# How Artificial Intelligence Can Link Up with Human Science

Mitra Zibanejad
*University of Burgundy, France*

## Abstract

*Enhancing students' level of learning and ensuring academic success are the final goals of educational policy. To reach these goals, such policy seeks a way to simultaneously increase the skills and knowledge of students. We were interested to explore how the other sciences can help us draw closer to this goal. We therefore aim to demonstrate in this article an approach to help students at university find solutions to their learning problems. In an attempt to reach this goal, we suggest that other sciences can help us to the extent that the combination of the various sciences can be more effective than a single branch. Artificial intelligence (AI) is a branch of science that has many applications. We decided to show here the relation between AI and the sciences of education. Our first suggestion is that students have the basic knowledge they need but are unable to use it correctly. Thus they require specific skills. We will try to identify these skills and a way to acquire them by means of a conjunction between the sciences of education and the science of artificial intelligence.*

## 1. Introduction

Many students at university have various problems in dealing with their subjects of study. Although they have in principle the basic knowledge of their subjects, they are sometimes in difficulty in the classroom or at exam time. This problem does not always result from their weakness in terms of cognitive capacities or intelligence, but rather from the lack of certain skills. What we aim to present in this research is the justification of the structure and definition of the skills that we suggest are important for solving this problem. That is precisely the role of the science of education. Science of education is a branch of the human sciences that is involved in finding ways for students to succeed throughout their academic career, from their first year of school through to university. This long period is a sign of the importance of this branch of human science. Much research has focused on finding solutions for the specific, as well as general, problems in education.

The science of education is a science combining mathematics, psychology, economics, sociology, etc. This cooperation provides better results. In this article, we add another branch of science to the list: artificial intelligence. We formulate a hypothesis in the hope of solving part of the general problems students have in using their knowledge wisely and in the right place. To reach this goal, we try to show which skills are needed to correctly use one's cognitive capacities and how we can construct these skills by means of artificial intelligence.

## 2. What is Artificial Intelligence?

Artificial intelligence (AI) is not a very new subject of research. Many researchers have written about it. (Artificial Intelligence: A New Synthesis by Nils Nilsson, Morgan Kaufman, or ‘’Computational Intelligence’’ by David Poole, Alan Mackworth, and Randy Goebel, Oxford, 1998.). In 1950, A. Alan Turing (Turing’s 1950) wrote an article, “Computing Machinery and Intelligence,” in which he discussed conditions for considering a machine to be intelligent. Until 1974, AI was used in expert systems (MYCIN) and to help scientists diagnose bacterial infections of the blood and suggest treatments. In the 1990s, computer speech recognition reached a practical level for limited purposes, testifying to the evolution in this science. Today, we can see the other domains that are involved in this science. AI is a science that has a role to play in many domains such as electronics, animation, medical sciences, banking, exploration, robotics, security, speech recognition, understanding natural language, expert systems, philosophy, baking, industry, and even speaking. But what is this intelligence? Intelligence is the computational element of the ability to achieve goals in the world. This intelligence is provided by the neural networks [8]. They are the basis of AI and the point of intersection for the sciences of biology, psychology, mathematics and computer science. In what follows, we will connect all these sciences with the science of education.

Our goal here is to show the use of this science in education. The field of human sciences also has its connection with AI. A definition given by Alain

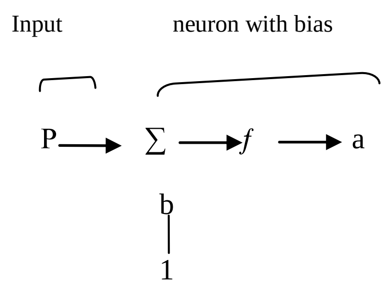
McCarthy [8] in 2007 can help us to define this term. He says that AI "is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence.'' A type of application of AI is statistical packages. To apply this to education, we begin by choosing two statistical packages (LISREL and SPSS) which we can test and thus define human intelligence and the skills that are needed for better learning.

