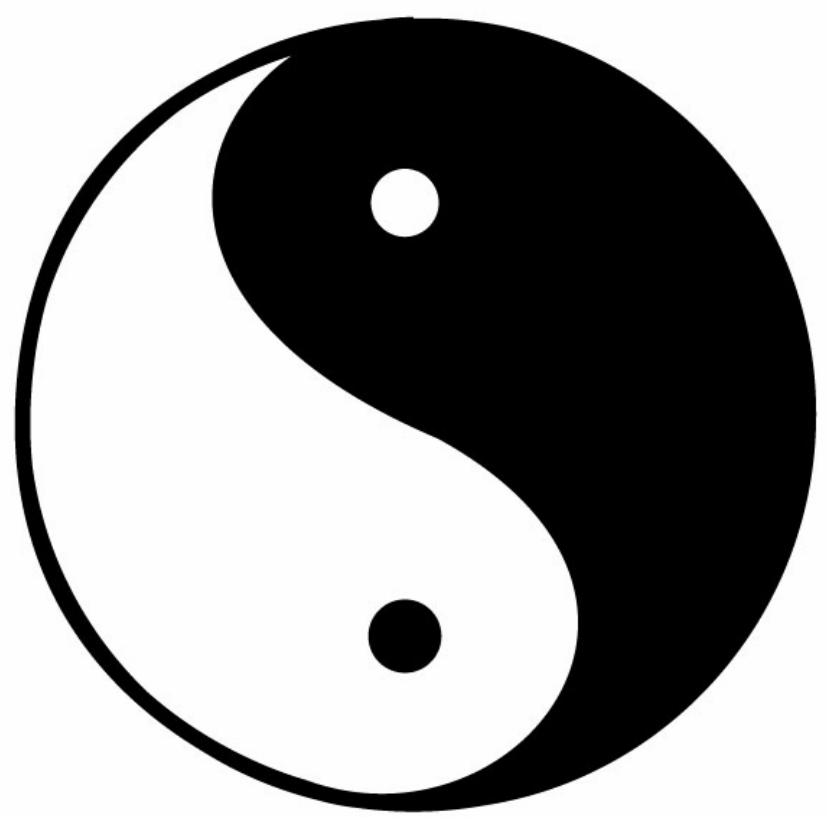
(INTER)DEPENDENT LEARNING

Learning is Interaction



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(INTER)DEPENDENT LEARNING

Learning is Interaction

Inaugural Address

Spoken upon the acceptance of the position of
Professor of Educational Psychology
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by

Prof. dr. Paul A. Kirschner

For Catherine, Femke, Jesse, Mara and Aron

We are truly interdependent

The community stagnates without the impulse of the individual.
The impulse dies away without the sympathy of the community.
William James (1842-1910)[1]

O chestnut-tree, great-rooted blossomer,
Are you the leaf, the blossom or the bole?
O body swayed to music, O brightening glance,
How can we know the dancer from the dance?
W. B. Yeats (1926)[2]

Interdependence is and ought to be as much the ideal of man
as self-sufficiency…His social interdependence enables him
to test his faith and to prove himself on the touchstone of reality.
Mohandas Gandhi (1929)[3]

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Mister vice-chancellor / Mijnheer de Rector Magnificus,

Colleagues,

Family and friends,

According to Wikipedia, a *dichotomy* is

> the division of concept or of a class of things into two parts which are both mutually exclusive (i.e. nothing can belong simultaneously to both parts) and jointly exhaustive (i.e. every member of the class is in one part or the other). They are often contrasting and spoken of as 'opposites'.

For just about as long as I can remember everything around me was presented as a dichotomy. In my earliest youth you were either an Elvis Pressley fan or a Pat Boone fan, a fellow-traveller (Julius & Ethel Rosenberg and Alger Hiss) or a patriot (Joseph McCarthy and Richard Nixon). When I was a little older the major dichotomies were that you were either for or against the war in Vietnam, you were a militarist or a pacifist, a hippie or a greaser, and even a Beatles or a Stones fan. And today it is still the same. Proponents of each side of the dichotomy have their own set of rules, values, and norms and the slogan is always "If you're not with us, you're against us".

This dichotomous way of thinking is not only prevalent in society and politics, but also in the sciences. We find/found this in the natural sciences, for example, for the natural selection theory of inheritance according to Darwinism versus the inheritance of acquired traits according to Lamarck (Lamarck was wrong), the wave theory versus the particle theory of light (both are the case), and classical Newtonian physics versus relativistic quantum physics (each works, but in a different world). As can be seen, in the natural sciences, theories or approaches can apparently be definitively proven to be wrong as was the case for the inheritance of acquired traits, can both be right but in different situations as is the case for light which sometimes acts as a wave as is the case when interference effects are observed and sometimes as a collection of particles as is the case when the photoelectric effect is observed, and even for the basic laws of physics where Newtonian mechanics works in the macroscopic world of classical physics, but not in the microscopic or sub-atomic world of quantum mechanics where quantum physics works.

Why then is it that we in the social sciences, and I specifically the psychological or educational sciences, are constantly bickering with each other and thinking in terms of dichotomies?

Dichotomies in Educational Psychology and Educational Sciences

In an earlier inaugural address at Maastricht University in 2000, I attacked this idea of such dichotomies in education and learning, speaking of what I called the inevitable duality of education (Kirschner, 2000). In that address, I showed that the dichotomy between learning and working, especially at the university level, should be abandoned. I started my address by showing that this idea of categorisation and mutual exclusivity was not necessarily true, giving the example of the particle-wave duality and then of Jamie Lee Curtis, the actress whom many of you might know from films such as *A fish called Wanda* who, though phenotypically definitely a woman is genotypically a man[4]. Yes, within one person, the man-woman dichotomy becomes a duality.

In the next few sections of this address I will touch upon just a few of these apparently unsolvable dichotomies which are beginning to be solved.

Methodology

One of the first social-scientific dichotomies that I ran up against appeared after I had begun studying for my master's degree on the University of Amsterdam, namely the *objectivism-subjectivism* dichotomy.

I was a product of the Bronx High School of Science[5], a specialized senior high school whose job it was to begin on the production of tomorrow's scientists, and the State University of New York at Stony Brook[6] – whose job it was to finish it. At Stony Brook I made the switch from hard science (electrical engineering) to soft science (psychology and education), but the soft science taught there was as hard as they could make it with an extremely high level of behaviourism. Both of these institutions were redefined by and caught up in the aftermath of the Sputnik 'shock'[7].

