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The Learning Process According to the Brain

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Abstract: Brain research provides a lot of findings more than relevant for educational planning and performance. On the basis of six characteristics of learning this paper tries to draw practical conclusions for teaching in general and for technology enhanced learning in particular.

1 What is Learning?

When teachers talk about learning they very often are thinking of a more or less mechanical process, at least in Austria and in particular concerning to technical teachers. One of the most popular models in this community is the simple sender-receiver relation: the input (information given by the teacher) is identical with the output (knowledge gained by students) as long as the teaching/learning process is working free of defects.



Another visualisation is the bricklayer-conception which means that knowledge can only be built up in a strictly systematic way: first the basics (principles and methods), then all the theories in detail, and at last some applications of those theories. Again a more or less linear input-output relation aggravated by the necessity to follow a rigorous sequence.

Behind both models stands the idea of learning as sedimentation of knowledge objects from outside in the brain of learners. According to this approach, knowledge is not the subjective and personal achievement of the individual, but an objective item absorbed by learners experiencing this transfer rather passively.



Real learning, in contrast, is completely different – as far as we know from brain research. The following short overview to the current state of knowledge is motivated didactically, therefore truncated and not complete.¹ Experts in learning psychology will not learn anything new. But teaching practitioners of many other subject matters hopefully will.

1.1 The Brain is no Battery

In contrast to some widespread opinions learning *never* can be passive transmission and storage of information comparable to the transmission of electric current in a power cable and its storage in a battery. In fact learning is the active reaction of the individual to signals coming from the outside or inside world – according to his or her momentary state and needs. This means that the result of the reaction to one and the same stimulus may differ from time to time and from person to person. In educational terms: the success of a single teaching stimulus can *never* be guaranteed to 100% – even under the most standardized conditions. This leads to the next quality of learning.

1.2 Learning is Subjective

How an individual person will react to one single stimulus, to a number of simultaneous signals or to the complete situation depends on the experiences made in the lifetime before – in every single moment of his or her life. It is the history of experiences that determines our reactions at the moment. Since their biographic experiences overlap to a certain amount if people are members of the same culture their reactions will be similar to some degree too. But they can *never* be *identical*.

¹ German readers can find the details in Spitzer (2000; 2003). English readers may choose Jensen (2000) or Jossey-Bass Publishers (2007).

1.3 *Misunderstanding is the Rule*

Perception and learning of humans do *not* result in an *image* of the outside world – like a multi-dimensional picture. Humans construct the individual *world* they are living in at the moment according firstly to the signals they got in the past, secondly according to the signals they get at the moment and thirdly according to the feedback from outside to our reactions to the received signals. In other words: We see – we understand what we see according to what we have seen yesterday – we act according to this understanding of the world – we receive feedback from the world to our actions – and we reconstruct our understanding according to this feedback. This process is endless and permanently adopting and approving our actions. In this cycle we have to make conclusions on the basis of insufficient information. Consequently human knowledge is always limited to the status of assumptions.² Consequently our subjective construction of reality is not a common property, but it is *different* as a matter of principle and *may* show some *similarities* with the reality of our neighbour individuals. Misunderstanding is the rule – and not the exception. Humans must learn to handle this permanent conflict – especially in an educational context.

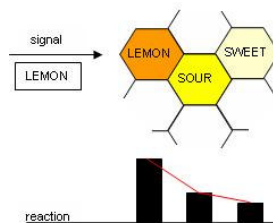
1.4 *Learning Depends on the Situation*

This is a very important aspect for our context. The information processing in human brains always deals with the whole situation which encloses – *amongst others* – the processed information. If the situation changes the learning outcomes will also change. If, for instance, a special content is learnt under water (wearing a diving suit) the learning results will be better under water than on solid floor (Godden & Baddeley, 1975).

1.5 *Learning is Cross-Linked*

Considered from an electro-physical point of view learning is the transmission of weak electric currents within a neuronal network increasing the capacity of the circuit with each pass. A single neuron (out of some billiards in one human brain) is connected to approximately 10.000 other cells. Consequently the arousal is passed on not to one but to hundreds or thousands neighbouring neurons. A network is generated and the nearer the neurons are located to each other the higher the impact from the source cell on the target cell.