## 3. Comparing Artificial Intelligence and Human Skill

Today the way to progress in a subject is to combine many sciences. Combining various sciences will make the results as sure as possible. Such engineering helps medical researchers to discover a faster and easier way to treat patients. Mathematicians, computer programmers, biologists, and psychologists cooperate to obtain results that are more scientific and more exact. The widespread use of different statistical programs like SPSS, MATLAB, LISREL, STATA, SASS, etc. is another example of the cooperation between computer science, mathematics and human sciences. The central point of this cooperation is AI. "AI research is highly technical and specialized, deeply divided into subfields that often fail to communicate with each other. There are subfields which are focused on the solution of specific problems. AI includes such traits as reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects." [3]. Statistical packages offer an enormous number of capacities in helping us find the reasons for or the answer to different specific problems in education.

One of the abilities of these statistical programs is regression. Regression is the attempt to produce a function that describes the relationship between inputs and outputs and predicts how the outputs should change as the inputs change [3]. We use this definition to show what input and output for the construction or definition of skills may be. To reach this goal, we chose two programs: LISREL and SPSS. What happens in these software applications is comparable to the process of human intelligence. When we learn something, in effect we make a relationship between our acquired information and knowledge already stored in our memory. "Learning means establishing a new relationship between neurons and storing this new relationship" [8]. According to new discoveries, all neuronal functions are stored inside neurons and their relationships. Some of these neural structures are present at birth and others will be constructed by our experiences, such as learning [8]. What we obtain by learning is, in effect, a series of new data from stored information. When we find ourselves in a new situation, we start a process: we use this source of data, make some changes, and finally find the new relationships. The result of this process is "learning." This same process is used in the construction of artificial neurons and ultimately artificial intelligence. This artificial intelligence is designed according to human intelligence in such a way that we can use it to define human intelligence, ability and skills. The ability of these packages makes possible a definition of the appropriate indicators for the construction of skills. These skills constitute unobservable variables. By means of the study of these computer packages, we will be able to define and measure students' skills in choosing and combining the correct information from their source of data. This approach helps us to define a student's strong and weak points. But how does this happen?

Both humans and animals are inclined to make relationships between events that occur simultaneously. Hebb's hypotheses [15] inform us about these relationships in artificial intelligence. Such relationships must be strengthened in order to find appropriate answers. And in the future, this will be done automatically. This automatization helps us to quickly find the relationship or dependence that exists between the events. In addition, we will learn faster and more easily, because we will be able to recognize the stimulus and use it as a model in the future. This is also a skill that must be learned. In artificial intelligence, this process is depicted by the following function. It is a cell of neural networks:




"P" is a conditional input; "a" is an output that is defined by the formula:

$$a= f\ (wp+b)$$

A person who uses his/her knowledge, speed, and capacity of reorganization of relationships (the input "p") is more likely than others (who lack these capacities) to acquire good output. A good output is defined in artificial intelligence as "1". (In artificial intelligence, "1" is the sign of the presence of an answer and/or stimulus and "0" indicates the absence of the answer and/or stimulus). A student must, like artificial intelligence, recognize the stimulus and make the relationship or find the dependency so he/she can obtain a correct response (output). She/he completes the process by using her/his data, including knowledge or capacities, during a process similar to what happens in AI. This is, in effect, a kind of classical conditioning.

A relationship is created by repetition. By means of the formula below, we can define the speed at which a machine learns "α"; we can define how many times (q) the answer (a) and stimulus or input (p) must happen simultaneously before it makes the relationship [15].

$$Wij(q)=Wij(q-1) + \alpha a_1(q)\ pj(q)$$

Repetition is a method of learning for certain students. It may help a student learn how to find a solution quickly in the case of a simple problem, but it does not help her/him to find a solution in complex cases or inert situations (for example the case of simple digit multiplication and complex multiplication). When we are in a situation that has happened repeatedly, we are able to use data from our working memory; however, the new situation may be more complex than those cases that have been repeated. In the new cases, we must mobilize our data (input), but mobilization is a complex process that implies certain skills. One of these is "selection''.