Since as an American I was not entitled to a scholarship, I worked as student-assistant at the department of General and Comparative Education of the Pedagogisch Didactisch Instituut on the Prinsengracht in Amsterdam, while studying educational psychology at the GU[8]. The department was then known as the group Kallen (how many readers remember the Contouren-nota?[9]), and was politically middle of the road. But this quickly changed. I worked for a fairly positivistic staff member in the room next to the Comeniuskamer which, at that time, was a fairly left of centre (euphemistically stated) student society at the institute. I was also a member of the ISVOK (the Inter Sub-departmental Education Section) which was set up to try and form one large educational section at the university with a common curriculum for educational psychologists, educationists, and those working in adult and further education[10]. In both the department and the ISVOK I experienced the dichotomy between objectivist[11] empirical positivism[12] (used by many as a term of abuse) and subjectivist[13] critical psychology[14]. The *objectivists*, in the tradition of Popper (1959), were quantitative purists who believed that "social observations should be treated as entities in much the same way that physical scientists treat physical phenomena… [and contended] that the observer is separate from the entities that are subject to observation" (Burke Johnson & Onwuegbuzie, 2004, p. 14). The *subjectivists*, as defined by Guba (1990) contended that "multiple-constructed realities abound, that time- and context-free generalizations are neither desirable nor possible, that research is value-bound, …and that knower and known cannot be separated because the subjective knower is the only source of reality" (Burke Johnson & Onwuegbuzie, 2004, p. 14). Unfortunately this dichotomy was unsolvable and a good idea died an anonymous death.

At the moment we are noting a change in thinking about this dichotomy. Voices are being raised on making use of mixed methodologies in social science research. In articles (Burke Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Leech, 2005) and books (Tashakkori & Teddlie, 1998, 2003) we see a call for mixed-methods research, not to replace each of the individual

approaches, but rather to draw upon the strengths of both approaches and thus to minimise their weaknesses in and across studies thus "bridge the schism between quantitative and qualitative research" (Burke Johnson & Onwuegbuzie, 2004, p. 15). Recent example of this being put into practice can be found in the research being done both at our Research Centre Learning in Interaction and other University of Utrecht departments, for example by Lisette Munnike (2006) and the PhD theses recently defended by Jannet van Drie (2005) en Maarten de Laat (2006).

Teaching / educating / learning

How we teach – or actually how we educate – is often presented as a web of interrelated dichotomies. Typical examples are the passive vs. active learner dichotomy, the teacher-centred vs. student-centred education dichotomy, and the supply-driven vs. demand-driven curriculum dichotomy.

Passive learning versus active learning

The discussion on active versus passive learning can possibly be traced back to the moment that another dichotomy was being fought out, namely between behavioural and cognitive psychology. In the first half of the 20th century, the basic paradigm guiding learning and instruction was *behaviourist*. The basis of this paradigm was laid in 1913 when John Watson put forth the notion that psychology did not have to use terms such as consciousness, mind, or images (Burton, Moore, & Holmes, 1995), but that the behaviour itself was enough. Based upon this paradigm, design models emphasised the success of instructor / teacher instead of learner. B.F. Skinner took this a step further and tried to explain almost every type of human behaviour in terms of stimulus response chains. The learner was *passive*; (s)he was *acted upon*, rewarded (positively reinforced) or punished (negatively reinforced), and thus acquired what was meant to be acquired.

Cognitive psychology's reaction to the inability of behaviourism to account that much human activity arose mainly from a concern that the link between a stimulus and a response was not straightforward; that there were mechanisms that intervened to reduce the predictability of a response to a given stimulus, and that stimulus-response accounts of complex behaviour, such as the acquisition and use of language, were extremely complex and contrived (Winn & Snyder, 1996). The learner was not someone who was acted upon, but the learner played an *active* role in the acquisition of knowledge. And in teams, this is even more the case (Kirschner, Martens, & Strijbos, 2004).

One of the first researchers in this respect was David Ausubel (1962, 1968) who advanced a theory contrasting meaningful learning with rote learning[15]. *Meaningful learning*, in Ausubel's eyes, involves students actively relating new knowledge such as concepts and propositions to what they already know. It results when learners consciously and explicitly tie new knowledge to relevant concepts within their existing cognitive schemas, producing a series of changes within the existing cognitive structure. Existing concepts are modified and new linkages between concepts are formed.

Shortly thereafter, Ernst Rothkopf (1970, p. 325), paraphrasing a well-known saying, said "you can lead a horse to water but the only water that gets into his stomach is what he drinks". What he meant is that learning depends less on what teachers or instructional designers plan or want to have happen in learning situations than on what the learners them-selves actually do. Central to this idea is that, just as in the case of the horse at a watering hole, what actually occurs is "a matter of choice on the part of the student. In relevant circumstances, students choose whether they will pay attention in lectures, read assignments, or review what has previously been read; rarely are these activities the only ones available" (Rhodes, 1993, p. 6). This is also evident in collaborative learning where learners not only react to the teacher and/or the learning materials, but also to each other in a probabilistic way (Kirschner, Martens, & Strijbos, 2004).

Finally, Gagné (1977) in his landmark book *The Conditions of Learning* sealed the fate of behaviourism when he described learning as a *change in the cognitive structures* in the mind of the learner. These changes may be supposed by a change in behaviour, or by a more direct measure of cognition such as learner created representations of concepts and their mutual relations. The learner, thus, became an active participant in the process and instruction was based upon the idea that the optimal conditions for learning depend on the goal of the learning process. It assumes that a subject matter domain can be described in terms of learning goals, and instruction for each of the learning goals - taking the optimal conditions of learning for each goal into account – can be developed.

Student-centred / Teacher-centred

An extension of this discussion, and one that perseveres long after the much debated behaviourist / cognitivist dichotomy was settled, is the student or learner-centred versus teacher-centred discussion.

Disputes about the impact of instructional guidance during teaching have been ongoing for at least the past half-century (Craig, 1956; Ausubel, 1964; Shulman & Keisler, 1966; Mayer, 2004). On one side of this argument are those advocating that people learn best in an unguided or minimally guided environment, generally defined as one in which learners, rather than being presented with essential information, must discover or construct essential information for themselves and that they take full responsibility for what is taught and learnt (e.g. Bruner, 1961; Papert, 1980; Steffe & Gale, 1995). On the other side of the fence are those advocating that novice learners should be provided with direct instructional guidance on the concepts and procedures required by a particular discipline and should not be left to discover those procedures by themselves (e.g. Cronbach & Snow, 1977; Klahr & Nigam, 2004; Mayer, 2004; Shulman & Keisler, 1966; Sweller, 2003)[16].

The former approach - *student-centred* (or learner-centred) *learning* - involves activities, techniques, methods where the students/learners are the focus and the teacher plays only a peripheral role. Students are allowed – depending on how radically this is applied – varying degrees of control over the activity or input into the curriculum so as to encourage student creativity. To 'teach' in this approach consists of getting students involved in the actual construction of knowledge and thus requires active participation from teachers and students, putting much of the responsibility for learning on the student. The student-centred approach has many different names and forms, the best known of which are discovery learning (Bruner, 1961; Anthony, 1973), problem-based learning (Barrows & Tamblyn, 1980; Schmidt, 1983), inquiry learning (Papert, 1980; Rutherford, 1964), experiential learning (Boud, Keogh, & Walker, 1985; Kolb & Fry, 1975) and constructivist learning (Jonassen, 1991; Steffe & Gale, 1995).

