in more ways than can be described in this space.

Evolutionary psychology shows us that once humans developed the ability of complex speech and thought, nature imprinted in our genetic information the need to form groups. Human groups (bands, tribes, nations, etc.) are formed through something called reciprocal altruism. Reciprocal altruism is the human impulse to help someone in need as an investment for future help. It may not make that much sense in our modern world, but back in time when we were hunters and gatherers, hunger and danger were constant threats. Thus, a little token of help that might not be too important now for the donor, may transform in the future as that extra token of help that will mean the difference between life and death [6].

Human beings have within their brains a wiring that compel them to form groups in order to gain support and strength, and to exchange useful information about the environment through speech [7]. Not only that, but whenever different groups find themselves side-by-side in most situations, they will fill a strong urge to compete. Thus learning environments that enable students to collaborate, debate and discuss, while presenting dangers because of the possible competition that might follow, will have a positive impact on student motivation as they mimic how human beings conquered nature.

3.3 Learning Balance

A traditional teacher will observe that the natural learning cycle in fact supports her method of teaching: explain & demonstrate, followed by drill & practice, followed by problem solving. This time honored practice follows the natural learning cycle. It is not wrong. But it is incomplete. Different studies show that the traditional approach to teaching may be heavily tilted towards the back cortex, which means that learning is passive and may not be translated into efficient plans, strategies and actions [8].

On the other hand, new approaches about education emphasize action based learning, such as problem based learning, project based learning and the like. Those approaches themselves derive from what is called **social constructivism**, which aims to build new knowledge using previous knowledge and constructing upon it through social interactions. Action based learning can tilt learning towards the front cortex, making it much action with little substance [8]. The natural learning process seems to imply that for learning to be effective, some concrete information must be given to the brain in order to start the learning process. All educational models should aims to achieve such a balance that will produce steady increase of understanding and competence and reach deep understanding and complete problem solving skills.

This is achieved by using a balanced approach to learning, where students progress by both using information given didactically, through digital materials and tutoring, and their own experience, which through constructivism provides empowerment to students.

4 Collaborative Learning

We start by using a common definition of Collaborative Learning (CL): "involved joint intellectual effort by students or students and teachers. Groups of students work together in searching for understanding, meaning, solutions or in creating a product" [9].

One of the most important principles in collaborative learning is "**Positive Interdependence**". Positive interdependence is "the degrees to which participants perceive they are interdependent in that they share a mutual fate and that their success is mutually caused" [10]. Although there are other important aspects of collaborative learning, positive interdependence stands out because is not only encourages knowledge and skills acquisition, but it also encourages the practice of certain attitudes and values such as respect, responsibility to others, personal accountability, self-evaluation, etc. [11, 12].

Elements of Collaborative Learning

There are five elements of collaborative learning [10]:

1. **Clearly Perceived Positive Interdependence**. In collaborative learning the success of one person is bound up with the success of others. There are many ways to ensure positive interdependence. Goal sharing is one way. This might include shared subject matter, a particular assessment, joint problem solving or creating and discovering something of value. Another way is role sharing. This occurs when each group member is given a specific role that gives a person specific responsibilities. The role describes what group activities that person might take and the contribution to the overall task. Also, resource information contributes to positive interdependence and exists when each group member has only part of the information, cases, material or other resources necessary for the group to achieve its task. Finally, task interdependence is structured by creating a division of labor so that the actions of one group member have to be completed before the next member can complete their tasks.

2. **Interaction**. Individual students are encouraged to assist others in the group to complete tasks in order to reach the group's goals. In other words there is an expectation that students will help each other so that common goals can be achieved. Help may be resources, advice, provision of feedback and challenging conclusions.

3. **Individual Accountability and Personal Responsibility**. Everyone is expected to do their fair share of work and it is important for all group members to know that they cannot 'free ride.' Fair sharing of work can be achieved by:

    a. Keeping the group small: the smaller the group, the greater the individual accountability
    b. Testing every student
    c. Observing the group and recording the frequency with which each member contributes to the group's work
    d. Ask one group member to check the work of others through use of reasoning
    e. Having students teach what they have learned to someone else

4. **Small Group Skills**. Interpersonal skills are important. In order to achieve these goals students must

a. Get to know and trust each other
b. Communicate clearly
c. Provide and accept support
d. Resolve conflict constructively

5. **Group Processing**. Group work is effective when group participants reflect on how well they function as a group. This reflection assists members to maintain good working relationships. Reflection may focus on such things as relationships between people, facilitation of collaborative skills, rewarding of positive behavior and the celebration of success.