Imagine a machine that selects two or three products in a factory. With the help of pre-data, it is able to select the different products as asked. To recognize the properties of an element, it chooses between two or three properties. A student has a system of high recognition which is more efficient than that of artificial intelligence, so she/he can select between more than two factors (properties). This selection is an important part of learning. To effect a selection, the student must have the skill necessary to select the appropriate factors. This is the same process that takes place in the LISREL statistical package. This AI can identify the relationship between two (in a simple regression) or more variables (in multiple regressions). The LISREL package can also select the indicators that are most relevant in the construction of the skills which have the strongest impact on student success. The successful student is able to establish the relationship between the tasks required and multiple data. We can also compare this capacity with the multiple regressions in SPSS. This comparison illustrates how we are able to test the student's skills, or predict the necessary inputs for these skills by means of AI. Selection is a part of mobilization but not all of it. Thus it is crucial to explain mobilization first in order to clarify the process of the acquisition of skills.

## 4. What is Mobilization?

In order to mobilize our data, we need to study some strategic methods. These methods fall principally into the category of supplemental knowledge, including: "select," "combine," and "transfer" knowledge, and even skills. Each of these methods helps us to use our acquired knowledge in the appropriate way. Thus when you are in a situation that is different from what you have known a priori, you must have some strategies to manage it. Solving the problem is easy if you possess a rich cognitive structure, but even that is not enough. Because problem situations are not always the same; it is necessary to have different strategic approaches to various and complex situations in order to successfully solve a problematic situation.

As stated above, "select" is a skill that allows us to choose knowledge in our cognitive structure to obtain the best result, but alone it is not effective. Sometimes we need to combine knowledge with developed skills or with additional new skills. Thus skill production lies in the combination of resources. For a student, using multiple data sometimes calls for another specific skill such as "combination." She/he must combine certain variables/stimuli to obtain the right answer. However, in order to achieve this combination, it is first necessary to choose the most relevant resources and then combine them. Thus "select" and "combine" are two inseparable elements with a reciprocal effect.

We must combine our data in a useful and appropriate manner. Thus, according to Le Boterf [6], a competent student is one who is capable of reacting with what he/she knows and (....) building a link between bodies of knowledge. Thus, in order to obtain a positive result, we need to "transfer" the knowledge that we have selected and combined.

To ensure the mobilization of knowledge in a variety of contexts, it is necessary to articulate three stages: first, a construction phase of learning in context (or recontextualization), then a phase of decontextualization or transfer (or diversification context), and finally, the metacognitive ability to reflect on this learning [9] or re-codifying. As Le Boterf has also noted: "a person does not have competence if he fails to transfer his knowledge and skills in a new problem situation." [7].

We must codify our new knowledge and consider the transfer as a link between stored knowledge and necessary skills to treat the situation as needed.

In addition, this knowledge is necessary because the student needs to assimilate situations to form a connection not only between existing knowledge and required knowledge, but also between existing knowledge and required skills. In effect, the student must make the link between existing knowledge and required skills in order to acquire the new knowledge and to develop her/his skills. To develop skills, as Perrenoud has noted [11], is first to establish a link between knowledge and social practice or skills; this is part of the “transfer” stage.

If the transfer is not accomplished, there is no decontextualization so there is no mobility and therefore no creation of skill.

The role of these strategic methods is so important that we must delve more deeply into them.

## 5. Select

The acquisition of cognitive knowledge is necessary for the production of skills, but is not enough. The student who is armed with some methods and knows how to apply them to produce skills may be more likely to solve a problem situation. As stated above, knowing how we can select is a method that we have suggested as effective in the production of skills.

Rey et al. [12], giving another meaning of competence, confirms the relationship between skills and method of selection:

"When, in common language, we say that someone is competent in one area, we mean, not only he is capable of doing something in response to a signal, but much more, including:

-He/she has a wide range of basic skills;

-He/she is able to choose from his/her automated procedures that one is appropriate to a problem or to a situation. "

This study also states that to know how to select is already a skill. This skill asks us to choose from our acquired knowledge. The choice involved means that this skill is "synthesis and not juxtaposition, it is permanent reconstruction and not simple addition." [13].

We have already noted that the resolution of the problem situation is easier if one has a richer cognitive structure but this is not nearly enough. Synthesis has more sense when we admit that problem situations are not always the same; it is necessary to have different strategic methods in order to have different production functions and thus to deal with a difficult situation successfully.