The latter approach - *teacher-centred learning* - involves methods, activities, and techniques where the teacher conveys information to students and decides what to teach, how to organize the subject material, and the means of communicating the material to students. Learning is judged by how well students can report back what the teacher has told them. The teacher is in the centre of the classroom giving instruction with little input from students and where the goals of the class are usually based on some outside criteria. The teacher-centred approach commonly takes the form of the note-taking/lecture ("listen and learn") model and makes use of didactic or direct instructional guidance; providing information that fully explains the concepts and procedures that students are required to learn as well as learning strategy support that is compatible with human cognitive architecture. Learning, in turn, is defined as a change in long-term memory (Kirschner, Sweller, & Clark, 2006, in press).

Supply-driven / Demand-driven

Strongly related to the previous dichotomy, is the dichotomy between *supply-driven* and *demand-driven* education. In an article that I wrote with my esteemed colleague Martin Valcke (1993) we posited that education

> in pre-industrialized society was primarily a one-way relationship only controlled by those who had 'acquired' education during youth. They were, more often than not, members of the ruling class. One who wished to learn a science (pupil) or vocation (apprentice) was chosen by a master who would teach or train him[17]. At best there was an invitation to follow in the steps of those who knew best (Boyd & King, 1975). The learner/apprentice entered a learning situation with the master (situated cognition) and learned, often via dialogue and modelling (p. 36).

Supply-driven education can be characterised as a teaching or instructional process in which a teacher - as both the expert in a field or domain as well as representor of societal norms and values - defines the goals to be pursued, selects the contents to pursue these goals, selects the methods and paths to achieve these goals, and defines the standards to determine attainment of the goals. The central actor is the teacher. The knowledge base is restricted to declarative knowledge or craft-like procedural knowledge. The view on learning is restricted to passive 'relearning' and reproductive processing.

In *demand-driven education* "the student is the principal arbiter in making judgments as to what, when and how learning will occur. Typically, students not only select and sequence educational activities, but identify, create, cultivate, pursue, and satisfy their individual learning needs" (Hannafin, 1992, p. 54). Students make decisions in relation to both content and didactic elaboration. Content decisions are related to the specific themes, objectives, and activities that the students want to be involved in when tackling a specific domain. The central role of education is no longer the provision of basic standard arrangements, but rather allowing a divergence of thought and actions necessary for participatory (of both the 'teacher' and the 'learner') lifelong education.

Communicative systems theory and the way it is approached for education and teaching at the Research Centre Learning in Interaction at Utrecht University is playing an important role in finding a middle-ground between these three dichotomies. This systems approach demonstrates that behaviour is reciprocal and comprises sequences of interchanges that develop during the interchange process. The behaviour of Person A (e.g., a teacher, a peer, etcetera) influences the thoughts, actions, and even the desires of Person B (e.g., a learner, a peer, etcetera), and the behaviour of Person B in turn influences Person A. It is, thus, not a question of passive or active, student-centred or teacher-centred, supply-driven or demand-driven, but rather a fusion of the extremes.

At the Research Centre, learning in interaction in classrooms, school-based training environments, and the workplace (e.g., traineeships and internships) implies communication and interaction between teachers/trainers and their students or between students themselves. In this light, the systems approach to classroom communication (Wubbels, Brekelmans, Den Brok, & Tartwijk, in press; Wubbels, Créton, & Holvast, 1988) sheds important light on interactivity and learning in education. Further, the PhD research work being carried out by Tim Mainhard on the speed and stability of learner impression-formation about teachers will shed light on the determinants student-teacher interchange.

Cognitivism / Constructivism

The current dichotomy dominating the educational sciences – or maybe I should say the latest holy war that is raging – is between cognitivism and constructivism. Cognitivism, as theory and basis for teaching and learning, was discussed in a previous section.

Constructivism is neither an approach to nor a model for instructional design, but a philosophy of learning based on the idea that knowledge is constructed by the learner – and eventually 'the one(s) who know(s)' - based on his/her/their mental activity (Kirschner, Carr, Merriënboer, & Sloep, 2002; Stahl, 2004). The cognitive focus of learning as an intra-individual cognitive process (see earlier) shifted towards viewing learning as a predominantly social process whereby knowledge doesn't exist (see subjectivism), but is collectively constructed as a shared interpretation of 'the world around us' (Linden, Erkens, Schmidt, & Renshaw, 2001). From this point of view, an educational learning situation is seen as a community of learners where learners learn to take part in interactions in sub-communities of co-learners, practitioners, and professionals (Bruijn, 2004; Scardamalia, Bereiter, & Lamon, 1994). Discussion, argumentation, and presentation are important processes here, as are planning, organising, and carrying out communal activities. Sharing knowledge and information, and negotiating meaning and position are the constructive activities that determine learning as a social process.

Social constructivism also emphasises the importance of culture and context (historical, social, vocational) in understanding what occurs in society and work and in constructing knowledge and developing competent professional behaviour based on this understanding (Derry, 1999; McMahon, 1997). It contends that categories of knowledge and reality are actively created by social relationships and interactions. These interactions also alter the way that scientific categories are created and scientific objects are perceived.

Strangely enough, the most prevalent practices we encounter in education and whose proponents state that they are constructivist in nature, are actually firmly rooted in cognitive - or maybe better said socio-cognitive - theory. The pedagogy being espoused and used is primarily based upon the idea that learning needs to be situated in tasks and problem solving situations that are encountered in real-life contexts (situated learning / situated cognition; Brown, Collins, & Duguid, 1989), where the environment is rich in information, and where there are no correct answers. The tasks should be authentic and are best learnt through cognitive apprenticeship (Collins, 1988) of the learner in that rich environment. Meaning is negotiated through interactions with others where multiple perspectives on reality exist (social construction of shared perspectives: Von Glasersfeld, 1988). Reflexivity is essential and must be nurtured. Finally, all of this is best (and possibly only) achieved when learning takes place in ill-structured domains (cognitive flexibility; Spiro, Coulson, Feltovich, & Anderson, 1988).

The Research Centre Learning in Interaction is attempting to find a middle ground between these two warring tribes, making use of techniques such as argumentation and dialogue, and with them the accompanying tools and pedagogies. As such, it attempts to bridge the gap between the often objective cognitivist view of knowledge that needs to be 'acquired' and put into and/or organised in schemata and the subjective constructivist view that all knowledge needs to be discovered and constructed.