The notions “LEMON”, “SOUR”, and “SWEET” for instance are represented by neighbouring groups of neurons, so called cards. If “LEMON” is addressed by a neuronal signal, not only the next card “SOUR” will be activated (a little less) but also the next but one “SWEET” (again a little less).



2 Who Is Learning?

In the context of open distance learning (ODL) and e-learning or technology enhanced learning a specific category of terms – all beginning with “self” – has become popular: e.g. self study, self-learning, self-study phases, self-learning course, or self-learning method. Now the question arises: If there are *self-learning* phases, methods, etc. – *who* is doing the job of learning for the rest of the time respectively in the rest of situations?

We could – benevolently – suppose that all these terms are the result of linguistic impreciseness. What they actually mean is self directed learning. But this assumption cannot solve the problem completely because many of the learning situations mentioned above are highly structured – and therefore the definite *contradiction* of *self-directedness*. The background of these terms might be a rather different one: it seems to be the individual believe that in reality there are *two* forms of learning. One for which the effective activities and the main responsibility are the job of the teachers. And another one for which the students count responsible and have to show the significant activities. A passive and an active level of learning seem to be assumed.

But from learning psychology we undoubtedly know that learning *is* an activity of learners – without any exception. It can be supported – but also obstructed – by teachers. But *learning* can never be determined or replaced by *teaching*. Terms like self learning or self-study phase are meaningless because there is no alternative.

² Learning resembles very much the process of scientific research. Hypotheses or theories on the one hand and assumptions on the other hand are analogue structures.

3 Why Learning?

The natural purpose of learning is to improve the individual fitness to survive. This means to develop competencies and strategies to act or react successfully in vital situations. Humans have developed this natural gift very successfully to a degree that allows even possibly useless outcomes: theoretical knowledge. Possibly useless means – from a biological point of view – that the affected person may never face a single situation in his or her life activating this knowledge. This potential differentiates animals and humans. Thus it is part of human condition. But nevertheless our brain and nervous system is still primarily made for developing skills to master practical situations already experienced in the past. This defines the learning goals for which motivation is spontaneously the highest.

4 How Does Learning Work?

The brain is permanently active – no matter if the learning individual is seeking for knowledge and new insights or not. The human brain is a learning engine even working while we are sleeping. *We are not able not to learn!* Humans are continuously in learning interaction with their physical and social environment and draw their individual conclusions from their experiences. Thus we are changing from day to day – in very small steps. But this automatic, mainly unconscious learning might not be the one we are aiming for, especially if we are thinking of students. Teachers want them to gain factual knowledge, to acquire professional skills and to develop moral attitudes. And what are students doing? They become professionals in passing exams with minimal effort. In the first instance students learn to master those situations they are confronted with at university (see chapter 1.4). That's normal. That's biologically determined. And there is no way to *change* this aspect of human condition. But there are some ways to *use* it for improving the learning offers schools and universities are responsible for.

5 Consequences for Teaching

5.1 Do We Need Teachers?

Humans can and will learn completely independent of the influence of teachers – at least if they are beyond puberty. Maybe the results of such autonomous learning processes would not always be satisfying: on the one hand, because – from the teachers' point of view (and the authorities behind them) – the *planned* learning goals could not always be reached. On the other hand because students would not reach *their* learning goals and attain employability (and future wealth) in the most *efficient* way. Every learner can make use of teachers to enhance the learning process by support and counselling. But a counsellor has to commit him- or herself primarily to the student and only secondarily to the subject. Thus a successful teacher must have psychological competencies – and cannot be reduced to an expert for the respective subject matter.³

5.2 What about Content?

Content of high relevance and quality is still one of the keys to success of academic learning. But production of high quality content is time-consuming and expensive. The good thing is that content can be used worldwide if once created in adequate quality. Institutions should stop to develop every little presentation by themselves and share their results with the worldwide community. Content creation and production is the adequate aspect of (academic) learning that can be industrialised without disadvantages – in the same way as printing textbooks is industrialised, but in a much more economic way.