Using this method, we hope that the student will be able to choose from his/her knowledge, known as a network of cognitive structures, and to draw forth the most appropriate elements. Thus, this selection may be interpreted as an argument, or, in fact, a decision. For Matlin [17], ‘to select’ is the "processes of logical reasoning and decision making. To reason is to draw conclusions from the already known."

If selection is a decision, it becomes a completely parallel action. This means that we must decide between several elements. The diversity gives us the possibility to select, otherwise, there is repetition in production. This is the difference between AI and human intelligence. Despite the fact that a machine can select, it repeats the same productions but only the human can choose. To select is a parallel act and not serial processing [17]. Serial means that there is only one possible operation. Acquiring a skill is not limited to a single operation.

If selection is a parallel action, it thus allows us to manage our act by considering several possible solutions. A part of the AI process is akin to human intelligence, but what a human does in a problem situation is an act and not an operation. The computer effects an operation but it cannot perform an action. Therefore, we have some limitations inherent in AI. ‘’AI cannot automatically generate their algorithms, formulate new abstractions, or develop new solutions by drawing analogies to old ones, or through discovery.’’[1] It needs to be programmed. But a human can do this automatically if he/she has enough cognitive knowledge. In the case of a lack of knowledge, a human being must be “programmed”. This means that he/she must learn more and stock to the learned elements in his/her memory. “Learning involves making changes in the system that will improve it in some way. "Learning is making the useful changes in our minds." (Minsky, 1985) The knowledge acquisition aspect of learning seems to be the essence of most learning acts. Those acts where it appears to play only a small role are cases of what is usually termed skill acquisition.’’[1]

Gavens and Camos [4], explain the process of selection relative to the cognitive structure already stored in our working memory. They give us the example of reading a text. They say that reading a text gives us at first a semantic schema which interacts "in the selection of appropriate knowledge stored in long-term memory and linked with perceptual information" [4]. Thus we can understand the text or seize the main idea.

But what is a good selection? Selecting first requires an analysis of the situation to define the needs and the difficulties. Analysis of the situation is always required because "it defines what is allowed and not allowed to do, what can be accepted and what would be inappropriate." [6].

Thus to implement this method two conditions are required: first, action and second, good cognitive storage.

This method is applicable in the case in which the situation at hand is unprecedented. Selection helps us to act and produce new skills because we choose among skills already acquired those necessary to solve our problem. But sometimes we cannot use them directly and need to choose between knowledge and skills already acquired and to combine certain of them. However, for more complex skills there are other methods. One of them is to “combine knowledge”.

## 6. Combine

Combining is also a method to develop skills. If “skills are defined as a combination of knowledge, abilities and attitudes" (as defined by the High Council of Education in 2006) we obviously need to know how we must combine all these elements. Le Boterf [5] considers the skill as a system, a structured organization, which combines various elements. Skills for him as well as for other authors are “sets of knowledge’’ [7].

Selection and combination are two methods of production of new skills. For Le Boterf [6] a competent person must be able to "combine resources in an original way." Combining in a useful and appropriate way, while keeping the original features is a necessary step, but it is not a solution in problem situations. Combination doesn’t mean simple "addition". It is an action whereby each element changes according to the characteristics of those elements with which it associates and finally the action does not exactly produce the original elements. If it has these characteristics, we can say that the act is a method of production of skills. In other words, it is creativity.

When a new skill is created by the selection and combination of knowledge and skills, it must be put to use. To reach this aim for the individual, whatever her/his own operative scheme or form of action, one thing is undeniable: she/he must be capable of transferring in some way this new skill to the new situation for use.

If we want to give a simple and concrete example of combination, we can show what happens with AI and music. Music is another domain that has used many developments in AI and especially in composition, which is an example of combination. “The role of computers here is not simply to automate existing practice but to enable the development of an entirely new conceptual approach to music composition.’’ [2]. The use of the method of combination is central to this domain. For example, three computer music problems have been described in which Machine Learning promises to solve problems and advance the state of this art. By means of combination, we can produce higher quality music (development). This is only one advantage of computer use in art. Otherwise Machine learning allows us to transfer our data into operations such as understanding in interactive composition or music synthesis. We can program a computer to transfer some combined information for use where we need it.