Examples of research being done at the Research Centre are projects being carried out with the Virtual Collaborative Research Institute (VCRI) environment for project-based learning (Erkens, Jaspers, Gisbergen, Phielix, & Kanselaar, 2003; Jaspers & Erkens, 2002), Computer-Support for Collaborative and Argumentative wRiting (COSAR; Erkens, Prangsma, Jaspers, & Kanselaar, 2002), Dialogic and argUmentative Negotiation Educational Software (DUNES; Diggelen, Overdijk, & Andriessen, 2004), Supporting Collaborative Argumentation-based Learning (SCALE; Amelsvoort & Andriessen, 2003), and Knowledge Construction during

Computer supported collaborative writing (Twins; Munneke, Amelsvoort, & Andriessen, 2003). Generally speaking, during problem solving students are expected to make various claims about the domain and the potential solutions of problems that they are presented. On the one hand they must make use of the knowledge that they either already have or the knowledge present in the learning materials to solve problems. On the other hand, they are expected to express their doubts regarding claims and solutions, and thus to build argument structures and new knowledge during problem solving. In other words, the active engagement of learners in collaborative argumentation and constructive dialogue during problem solving gives prominence to cognitive conflict and query as mechanisms for enriching, combining and expanding understanding of problems that have to be solved (Savery & Duffy, 1995) while carrying out activities that encourage learning through mechanisms such as externalising knowledge and opinions, self-explanation, reflecting on each other's information, and reconstructing knowledge through critical discussion (Andriessen, 2006; Kanselaar, de Jong, Andriessen, & Goodyear, 2000; Kanselaar & Erkens, 1996).

Another fine example of research within the Research Centre is the post-doc project acquired and being carried out by Marieke van der Schaaf on internal dialogue in the form of self assessment and reflection and external dialogue in the form of peer feedback of co learners and feedback by teachers in terms of formative assessment and the interaction between these two types of dialogue (Stokking & Schaaf, 2004).

Independent / Dependent

At present, education is having a very tough job with the final dichotomy that I will discuss, namely that of independence versus dependence with respect to both learning and assessment. The reason that this dichotomy is giving the field such a great headache is that there is a direct relationship between dependence/independence and the examination and certification functions of education and educational institutions.

Independent learning[18], as used here, is based upon a *competitive* and *individualistic* learning paradigm. Students study and learn independently of one other and of the educational context, and are often assessed in competition with each other. Learning, which is often seen as the acquisition of knowledge and skills, is considered an individualistic achievement of each learner herself/himself and is assessed as such. Goal achievement is autonomous and unrelated to what other students do (Deutsch, 1962, Johnson & Johnson, 1989).

> In an individualistic learning situation, students are independent of one another and are working toward a set criteria [*sic*] where their success depends on their own performance in relation to an established criteria [*sic*]. The success or failure of other students does not affect their score (Johnson & Johnson, 1988, ¶7).

In this situation, students focus on self-interest and personal success and ignore the successes and failures of others since this is irrelevant to them. This is complicated by the testing culture[19] prevalent in most educational institutions. From the point of view of the educational institution, independence means that testing and its results can be classified as objectively reliable and valid and that they give a good idea about what the learner has learnt and/or the student has achieved. Decisions, including high-stakes decisions, affecting the educational and societal future of the learner can be made based upon the testing. From the point of view of the learner, this independence and with it the competition involved, would logically lead to a refusal to exchange information and to behaviour that is oppositional, distrusting, and misleading. Since many teachers grade 'on the curve', helping another learner can even be detrimental to the individual learner. If learner A helps learner B to learn, then learner B will possibly score higher on an examination than (s)he originally would have and thus the value (in terms of a grade) of learner A's test-result will be lower!

Dependent learning is defined here as learning whereby learning goals, goal achievement, the learning processes employed, and ultimately the assessment of learning is completely dependent upon others, Learning is seen as more than the acquisition of knowledge and skills, but rather as the acquisition of competencies which include not only individual knowledge and cognitive skills, but also attitudes and interpersonal skills (i.e., social and affective). The learning process is a group process leading to group achievement and is assessed as such. To paraphrase the quote by Johnson and Johnson in the previous paragraph:

> In a dependent learning situation, students are dependent upon one another and are working towards team-determined criteria where their individual and group success depends on both their own performance and the performance of the group in relation to common criteria. The success or failure of other students directly affects the score of each individual. Goal achievement is reliant and related to what other students do.

In this situation, students focus on common good and interest whereby the personal success is dependent on the successes and failures of others. Key terms in this respect are positive interdependence and promotive interaction.

Positive interdependence (Johnson, 1981) reflects the level to which group members are dependent upon each other for effective group performance. It holds that each individual can be held individually responsible for the work of the group and that the group as a whole is responsible for the learning of each of the individual group members. Team members are linked to each other in such a way that each team member cannot succeed unless the others succeed; each member's work benefits the others (and vice versa). Essential here is social cohesion and a heightened sense of 'belonging' to a group. *Promotive interaction*, according to Johnson and Johnson (1996),

> …exists when individuals encourage and facilitate each other's efforts to complete tasks in order to reach the group's goals. … [It] is characterized by individuals providing each other with efficient and effective help and assistance, exchanging needed resources … acting in trusting and trustworthy ways, being motivated to strive for mutual benefit …. Promoting each other's success results in group members' getting to know each other on a personal as well as a professional level (p. 1028-1029).

From the point of view of the learner, this dependence is expected to lead to behaviour that is characterised by information exchange and mutual influence upon each other's actions and to feelings of trust, liking, and acceptance. Since each learner's individual grade is dependent upon the learning of others, negative group behaviour such as free-riding / hitchhiking, social loafing, and suckering is eliminated (Kerr, 1983; Kerr & Bruun, 1983; Latané, Williams, & Harkins, 1979)[20]. In true dependent learning, if learner A helps learner B to learn, then the team grade will be higher due to:

- *shared understanding* where team members have equivalent expectations about a situation (i.e., explanations of the situation and predictions for how it might develop are the same);
- *accountability* leading to responsible behaviour (e.g., not working for the disadvantage of a fellow team member;
- *trust*, such that team members decide to accept risks based on the expectation that another party will meet the performance requirements;
- *social cohesion* whereby group members tend to stick together and like and trust one another; and
- *predictability* where team members expect an outcome on the basis of prior team experience (Kirschner, 2002).

What is the middle ground here? Interdependent learning!

Interdependency and Interdependent Learning

What, then, is interdependence? Going back to Wikipedia,

> *Interdependence* is a dynamic of being mutually responsible to and dependent on others. Some people advocate freedom or independence as a sort of ultimate good; others do the same with devotion to one's family, community, or society. Interdependence recognizes the truth in each position and weaves them together.