5 Designing New Generation of Collaborative Learning Activities

5.1 Traditional Learning Activities

To ensure positive interdependence, CL is normally carried out using predefined activity models such as Jigsaw, Coop-coop, Pyramid, etc. Table 1 shows a brief description of some CL techniques [13].

CL Technique	Description	Procedures
Jigsaw	Complex problem/task that can be easily divided into sections or independent sub-problems	Each participant studies or work around a particular sub-problem. The participants of different groups that study the same problem meet in an Expert Group for exchanging ideas. At last, participants of each Jigsaw group meet to contribute with their expertise in order to solve the whole problem
Pyramid (Snow Ball)	A problem whose resolution implies the achievement of gradual consensus among all the participants	Each individual participant studies the problem and proposes a solution. Groups of participants compare and discuss their proposals and, finally, propose a new shared solution. Those groups join in larger groups in order to generate new agreed proposal. At the end, all the participants must propose a final and agreed solution
Coop-Coop	Complex problem/task that can be easily divided into sections or independent sub-problems	Each participant studies a sub-problem that particularly interests her. The student explains why the item interests her. Students form expert groups to research the sub-problem with task division and deadlines. participants of each group meet to contribute with their expertise in order to solve the whole problem

Table 1. A Summary of Common CL Techniques

These techniques ensure positive interdependence because no student will learn the entire subject without the intervention of her team peers. But they also support the other elements of CL. For example, the techniques support interaction because students must communicate between themselves and with the teacher in order to clarify ideas and solver conflicts. They support accountability and responsibility because the failures of one will necessarily transform into the failure of all the team, thus peer pressure and personal reputation play a strong roll. Also, many of the activities related to the techniques are carried out in real time, thus an entire group will be witness of an individual student performance. They support small group skills and group processing because students are compelled to work with different teams of different sizes, from pairs, to permanent groups to entire classrooms.

5.2 New Collaborative Learning Cycles

As effective as these activity models are, they follow the traditional experience-abstract-act or experience-construct-act for learning. But as the ILP tells us, a true learning cycle has four components, therefore other cycles for collaborative learning techniques are possible such as: act-experience-construct-abstract and abstract-act-experience-construct. As long as those activities achieve social interaction, active learning and learning balance, we know that they will be effective. But the best part is, they will be innovative, which means change, which might mean motivation.

As an example, let us create a new CL technique by establishing a new learning situation. Let’s call this learning technique “Collaborative Creative Cross-Pollination”.

The goal of the Collaborative Creative Cross-Pollination (CCCP) technique is to have students solve seemingly unsolvable problems. This technique was inspired by Eduard De Bono’s book “The Use of Lateral Thinking in the Generation of New Ideas” [14].

Before the activities begin students are presented with rather very hard and very general problem which they seem not to be prepared to solve. They hear also the barriers and conditions which make this problem near impossible to solve. Students form three member teams by whichever mechanism is favored.

The general algorithm follows:

1. Each student individually creates a brain storm of possible solutions of the problems. It is VERY important that each student lists absolutely all possible solutions without any kind of constraint taken into consideration. Evaluation will come later. Even impossible solutions should be listed here. And no peeking. That will also come later. Ask students to use appropriate language and to be brief but clear, since many people will read those ideas. Ask students to produce an impossible amount of solutions. Say 15 or 20. After most students start to become idle as they believe they have come up with all possible solutions, ask them to make an extra effort and come up with some more. When all students have finished teachers could ask students to raise hands according to the number of solutions they came up with. This simple exercise will show students how they faired compared to the rest of the group and will motivate them to try harder next time. You are measuring your group’s creativity.
2. The next stage is called cross-pollination. Students will exchange their solutions listings in a clockwise direction. Students will carefully read their team-mate’s solutions and understand them completely. They can discuss with the creator of the idea to clarify.
3. Under the possible solutions already listed by team-mates, students will list more, that is new, possible solutions. This is made possible because each student’s solutions, as many as they are, are almost always completely different from their team-mates’ solutions and all other solutions in the classroom, thus by analogy, association and visualization new ideas are created. So each member’s solutions generate more solutions in the other member’s head, not as many as the first round, but many nonetheless.
    - The next stage is another round of clockwise rotation and pollination. A few more ideas are generated in this round. Teachers should motivate students to extract the last drop of creative juice from their brains. At the end of this stage, hundreds of solutions have been produced by the classroom. You will be surprise to find that some of them are quite ingenious, and even if the problem has been analyzed by the not-quite-qualified-to-act, the problem does not seem so impossible after all.