In the case of a student, none of these methods can be useful unless he/she is able to transfer them to the new situation or problem situation where they are needed. The next method we present is therefore the method of transfer of knowledge.

## 7. Transfer

It is a form of management, " portable knowledge" [11], which allow a person to use knowledge elsewhere. [9] Transfer is reinvesting a skill or knowledge in a different situation from that in which it was created.

The purpose of this method is to render more available our stored knowledge in utmost at will and for all problem situations. Therefore, at any time and in all situations, we have access to our stock to use it. The more complex the required skill, the more important the role of this transfer becomes. In a complex situation we need to use our stock of knowledge to a maximum degree. If we want to increase the rate of the availability of our stored knowledge, we have to codify and categorize [16] skills and strengthen the ability to diagnose the problem. In the next step, we need to make a relationship between skills. In codifying the new knowledge and skills we can establish links and connections between two or more situations. Thus we can treat new situations as effectively as we have already done in known and mastered situations. [6] The lack of this knowledge may explain why we have knowledge or a skill, but are unable to use it when we need it. "In another context, students behave" as if they had learned nothing, "while this is not the case. They simply "do not transfer".’’ [10] They cannot practice their knowledge, which is precisely the difference between AI and human skill. “By contrast, when we look at human intelligence we see that among its most striking aspects are the abilities to acquire the new knowledge, to learn new skills, and to improve with practice.” [1]

This method is necessary to build a bridge between the skills and knowledge acquired and those required. Arguably, this incorporation is the necessary condition in which stored knowledge can be used. This is a problem among students and Perrenoud [11] believes that the solution is to teach them to transfer their knowledge and use it outside the context of acquisition. As he puts it: "The idea of transfer evokes a move of knowledge from the place of its construction to the place of its use" [9]. Thus we come to reconstruct new knowledge that is part of a recontextualization. On the other hand, if the transfer is not made, there is no recontextualization so there is no mobility and therefore no skill.

This transfer provides an opportunity to reuse knowledge; in other words, to avoid disconnecting the knowledge already acquired so it can be mobilized and put into use. An artificial intelligence is able to make this transfer automatically, but it cannot decide, select or combine out of the boundaries of its program. Yet this program can help us to define a part of human skill. In this context, it is important to ask ourselves what the limitations of the current methods are and what new directions research in this field should take. “AI researchers began to study knowledge acquisition and representation. “Expert Systems” emerged from this and have found many applications. As researchers continued to tackle hard problems, some began to look for ways that computers could acquire their own knowledge, thus “learning” about problems and their solutions’’ [13].

The AI that we discuss in the present work is a kind of application via a statistical package. Obviously, there are certain advantages and certain limits to AI, but it can help us to define human skills and this is the aspect that we will highlight in what follows.

## 8. The Contributions of these Methods: How can we use AI?

The first step is to formulate some hypotheses concerning the skills which seem most important to a student’s success and then choose the skills that are accepted by the methods of selection.

LISREL is a statistical package that helps us to measure the degree of a factor’s acceptability and to identify skills which help to develop learning.

To demonstrate whether these factors are essential or not, we make use of two statistical AI methods: LISREL and SPSS. This example of the application of a covariance structure analysis model is a study of the skills most likely to predict the development of learning in higher education. This model allows us to test a causal theory previously formulated via a mathematical model of our observed data. This is a model of covariance. Thus for each concept of a skill we have at least two indicators to be measured. Two or more indicators will help explain a more complex concept. Latent (unobserved) variables will also be measured in part by the observed variables and also by their indicators. This model must rely, first, on a principal theory: "The principal theory is the basis of the model. It is used to develop a general theoretical model, the basis of the analysis, to establish relationships between variables targeted in (for) the proposed study. If we look, for example, to explain a concept A for which it is assumed that B and C are two explanatory factors and we assume again that A is divided into two dimensions (A' and A"), assumptions need to be made about the relations that link these different theoretical variables’’ [14].