From this definition, it is clear that interdependence has both an independent aspect (i.e., individual responsibility) and a dependent one (i.e., dependent upon others). This concept of interdependence is a 'given', for example, in biology where it is visible from the level of the earth and whole ecosystems down through local habitats, to individual cells in our bodies and one-celled organisms in nature. In biology/ecology every cell, plant, animal, and local habitat (including its topography and micro-climate) functions in ways that are on the one hand independent of all of other elements, while on the other hand integrally related to and dependent upon all of the others. A lake, for example, is a very complex system made up of water, fish, water plants, and innumerable other elements. However, a plant or fish or even the plankton in a lake is not 'just' an element of the lake, but are also complex systems on their own that interact with the lake. The lake too interacts with the rest of the environment including the rivers feeding it and running from it, the climate, etcetera. In other words there is an interaction and interdependency between all of the different systems. Too few phytoplankton eaters, whatever the cause, will lead to an increase in phytoplankton, less sunlight reaching the lower depths of the lake, the plant growth at the bottom of the lake, the amount of oxygen in the water, fish life and populations, and so forth. While the system can and does influence and affect each different component of that system, each individual element also can and does influence and affect the larger system. Coming back to my original argument at the beginning of this address, though other sciences seem at ease accepting this, the educational sciences are not that far.

Fortunately, this need not be the case. There are forms of teaching and learning that make use of this increasing awareness of interdependence such as reciprocal teaching[21], peer tutoring[22], cooperative or collaborative learning[23] and learning in communities. In these forms of teaching and learning we see, for example, interdependence with respect to:

- *product goals* that require contributions from all members;
- *resources* where individuals each possess specific resources needed for the group as a whole to succeed;
- *roles*, such as when team members are assigned specific roles or even when the teacher assumes a different roles as in team teaching situations;
- *tasks* or *work-flow* where one group member must first complete his/her task before the next task can be completed; and even
- *rewards* in the form of shared grades (Foundation Coalition, n.d.).

Educators and educational scientists, fortunately, are slowly-but-surely also seeing that education itself is a system composed of interdependent elements[24]. We see, for example, new and different forms of assessment together with research on accompanying new ideas about determining their reliability and validity (Baartman, Bastiaens, Kirschner, & Vleuten, 2006, in press) to assess both dependent and independent learning in competence assessment programmes.

Interdependence implies Interaction

All behaviour that someone or something displays in the presence of someone or something else is a form of interaction. As was seen in the previous biology example, there are numerous

interactions between the different animate and inanimate elements of the lake and its surroundings.

When two people interact, one person will infer meaning from the other person's behaviour, independent of what the other person's intentions are. When a person interacts with her/his environment, a change will occur in both the person and the environment (or at least that person's subjective perception of it[25]). As a result of this interaction, the person will infer specific meaning from the environment, independent of that 'objective' environment[26]. Going back to communication systems theory, this meaning has both a content aspect and a relational aspect (Watzlawick, Beavin, & Jackson, 1967). The content aspect conveys information or description while the relational aspect carries instructions about how the content can or should be interpreted. Teachers and students in a class or students in a team relate in ways that are external to and independent of the subject matter (content). A learner walking through a museum or a forest relates to the exhibits or the surroundings (in the terms used within the Research Centre, the *artefacts*) independent of those surroundings. What students (and teachers) learn depends on the meaning they attach to content influenced by the relation between the actors themselves or between the actors and the artefacts. In other words, learning is interdependent and a function of and directly related to how they interact!

The patterns of interaction that take place, according to Watzlawick c.s., are either symmetric or complementary, depending on whether they are based on equality or on difference. In symmetry, one person's behaviour is followed by the same kind of behaviour by the other person. In a symmetric interaction if Person A helps Person B, for example, then Person B will subsequently help Person A. For complementarity, the interactions show opposite behaviours. In a complementary interaction, if Person C comes up with a good idea, for example, then Person D will take the initiative to work it out. Research has shown regularities in how certain types of behaviour in one person elicit certain types of behaviour in others (Leary, 1957; Tracey, 1994). A dominant teacher, for example, can expect to elicit obedient student behaviour and a friendly teacher can expect to elicit a pleasant student reaction. These notions help explain and interpret responses of participants in sequences of interactions.

The rest of this address will discuss how the Research Centre Learning in Interaction will attempt to study this interdependence through studying interaction with as ultimate goal:

> Furthering the development of an *integrated theory of interaction* within learning and instructional processes.

Research Programme

The educational sciences is an international, multidisciplinary area of study with branches and specialisations relating to history, sociology, policy, administration, organisation, psychology, economy, and law, as well as a number of traditional core areas such as initial teacher education/training, curriculum development, and learning and instruction. The research programme of the Research Centre Learning in Interaction - *Interactivity and Learning in Education* - which I am charged with leading, concerns the core area learning and instruction, and specifically the individual and social regulation and coordination of the *interaction* between all participants and artefacts in the teaching and learning environment. The quality of the interaction, which is largely based upon and determined by individual and social regulation and coordination, plays a major role in determining the yield of the learning processes. The central question guiding the programme is:

> *How can we explain and/or account for the development, quality and yield of learning processes in terms of interaction and the individual and social regulation and coordination of that interaction?*

The central theme of the research programme is based upon the premise that learning processes best occur, and thus that learning can best take place, when instruction facilitates, stimulates or activates: (I) interaction with others such as peers and experts in pairs, teams, or communities through different forms of external dialogue, (2) interaction with oneself on the individual cognitive and metacognitive level via internal dialogue, (3) the confrontation between internal and external dialogue including the social relationships that arise as a result of this , and (4) the interaction between the individuals and others with the learning, training, and social environment in which learning and instruction is taking place, including the environment's physical, temporal and emotional attributes (i.e., its affordances, constraints, and conventions).

Research Foci

The research programme focuses on three global types of interaction in learning and instruction which are not mutually exclusive and are often complementary or supplementary to each other. This means that research can be limited to (or possibly better said: primarily focussed on) one of the three foci, but more often than not, the research being carried out will find itself either on the boundary of two or more foci or even within two or more foci. This 'crossing-borders' research is encouraged.

Interactivity between Instructor and Learner

The first focus of the research programme is concerned with interactivity between an instructor and/or trainer (including more knowledgeable peers; a situation more often experienced in vocational than in academic education) and one or more learners. Most educational settings, including vocational education settings, are based upon an instructor-learner (i.e., more knowledgeable vs. less knowledgeable) paradigm. The premise is usually one of transfer of knowledge, skills, and attitudes. The research programme *Interactivity and Learning in Education* takes this paradigm three steps further. First, it extends the usually unidirectional concept of transfer of knowledge, skills, and attitudes from a more knowledgeable to a less knowledgeable person to a *bidirectional* concept. Not only does the more knowledgeable participant in an interaction-process transfer knowledge, skills, and attitudes to the less knowledgeable participant, but the less knowledgeable participant also transfers knowledge, skills, and attitudes to the more knowledgeable participant. This interaction relates to not only transfer in the traditional sense, but also to transfer of information (i.e., communication) relating to the knowledge state of the learner/participant and the learning situation such that real adaptive and interactive learning and instruction can take place. Second, it extends the concept of 'more knowledgeable' to *peers* who, through age, experience, and/or situation can assume a role that they normally do not take in the teaching-learning process. This approach, though not often encountered in general and pre-university secondary education[27] (HAVO and VWO) where strict boundaries exist between levels and school types, is often encountered in vocational education where higher vocational education students (HBO) instruct/train those still studying at the vocational or pre-vocational levels (MBO and VMBO) in the workplace during traineeships or where those further within the same level of vocational education (e.g., seniors) assume this role with those less far (e.g., sophomores or juniors). Finally, it extends the paradigm from one of singular ownership and transfer (unidirectional or bidirectional) to one of *multi-ownership, multidirectional sharing and creation*.