4. The next stage is an evaluation stage. Students will discuss evaluation principles and establish evaluation methodology and metrics.
5. An evaluation is carried out that produces three feasible solutions per team.
6. Now students start to research the problem and learn some more about the problem.
7. Students must now analyze the pros and cons of the three remaining alternatives and decide on a winning solution.
8. A plan must be prepared to defend his solution in the plenary group (classroom)
    - At this stage, the plenary part of the technique begins. Students will try to reach a consensus. If principles, methodology and criteria have not been established at this point it must be done. It is better if the teacher or tutor presents a decision methodology as reaching a consensus on this may take too long. Each team will try to impose criteria that are similar to own and thus tend to favor own solution.
9. Students present their solutions in the plenary group.
10. Students listen carefully to other team's solutions and arguments.
11. Students analyze other team's solutions and compare them with own.
12. Students conjecture and hypothesize which solution is best.
13. Reach a consensus on best solution using an agreed upon procedure.

5.3 Analysis of CCCP according to the ILP

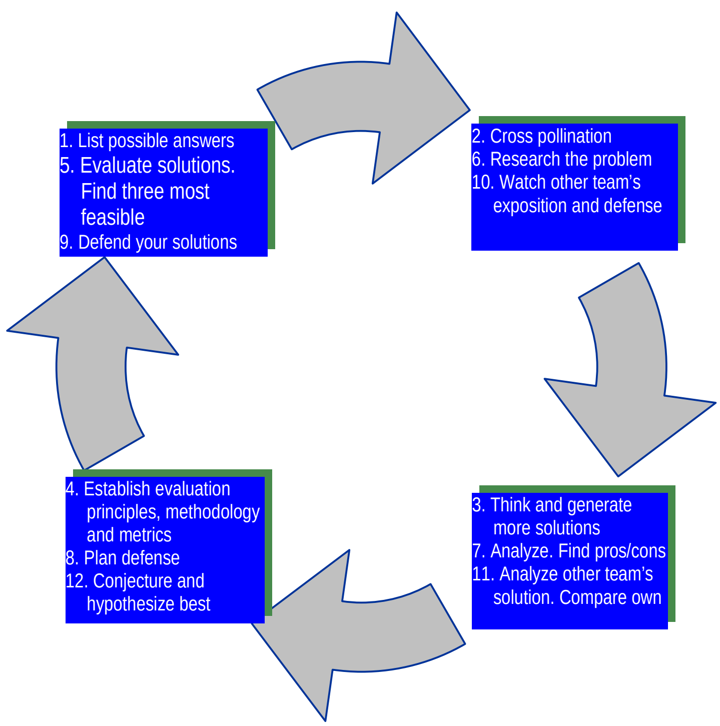

Figure 3. Relation between CCCP Technique and the ILP Model

It is important to observe that the CCCP does not start on the experience part of the ILP. It starts on the action part as students must **create** solutions out of thin air. Of course, in order to create those solutions students must see and hear, associate and visualize, which are belong to the experience, abstraction and construction parts of the ILP. Nevertheless, since the reading/listening time is rather small, the experience is small, and since no evaluation is carried out, the abstraction and construction is free-wheeling, thus, as no part of the brain and the thinking process is truly independent, the emphasis is on action. In Fig. 3 we compare CCCP under the light of the ILP model.

What must be clear is that the ILP applied to CL ensures learning balance, social interaction and active learning.