5.3 What Kind of Learning Situations?

³ In former times, when books were not existent or available in the required quantity and quality, the function of teachers as content providers was prevailing. But this has changed enormously – already some centuries ago with the invention of printing and, in particular, in our times with the internet.

As an indispensable consequence of the results of learning psychology and brain research (see chapter 1) only learner centred approaches can lead to success. The learners have to be the initial point of educational planning – not the subject matters. Target group analysis has to be a standard procedure for all planning processes on each level (curriculum to lesson). Variety of offers – regarding content, context and process – has to be part of the game. Students must have the opportunity to set individual focuses – according to their special interests and capacities. Furthermore, learning situations have to be as trustful and free of stress as possible (see Csanyi et al., 2007). This can only be reached if teaching – learning support and counselling – are strictly separated from examining and assessment. Otherwise students will always lay the stress of their efforts into mastering the examination situation – to the disadvantage of the learning output (see chapter 1.4).

5.4 Formal or Informal Learning?

At the first glance there may be a significant difference between formal and informal learning. The first seems to be centrally directed, the second seems to be free respectively self directed. Formal learning can be planned, informal learning develops spontaneously. The first is teacher centred, the second is student centred. But such different impressions may hide that learning is in principle an informal process. Regarding the characteristics explained above (active, subjective, constructive, situation-oriented, and cross-linked) the learning process does not fit to formal structures. Only teaching can be formalised. Formalising learning means to restrict it because it is a supremely individual phenomenon. This remains true even if it will not be possible anywhere and anytime to support individual learners in the best possible way.

5.5 Curriculum Design

The network-characteristic of learning (see chapter 1.5) and the subjective and constructive implications (see chapter 1.1 and 1.3) are leading to an integrated curriculum in contrast to systematic one (designed from the viewpoint of the subject matter). A predominant percentage of students are interested in the application of theoretic knowledge when they enter university. Basic methods – often part of other disciplines like mathematics or statistics – do not meet the expectations of freshmen, as long as they cannot feel the need based on practical challenges. If curiosity and, as natural consequence, motivation are allowed to emerge and develop and to direct the individual learning process success will be achievable more easily as if students have to start with strange basics they do not know and are not interested in.

5.6 Assessment

The learning process – including the corresponding learning situations – and examining have to be designed in different ways. The first consist of motivation, confrontation with the content, application and practice – and need a relaxed atmosphere. The second follows the task to control the outcomes of the learning process in terms of knowledge skills and attitudes – and needs a rigorous and objective setting to be of any value. Learning (including learning support or teaching) and assessment of learning are two different phenomena with quite opposite goal and must not be mixed.

6 Consequences for Technology Enhanced Learning

Technology enhanced learning (e-learning and blended learning) is nothing but a special case of learning in general. Accordingly everything said about the one also applies to the other. But in some aspects technology enhanced learning seems to be privileged.

6.1 Do We Need Teachers in Technology Enhanced Learning?

E-learning and blended learning per se change the role of teachers, if the use of technology is meant to have a significant positive effect. Providing and presenting content and/or giving assignments and a number of further tasks can be (partially or completely) delegated to technology. Thus teachers are released of routine activities and are able to fulfil their major tasks: establishing relationships and giving feedback. From this point of view technology enhanced learning can be a valuable promoter of the latest findings of brain research.

6.2 What about Content in Technology Enhanced Learning?

Content sharing has never before been so easy and inviting as it is under the circumstances of technology enhanced learning. Nearly each of some thousand universities worldwide is producing content. Nearly everything produced can be found in the world wide web. A respectable proportion of the accessible content is open or under the licence of creative commons. What still is missing on the other hand is a positive attitude of individual teachers and institutions towards (re)using external content. This could be more efficient – from an economic point of view as well as from the educational one – than to invent each and every wheel anew. But according to the experiences of the last 20 years we can hope that at least economy will catch on – if education does not. From this point of view technology enhanced learning could be a valuable promoter of the latest findings of brain research.