Interactivity between Equivalent Learners

The second focus concerns interaction between learners of equal knowledge. This can be learners who are all at a novice level, learners who are all at an expert level, and even learners who have a specific knowledge in one area, but not in another as is often the case when working in multidisciplinary fields. This last example could also be argued to fit in the prior focus since there is mention of more and less knowledgeable persons, depending upon the domain in question. Peer learning, team learning, collaborative and cooperative learning, communities of

learning, and communities of practice are all examples of modalities in which learners interact with each other in different ways. The focus here is on research on the underlying principles behind the affordances[28] that can be made available in these situations to stimulate and facilitate learning in interaction. These affordances can be either social (e.g., affordances that allow for the creation of warmth, trust, acceptance, liking, etcetera between learners in groups) or pedagogic and/or educational (e.g., affordances that allow for the creation of learning situations and/or learning tasks that promote positive interdependence, promotive interaction, feelings of control, and feelings of ownership), and will often make use of different dialogic and argumentative techniques (e.g., coercion/constraints, scripts, sentence-openers).

Interactivity between Learners and Artefacts/Tools

The final focus pertains to how learners interact with specific categories of tools meant to increase or facilitate interaction (i.e., technical affordances). Examples are collaborative teamware (e.g., TC3 - Text Composer, Computer supported and Collaborative; VCRI - Virtual Collaborative Research Institute; FLE3 - Future Learning Environment 3), mindtools / tools-for-thinking (e.g., graphical organisers, concept maps), widgets (e.g., sociability and awareness widgets, Participation Tool, Negotiation Tool), and representation tools (e.g., diagrams, lists, matrices). These all have the expressed intention of enabling learners to interact with each other so as to increase the effectiveness and efficiency of learning and/or to increase the sociability, social presence, or social space in which learners interact. Based upon fundamental theoretical premises, research in this area will focus on the design, development, and implementation of such tools.

Research in these three areas should lead to the achievement of three short-term goals.

Short-term Goals

Instructional Guidelines

The first goal of the programme is the *design, development, and testing of instructional guidelines for implementing interaction in learning and instruction*. The research programme should yield approaches to learning and instruction that can help practitioners build interaction into their courses. The insights and results gained through research should be transformed and/or translated into instructional guidelines that identify and account for: (a) instructional methods that can be used to establish and/or maintain interaction, (b) potential functions and benefits of the chosen methods, and (c) warnings about implementation difficulties of the methods. For example, Alamargot and Andriessen (2002) reviewed the learning mechanisms involved in individual writing, and extended these findings to general design principles for interactive learning during electronic communication from the viewpoint of electronic text production as an act of writing.

Affordances

The second goal of the research programme is concerned with creating *affordances for achieving interaction in learning and instruction*. Because interaction 'seems' to come both automatically and effortlessly in traditional communities (actually this is not the case), some tend to take it for granted that this social interaction will also come automatically in collaborative learning or CSCL environments since these environments have at their disposal tools that make interaction possible. Unfortunately, this is not true (for examples, see Kirschner, Martens &, Strijbos, 2004). Instead, careful design of technological, educational, and social affordances is necessary to promote effective group forming activities (Kirschner, 2002). Technological affordances can be as simple as a whiteboard (which affords written communication being captured and seen at a distance in a classroom) or as complex as a real-time, shared electronic whiteboard (which affords synchronous collaborative written communication across the planet within milliseconds).

Educational affordances are those characteristics of an artefact that determine if and how a particular design affords learning. In other words, the chosen educational paradigm – the artefact – is instrumental in determining if and how individual and team learning can take place within a given context (e.g., project team, distributed learning community). Social affordances are "properties of a [CSCL] environment that act as social-contextual evocators relevant for the learner's social interaction" (Kreijns, Kirschner, & Jochems, 2002, p. 13). Social affordance theory offers a relatively new perspective on the design of CSCL and learning communities. While it is a promising approach, the instructional theory is still in its infancy.

Tools

The third goal of the research programme pertains to developing both *generic and dedicated tools for achieving interaction in learning and instruction*. These tools range from simple, ubiquitous, yet unobtrusive widgets and agents (that can trigger or support interaction) via generic and dedicated tools (that can stimulate, coerce and/or facilitate interactive and collaborative execution of design-based or project-centred tasks, problem solving, debate, discussion and/or argumentation) to complete environments dedicated to interactive learning processes.

Longer-term Goal

With respect to the field of the educational sciences (and its allied fields of educational psychology, educational technology, and the learning sciences), the research programme is aimed at furthering the development of an *integrated theory of interaction* within the learning and instructional processes. Current theories often focus on one or more aspects of enhancing the understanding of how learning occurs, how knowledge (and skills and competences) are acquired, constructed and used, and how learning can be organised both in various phases of life and in different contexts. The research programme *Interactivity and Learning in Education* endeavours to integrate these different aspects of learning and knowledge acquisition into a framework.

By definition, the educational sciences are multidisciplinary (note the use of the plural in the name itself). Theories from many different research fields yield valuable input for the further development of theory within the educational sciences. Broadly speaking it should be clear that, for example, theories in the fields of perception and cognition, teaching, learning, social psychology, self-regulation and motivation, and student perceptions can have far reaching implications for the further development of a theory of interactivity in educational learning processes.

To this end, the programme stresses research on education, learning, and interactivity that (1) is based upon a well thought-out and worked-out theoretical framework (preferably from one of the four theoretical bases discussed in the next section), (2) is aimed at making real progress in our thinking and in the practice of instruction and learning (preferably ecologically valid, though not to the exclusion of more experimental research), (3) aspires to the discovery and the production of guidelines and tools for designing, developing and implementing effective, efficient, and/or enjoyable learning, and (4) ultimately leads to furthering our understanding of the role of interactivity in learning and education.

The ultimate goal of the research programme is, thus,

> to make meaningful advances towards an integrated theory of interactivity in learning and education based upon a socio-cognitive foundation.