6 Metacognition

Section 4 mentions 5 elements of CL. These elements are not evident in the ILP model. This is because positive interdependence, interaction, individual accountability and personal responsibility, small group skills and group processing are metacognitive skills, skills that aid the cognitive process. Thus a new model, a metacognitive model, is need.

6.1 The Integrated Metacognitive Processes Model

The Integrated Metacognitive Processes Model (IMP) establishes certain variables that once an activity model with specific needs instantiates, it produces a unique educational model. The IMP model has the five components shown in Fig. 4 and described below.

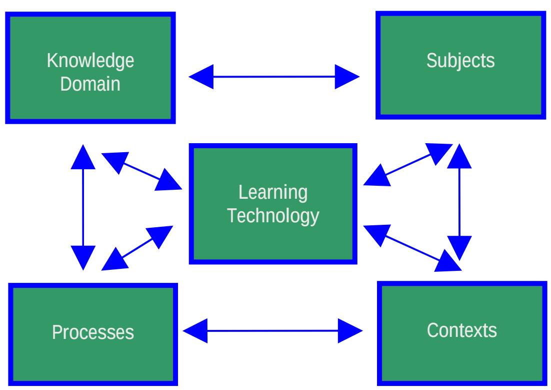

Figure 4. The Integrated Metacognitive Processes Model

1. **Knowledge domain**. This not only describes the knowledge that we desire students to acquire, but also certain different skills, which can be cognitive, affective and motor, or conceptual, procedural and metacognitive. This classification is important, as students must construct knowledge in increasing phases of complexity.
2. **Educational subjects**. It indicates the nature and origins of students and teachers and the relationship between them. Effective learning is achieved when the process is focused on student's interests, culture, and environment, and when new knowledge and skills is constructed upon a well identified academic base (student background).
3. **Contexts and environments**. They establish the variables that make-up the learning space. The same knowledge domain may be taught to different people with different culture, in different locations with different resources, and at different times with different emphasis, by different teachers with different types of communication.
4. **Educational processes**. In general, this term identifies the activities that must be carried out by students in order to acquire skills and knowledge. Those activities take into account the knowledge domain, student's background and learning contents.
5. **Learning technology**. Learning technology is closely tied to the educational processes for basic learning activities are carried out using them. Learning technology must endeavor to target as many communications channels as possible as well as students' different

intelligence capacities such as linguistic, visual, kinaesthetic, musical, logical-mathematic, interpersonal, etc.

6.2 Metacognition in the Collaborative Creative Cross-Pollination Technique

In order to be able to develop new activity models a designer must not only establish the relation between the different activity stages and the Integrated Learning Processes, but also to establish the metacognitive blueprint. A designer thus establishes a range of goals, conditions and boundaries that will differentiate the activity model from others. Table 2 establishes the relationship between the different CL elements that an activity model must support and the elements of the Integrated Metacognitive Processes model and provide specific example for the CCCP activity model.

CL Element		IMP Model Element	Relation
Knowledge domain	Cognitive	Subject matter	What are the conceptual and procedural goals?
	Affective	Small group skills, individual accountability and responsibility	Develop sensations of fairness, trust and support. *All students contribute, according to creativity in the generation of ideas and the establishment of evaluation procedure. All students browse for information and respect each other's contributions*.
	Motor	Individual meta-procedures	Understand how to do certain CCCP procedures like brainstorm, browse internet, evaluate, discuss, vote
Educational subjects		Team integration	The manner in which teams are created depends almost completely on the nature of students. *Specifically, CL requires mixed background students for permanent teams, and similar background students for temporary teams (subject experts)*
Contexts and environments		Group processing	Group meta-procedures depend on contexts such as location, student background, time synchronicity, etc. *Group processing can be carried out using polling tools, a simple paper form or direct confrontation*
Educational processes		Positive Interdependence	Activity models try to ensure sharing of rolls, goals, and resources. *Without the pollination procedure the amount of generated ideas diminishes exponentially*
Learning technology		Interaction. Group activities, such as discussion, decision making and others	Learning technology is determined by all the other elements. *The way in which students will interact with team mates, class members, and teachers and tutors depends mostly on available technology. For example, synchronous discussion can be carried out using discussion forums within an LMS, or in class.*