6.3 What Kind of Learning Situations in Technology Enhanced Learning?

Consonant with the changing role of teachers (see chapter 6.1) also the characteristics of most learning situations will change in the long run. Successful learning offers following learning goals of the 21st century *are* student centred. Teachers, exempt from production and presentation of content at least to some extent, will have the capacities for individual mentoring, coaching and giving feedback to the students. In blended learning environments (the standard for most universities) teachers must invest a great proportion of their time into establishing relationships to the students, helping them to find and keep their motivation and to give them high level feedback. (Low level feedback can also be given by electronic systems.) From this point of view technology enhanced learning is a valuable promoter of the latest findings of brain research.

6.4 Formal/Informal Learning in Technology Enhanced Learning

Technology enhanced learning is one possible key to individualisation of education. Teachers can offer their students even more opportunities for individual ways than in traditional (face-to-face) teaching. The choice of content representation, of assignments, and of co-operation or collaboration alternatives will give students the chance to really follow an individual path with individual learning goals (within a defined frame) timing, social setting, and outcomes. From this point of view technology enhanced learning is a valuable promoter of the latest findings of brain research.

6.5 Curriculum Design in Technology Enhanced Learning

Regarding curriculum design in technology enhanced learning there is no big difference to the consequences for learning and teaching in general (see chapter 5). But there is one dimension that will become important: the international interchange. The Bologna Process⁴ and e-Bologna⁵ try to foster the (physical or virtual) mobility of European students. With the instruments of technology enhanced learning there is the opportunity to compose international curricula combining the strengths of a number of national or regional offers – resulting in a study course fitting to the needs of a very distinctive target group spread all over Europe. From this point of view technology enhanced learning could be a valuable promoter of the latest findings of brain research.

6.6 Assessment in Technology Enhanced Learning

E-assessment will not be the best solution for every single learning outcome, but it can be applied for a significant number of learning goals. If we look at the practice of assessment by universities (at least in the German speaking world) a lot of present exams could be conducted online – sometimes even with better quality. But the main advantages are twofold: evaluation and feedback are accomplished automatically and students can get individual feedback immediately. Both features are very important for learning motivation and the improvement of individual subjective concepts (respectively assumptions; see chapter 1.3). From this point of view technology enhanced learning will be a valuable promoter of the latest findings of brain research.

⁴ See: http://ec.europa.eu/education/policies/educ/bologna/bologna_en.html

⁵ See: <http://www.eadtu.nl/e-bologna/about.asp>

7 Conclusions

In Contrary to the subjective theories of many teachers learning is a very individual and informal (not to say: chaotic) process, that cannot be pressed into formal structures without loss of quality. Universities should therefore take note of the current findings of brain research and learning psychology to be able to design their programmes in the best and most successful way. Technology enhanced learning and its didactic and organisational implications could be a valuable catalyser for the necessary transformation processes.

Following these considerations a consortium of some European universities developed a research project called SHARING aiming at the following outcomes:

“To provide an overview of European and Worldwide initiatives on the quality of e-learning, that address the issue of Learning Outcomes, and analyse the methods in use

To define a methodology to evaluate the general quality of e-learning through the analysis of Learning Outcomes

To collect and compile case-studies of e-learning at the partners’ institutions and others, including information about strategies and Learning Outcomes

To identify factors of success or failure in e-learning, based on the analysis of provided case studies

To develop indicators of quality in e-learning supported by case studies derived from best practice and taking account of definitions and practices in different countries

To create a Guide for Good-Practice in e-learning, focusing on Learning Outcomes

To disseminate the results through existing networks.” (SHARING 2008, p.29)

A collection of best-practice examples combined with an analysis of quality factors should result in a repository of templates, ideas, arguments and practical theories fitting to nearly every single educational decision in academic context to be made in the near future. Thus the quality of educational decisions and strategies (in terms of learning psychology and brain research) can hopefully be improved in the long run.

8 References

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Bricklayer: www.ahajokes.com/funpages/brick01.gif

Megaphone: <http://www.bds-muenchen.de/grafiken-bilder/interessenvertretung.jpg>

Ear: <http://pix.nofrag.com/2/3/9/e67de61a664a7ef4ff313034d770.jpg>

Funnel of Nuremberg: http://www.gerresheim.net/assets/images/autogen/a_Trichter.gif