The main theory will be supplemented by an auxiliary theory. Here we have the opportunity to explain the relationship between the latent variables as well as between these variables and their indicators and then to measure the impact of each of these elements (variables observed, their indicators, unobserved variables, etc.) on each other (see Figure 1).

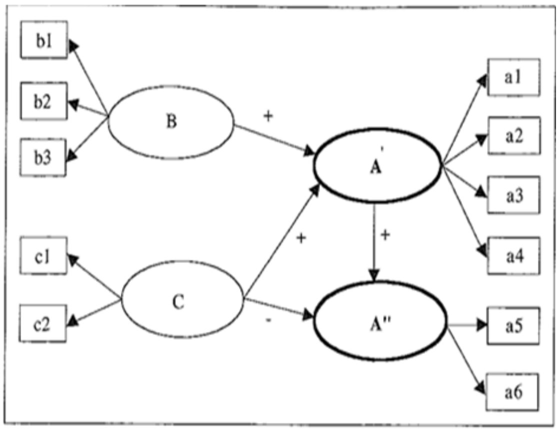



Figure 1. Presentation of the main theory and the auxiliary theories. Morlaix [14]

LISREL will verify the degree of acceptability of the measurement and estimate the links that are assumed.

This example of AI is a package that provides the advantage of confirming our assumptions and the reliability of knowledge and capacities initially chosen. LISREL allows us to identify from among our hypotheses those that are acceptable and those that are not. Because human intelligence cannot be reduced to the workings of a machine, the result obtained is not the same every time; many other factors are included, such as age, sex, time, socio demographic characteristics, etc. They must be studied by means of other statistical packages, such as SPSS.

The skills of “select, combine and transfer” are measured by means of psychological tests (Raven, SRT, TBRS, etc.). These indicators are represented by the xi boxes of the coefficients in figure 1. Determining the sources of skills will never be a perfect process and other factors may still play a role in the process of the production and development of new skills. In the auxiliary model we will therefore attempt to explain the impact of other factors in the development of skills, such as certain divisions that occur due to social and cultural factors.

As discussed above, new skills are developed when individuals are able to use the underlying data. The AI of SPSS and LISREL define the factors which have a positive impact and those which have a negative impact in the construction of these new skills.

In the following example we show how a simple skill can be constructed. We show in this graph (see Figure 2) a finding from our study gathering data from research conducted on the students at the University of Burgundy. In this graph, we demonstrate that a skill (Com4) is constructed by different indicators. LISREL tested the impact of these indicators and measured the role of each of them on this skill. This means that the machine selected the best and the most important indicators. It allows us to combine what it has chosen to obtain the best result and to delete the other options. In this way, we are able to construct skills with the indicators that are most effective in producing a correct answer (output). We can then introduce this skill to our students and show them how to obtain it. This is how we can use AI to constitute human skills. These indicators are the knowledge and capacities of students tested by psychological tests.

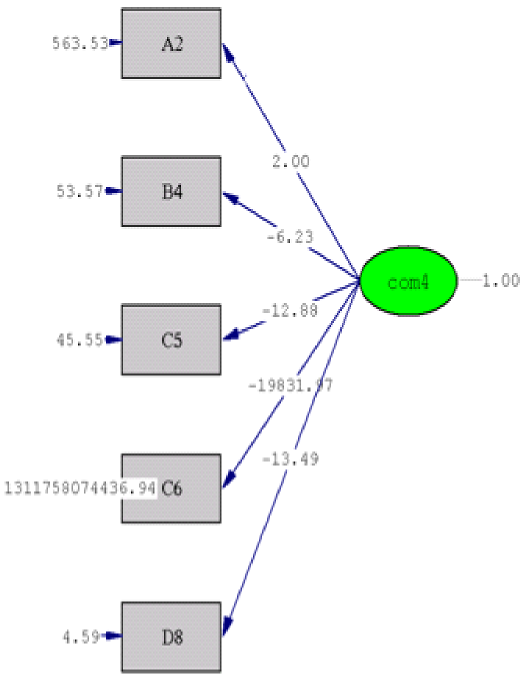



Figure 2. Construction of a competence

The program can also tell us about the relationship between skills as well as how they need to be combined. In the following figure (see Figure 3), we show two neural cells and the relationship between them; this relationship is negative. The negative relationship between these two skills means that the use of one of them will result in failure in the other one. The other side of this graph shows which indicators have a negative or positive impact in the structure of these skills. The interest of this example of AI use is that it allows us to construct skills by determining the indicators which are most important in the process.