In addition to this, the research programme need be a breeding ground for the new Research Master Programme at Utrecht University, *Learning in Interaction.*

Research Master

The research programme *Interactivity and Learning in Education* will contribute to the realisation of the goals of the new Langeveld Institute for the Study of Education and Development in Childhood and Adolescence at Utrecht University, and specifically the study programme for the research Master of Sciences in the Educational Sciences: Learning in Interaction (MSc EdSci). This programme offers a systematic analysis of educational phenomena and problems, preparing its students for careers in scholarly research and in teaching with the goal of developing theory and research. Domains – and developments within them – which contribute to the theoretical knowledge base of the programme are:

- recent developments in cognitive neuroscience and learning theories on understanding mind, cognition, and learning for application to teaching-learning processes,
- advances in educational psychology concerning processes of interaction in education between students, teachers, and new media,
- advances in theories on group processes from social psychology, pedagogy, and sociology to understand classrooms as social settings,
- socio-constructivism and theories on knowledge acquisition in the subject domains, and
- theories on longitudinal pathways in student and teacher cognitive development.

The research master programme emphasises an apprenticeship model of scholarship (i.e., based upon interaction between more knowledgeable and less knowledgeable actors) with engagement in substantive problems of learning and teaching. Students collaborate with faculty to develop research studies in each of the two years of study. Courses are coordinated to promote the development of research and communication skills, so that students can become involved with important problems in educational research. This graduate programme emphasises the development of:

- a strong foundation in research, principles, and theories of learning, instruction and teaching as the basis for growth throughout the professional career,
- competence in conducting high-quality educational research, and
- capacities and skills to apply basic knowledge and specific research methods from different domains to the study of learning in interaction.

In other words, a programme about interaction in learning and education based upon a pedagogy of interaction.

A Few Words of Thanks

I've now arrived at the end of my address, where I get to thank people. Although there are many people who need thanking, I'll use this space to single out a few.

To begin, I would like to thank both the members of the Board of Governors of Utrecht University and the Dean of the Faculty of Social and Behavioural Sciences, Prof. Willem Koops, for their faith in me. I only hope that I can live up to their expectations of setting up both a Research Master and a research programme. I would also, in this respect, like especially thank both Prof. Theo Wubbels, Director of IPEDON and Vice-Dean of the faculty and my 'predecessor' Prof. Gellof Kanselaar. Theo, from the moment that you telephoned me with a very unexpected question until this very minute you have been a wise and understanding colleague and coach. Thanks for making a very difficult transition much easier. And Gellof, your peer teaching in the first few months that we shared a room helped clear a path in the UU-jungle.

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Femke, Jesse, Mara, and Aron. As defining elements of my nuclear family you are the electrons that determine our particle-wave duality. At times you are the waves whose interactions with each other and with me form the interference effects that cause me to sit-up-and-think, to learn, and to grow. At other times you are particles, moving to new energy and intellectual levels that make me sit-back-and-enjoy and just be proud.

And finally Catherine. They say that there is an exception to every rule and that this exception actually makes the rule. Well, you are the exception to rule about interdependence. The longer we are together, the more I realise that I am completely dependent upon you. As the Supremes sang, "my world is empty without you". There is nothing more that I can say or do to express my love for you and my gratitude to you for putting up for me for this long. Thank you for letting me depend on you.

I have spoken.

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Notes:

[1] Great Men, Great Thoughts, and the Environment William James lecture delivered before the Harvard Natural History Society in 1980 (*Atlantic Monthly, 46*(276), 441-459).

[2] These are the last four lines of *Among School Children*, written by William Butler Yeats in 1926. With these lines Yeats describes the synergy between art and its creation as being one and interdependent.

[3] "Interdependence is and ought to be as much the ideal of man as self-sufficiency. Man is a social being. Without interrelation with society he cannot realize his oneness with the universe or suppress his egotism. His social interdependence enables him to test his faith and to prove himself on the touchstone of reality. If man were so placed or could so place himself as to be absolutely above all dependence on his fellow beings he would become so proud and arrogant as to be a veritable burden and nuisance to the world. Dependence on society teaches him the lesson of humanity. That a man ought to be able to satisfy most of his essential needs himself is obvious; but it is no less obvious to me that when self-sufficiency is carried to the length of isolating oneself from society it almost amounts to sin. A man cannot become self-sufficient even in respect of all the various operations from the growing of cotton to the spinning of the yarn. He has at some stage or other to take the aid of the members of his family. And if one may take help from one's own family, why not from one's neighbors? Or otherwise what is the significance of the great saying, "The world is my family?"" Mohandas K. Gandhi, Young India, March 21, 1929.

[4] Dr. Sterling Fausto (Myths of Gender: Biological Theories About Women and Men, 1992) speaks of a smooth continuum between 100% biologically male and 100% biologically female. She posits that between 1.7% (conservative estimate: http://www.isna.org/faq.html) and 4% (bold estimate) of the population are intersexual (a difference between anatomic, endocrine and genetic sex). That is 17,000 people per million. In comparison there are 4 Siamese twins, 1000 people with Down's syndrome and 1400 people with harelip per million in the population.

[5] Entrance to the Bronx High School of Science (http://www.bxscience.edu/) is based on a competitive written examination, known as the Specialized High School Admissions Test, which assesses knowledge and skills that are needed for success in a high school for high achieving students. This exam is open to all eighth and ninth grade New York City students, but of all of the applicants only 900 are admitted yearly. It has produced seven Nobel Prize winners. In comparison, Utrecht University has produced four.

[6] Stony Brook University has been ranked in the top 2% of all universities in the world. In 2005, the London Times Higher Education Supplement placed it 136 among more than 8,300 universities worldwide, and in the top 50 in North America. Among science universities, Stony Brook ranks in the top 100 in the world, top 25 in North America, and top 10 among public universities.

[7] The launching of Sputnik in 1957 signalled the onset of an increase in cooperative efforts between specialists in science and specialists in education in the United States, the so-called 'Sputnik shock', to improve science teaching and create special schools to help narrow the 'engineer/scientist gap'. Just after that, the Bronx High School of Science got a new building complete with telescope on the rook and mainframe computer (the first in a high school in the United States) and SUNY at Stony Brook got its new campus together with its dream to become the Stanford of the east coast.

[8] The UvA was then called the City University (Gemeente Universiteit), abbreviated to GU.

[9] Jos van Kemenade, the then minister of education, had an idea called the "middenschool" and produced a Contourennota (Contouren van een toekomstig onderwijsbestel [Profile of a

future educational system], Tweede Kamer, zitting 1974-1975, 13459, nr. 2) containing building blocks for a not-yet-completed future (the makable society as it was called) with the goal of distributing knowledge so as to distribute power (Soetenhorst, 1999).

[10] Onderwijspsychologie, Onderwijskunde en Andragologie

[11] Objectivism believes that objects are independent of mind and present their properties directly to the knower through sense data. Things known and sense data are one (epistemological realism as epistemological monism).