Table 2. CCCP and the IMP model

7 Conclusions

Modern effective learning is very complex. Multiple variables which imply a multidimensionality of complexity are present and may hinder learning. The models we have presented here provide tools that allow instructional designers, teachers and tutors to develop CL activities, that will support positive interdependence, interaction, individual accountability and personal responsibility, small group skills and group processing, as well as active learning and learning balance. The Integrated Learning Processes model helps by structuring learning activities through a learning cycle that is biologically correct. It follows the way humans naturally learn. Whereas the Integrated Metacognitive Processes model creates a blueprint for higher level skill development within a context and cognitive goals. These tools will not only create effective learning programs, but through innovation, will motivate students to learn.

References:

[1] Zull, J. “The Art of Changing the Brain”. Stylus Publishing, Sterling, USA, 2002.
[2] Kolb, A. and Kolb D. A. “Experiential Learning Theory Bibliography 1971-2001”. McBer and Co, Boston, USA, 2001.
[3] Alexandrov, N., Ramirez-Velarde, R. “Educational Meta-model and Collaborative Learning”. International Conference on Interactive Computer Aided Blended Learning, ICBL 2007, May 2007, Florianopolis, Brazil.
[4] Ramirez-Velarde, R. "New Science for e-Learning Educational Models". Escuela de Tecnologia de Informacion de la Universidad de Xalapa, Xalapa, Mexico, October, 2005.
[5] Alexandrov, V., Alexandrov, N. and Ramirez-Velarde, R. “Novel Pedagogical Paradigms facilitating mixed mode and collaborative learning using open source software”. International Conference on Interactive Computer Aided Learning ICL 2005, Villach, Austria, September, 2005.
[6] Wright, D. “The Moral Animal”. Vintage, Reprint edition, August 29, 1995.
[7] Diamond, J. “Germs, Guns and Steel”. W. W. Norton & Company, New York, 1999.
[8] Swartz, M. and Sadler, P. “Goals and Technology Education: The Example of Design Challenges”. Proc. of the Second AAAS Technology Education Research Conference, Washington, USA, 2001.
[9] http://en.wikipedia.org/wiki/Collaborative_learning
[10] Johnson, D. W., & Johnson, R. T. “Positive Interdependence: Key to Effective Cooperation”. In R. H. Herz-Lazarowitz, & N. Miller (Eds.), Interaction in Cooperative Groups: The Theoretical Anatomy of Group Learning, pp. 174 – 199. Cambridge University Press, 1991.
[11] Barkley, E., Cross, P. and Major, C. H. “Collaborative Learning Techniques: A Handbook for College Faculty” (Chapter 1). Jossey-Bass, 2004.
[12] Dale, V. H. M., Nasir, L. and Sullivan, M. “Evaluation of Student Attitudes to Cooperative Learning in Undergraduate Veterinary Medicine”. Journal of Veterinary Medical Education, Vol 32, Issue 4, 511-516, 2005.
[13] Hernandez, D., Asensio, J. I., and Dimitriadis, Y. A. “Collaborative Learning Strategies and Scenario-based Activities for Understanding Network Protocols”. ASEE/IEEE Frontiers in Education Conference, October, 2006, San Diego, U. S. A.
[14] De Bono, E. “Pensar bien / New Think: Utilice al Maximo el Potencial Intelectual y Creativo de Su Mente / The Use of Lateral Thinking in the Generation of New Ideas”. Selector S.A. de C.U., Buenos Aires, Argentina, 2005.

Authors:

Ramirez-Velarde, Raul V., P.h.D.
Tecnologico de Monterrey, Campus Monterrey, Computer Science Department
Eugenio Garza Sada 2501 Sur, Col. Tecnologico, Monterrey, N.L., Mexico
rramirez@itesm.mx

Alexandrov, Nia
ACET Centre, The University of Reading
University of Reading, Whiteknights Campus, Philip Lyle Building, Philip Lyle Building,
PO Box 68, Reading RG6 6BX, Berkshire, United Kingdom
n.s.alexandrov@reading.ac.uk