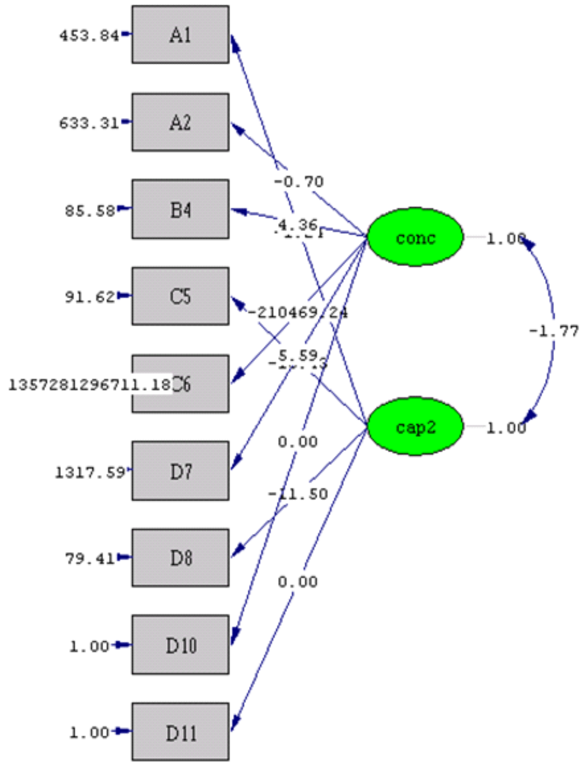



Figure 3. The relationship between two neural cells

Here we want to demonstrate that if a student selects knowledge that he/she believes to be efficient in order to acquire a skill, he/she must correctly combine the elements that have the highest impact on this skill. The machine here has an advantage. It can effect this selection and combination much faster than a human. A student requires more time and experiences to discover this skill. Thus, by means of AI, we can show him/her the "shortcut" and the most likely indicators that he/she should use (select and combine) to acquire a given skill.

## 9. Conclusion

Artificial intelligence is the result of a neuronal network. This network is two-sided. It is designed by copying human intelligence and can be used to define human skills. We call on this double characteristic of AI to confirm our hypothesis about the construction or development of human cognition which is not directly observable. AI can help us in this field because it "does not confine itself to methods that are biologically observable." [1]. But the matter is further complicated by the fact that neither the cognitive sciences nor biology has yet succeeded in determining exactly what human abilities are. Meanwhile, AI seems able to provide solutions in this uncertain situation and the hypotheses we formulate help us to advance.

In order to define so-called important learning skills, certain key skills must first be identified, as a hypothesis, by means of various sciences such as mathematics, computer science, psychology and AI. The key skills defined in this way may be of help first in strengthening a student's learning and secondly in helping us define the effective direction of educational policies.

In this paper we have attempted to show how we can define a key skill by means of a scientific method, and how this method may be of help in defining a learning strategy. The method presented in this manner can test every level of educational proficiency and in every field. This study is being conducted with students attending the University of Burgundy in France. In this case study, we are testing students who are in their first year of university studies. But we must mention that many factors are involved in developing practices for enhancing student learning in its optimal form**.** The role of culture, family, environment, the economic situation, the social situation, personal characteristics, etc., must be considered. So we also need to test all such factors but separately, as a second stage.

Every professional act requires strategies for its achievement. We consider student learning to be professional learning. After identifying the skills necessary for successful learning, we can test them by means of statistical methods and add the second consideration, that of variables, in order to achieve key development in professional learning. We can thus demonstrate more effective strategies to attain this learning.

All of this participates in the processing of the development of learning. Students not only need to increase their cognitive and academic 'inputs' but also need to learn to process their data for the appropriate 'outputs'. If students learn these skills and apply them correctly, they will be able to process data and accomplish the required output that is "learning."

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