[12] Guba and Lincoln (1982) talk about the nature of positivism in terms of the rationalist paradigm of inquiry. They discuss the positivist nature of reality like this: "There is a single tangible reality fragmentable into independent variables and processes, any of which can be studied independently of the others; inquiry can converge on this reality until, finally, it can be predicted and controlled."

[13] Subjectivism argues that because knowledge is confined to ideas in the mind of the knower, it is impossible to get beyond these ideas to an objective or material reality separate from and independent of the knower. Perceptions and things known are one (epistemological monism) and can only be known as ideas in the mind of the knower (epistemological idealism).

[14] Critical psychology started in the 1970s in Berlin at the Freie Universität Berlin. It tries to reformulate traditional psychology on a Marxist base as an attempt to come to grips with the social and the historical "conditionality" of human beings. (Wikipedia)
Broadly speaking, critical psychology is concerned with how 'realities' – objects, events, identities, experiences and everyday practices of living – are constructed within and by particular culturally-specific discourses or ways of talking or writing; with the ways in which culturally dominant (or subverting) 'versions of reality' are produced as 'truth'; and with the ways in which these 'regimes of truth' re-produce particular relations of power and regulate us in culturally-specific ways
(http://science.uwe.ac.uk/psychology/TheCriticalPsychologyResearchGroup.htm).

[15] Rote learning focuses on memorizing the learning material so that it can be recalled by the learner exactly the way it was read or heard.

[16] For a complete review of the discussion pertaining to this topic see:
Kirschner, P. A., Sweller, J., & Clark, R. E. (2006, In press). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*.

[17] Unfortunately formal learners were almost always men and, thus, the nonsexist him/her is not relevant here.

[18] Independent learning can be taken two ways. The first interpretation deals with the type of learning propagated by and implemented in open and/or distance teaching institutions such as the Open Universiteit Nederland. Here, students study and learn independent of direct tuition (i.e., there is no teacher, the materials are developed for guided independent study) and often at their own discretion with respect to place and time. The second way, and the way used in this address, refers to learning in traditional educational settings (i.e., with a teacher, at the same time and place) but completely individually.

[19] The testing culture is based on a classic view of education with a focus on whole-class teaching and individual knowledge acquisition and is based on the requirements of psychometric test development (Birenbaum, 1996). The learner is viewed as a passive receiver of the knowledge presented by the teacher, and assessment is used almost exclusively as a summative measurement (Dochy & Janssens, 2003).

[20] The *free-rider or hitchhiking effect* exists when group members exert less effort as the perceived dispensability of their efforts for the group success increases (Kerr & Bruun, 1983). In other words, they feel that the group is doing enough and that they don't have to

contribute. *Social loafing* (Latané, Williams, & Harkins, 1979) exists when group members exert less effort as the perceived salience of their efforts for the group success decreases. In other words, as the group size increases so does the anonymity and the non-participation. The social loafer differs from the free rider in that the first lacks the motivation to add to the group performance, while the last tries to profit from others while minimizing essential contributions. Finally, the *sucker effect* (Kerr, 1983) exists when the more productive group members exert less effort as the awareness of co-members free-riding increases Those group-members refuse to further support non-contributing members (they refuse to be 'suckers') and therefore reduce their individual efforts.

[21] Reciprocal teaching (Palincsar & Brown, 1984) manifests itself in a dialogue between teachers and learners where participants take turns assuming the role of teacher and/or learner. It is interactive instruction in which the teacher or peer leads a group of students. As they work together, group members will monitor their understanding by stopping at regular intervals to ask questions, summarize, predict, and clarify.

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*, 117-75.

[22] Peer teaching involves students learning from and with each other in ways that are mutually beneficial and involve sharing knowledge, ideas, and experience between participants. The emphasis is on the learning process, including the emotional support that learners offer each other, as much as the learning itself.

Boud, D., Cohen, R., & Sampson, J. (2001). *Peer learning in higher education: Learning from and with each other*, London: Kogan Press.

[23] Collaborative and cooperative learning are not the same. According to Panitz (1997), while collaboration is a philosophy of interaction and personal lifestyle, cooperation is a structure of interaction designed to facilitate the accomplishment of an end product or goal through people working together in groups. Although different, they share a large number of assumptions and areas of agreement such as:

- learning takes place in an active mode,
- the teacher is more a facilitator than a "sage on the stage",
- teaching/learning are shared experiences between teacher and learner,
- students participate in small-group activities,
- students must take responsibility for at least part of their learning,
- discussing/articulating ideas in a group enhances the ability to reflect on assumptions and thought processes,
- social and team skills can be developed, and
- students profit from belonging to a small and supportive academic community.

Panitz, T. (1997). Collaborative versus cooperative learning: A comparison of the two concepts which will help us understand the underlying nature of interactive learning. *Cooperative Learning and College Teaching, 8*(2). Also available at http://home.capecod.net/%7Etpanitz/tedsarticles/coopdefinition.htm

[24] Much of the failure of educational innovations may be due to the inability of educators, educational scientists, and/or educational administrators (up to the highest level of school and government) to realise that teaching, learning, and assessment are three parts of an interdependent system with feedback-loops between all three. The best laid plans for innovation are often thwarted by assessment (i.e., examination and certification) that is not properly aligned with the educational approach used and the learning approach strived for.

[25] Research attributes the experience encountered by almost all people making a trip that the return trip almost always seems shorter than the original journey to the fact that the return trip is familiar to the traveller since (s)he has already experienced it. In this case, the

objectively equal distance of both trips is experienced differently due to the original interaction between person and environment.

[26] When I walked in the hills of Limburg with a colleague we were in the exact same environment, but not only experienced completely different things, but also saw completely different things. My colleague is a geologist and sees geological deposits and planes of fracture, I am an avid cyclist and I see gear ratios and climbing gradients.

[27] Secondary education encompasses schools providing pre-university education (VWO), senior general secondary education (HAVO), vocational education (MBO), pre-vocational secondary education (VMBO) and practical training (PRO).

[28] The term affordance refers to the relationship between an object's physical properties (its artefacts) and the characteristics of an agent (user) that enables particular interactions between agent and object. Gibson defined that "the affordance of anything is a specific combination of the properties of its substance and its surfaces with reference to an animal" (Gibson, I977, p. 67). A pond, due to the surface tension of the water, affords a surface to walk on for certain species of flies while also affording a living environment for certain types of fish. Knobs are for turning and slots are for inserting things. These properties / artefacts interact with potential users and provide strong clues as to their operation (think of a child, his/her peanut butter sandwich, and the slot in a video recorder which affords a perfect place for propping the sandwich or a set of steps with risers four feet high which does not afford the act of climbing if the actor is a crawling infant). In other words, affordances have a perception-action coupling (i.e., you perceive something and this leads to one or more actions) and the relationship is reciprocal (i.e., you must have the ability to take the action and the artefact must support the action).