Constructivist Use of Business Simulators in Education
Authors

Viktor Vojtko and Marie Heskova
Abstract

The goal of this paper is to define and propose a model of possible use of business simulators to support education in constructivism.
sense and with a respect to revised Bloom’s taxonomy of learning objectives. This model is particularly focused on re-construction of prior partial knowledge using the falsification approach.
Keywords: Simulator, model, education, constructivism, falsification
Introduction

During final oral examinations we were often surprised by heuristics or shortcuts in the knowledge presented by our university students. There seemed to be common patterns
in misconceptions and similar missing links which were mainly on the deeper level of understanding.

The problem has been especially related to the
applicability of partial knowledge. Although many theories and models are alone understood quite well by the students, the whole is missing. It seems that according to Spiro, et al. (1991) one of the
reasons is that this is a viable strategy for the students. But because we teach business students, it is obvious that the proper understanding of all main principles working together in the right context is
crucial for their success in the real world. And thus we as teachers cannot be satisfied with such an outcome.

Sometimes suddenly a moment of “aha” appeared right in front
of us during the oral examination and the students realized their own knowledge gaps through falsification of their own heuristics, got the insight and felt the relevance – but we believe that
unfortunately mainly only according to the question examined.

Nevertheless, this situation was in several cases accompanied with positive
emotions and perceived satisfaction on both sides. Like in a good thriller where the meaning of all that has been shown before is shifted in a short while and the “hidden truth” is realized suddenly.
We suppose it is quite common for anyone not just in education to have such an experience. It is in the very heart of learning to discover new knowledge on the basis of
reconstructing the old one and change of meaning.

But we don’t want it to happen occasionally. Rather, we would like to manage this process and deliver insights like that also in
our curriculum. And not just in the curriculum but also in the practice, because we believe analogous situation may be also found in many organizations coping with
knowledge management issues. The goal of this paper is thus to define and propose a model of possible use of simulators supporting this managed change of meaning on the level
of individual knowledge using falsification and re-construction of prior partial knowledge.

The main method used here to gather relevant concepts and
data is based on one hand on a literature review and on the other hand on observations of the heuristics which we and our students were usually using to solve questions related to real world problems during
examinations and business simulator usage.

This means that our thoughts are mainly a qualitative inquiry and we need to test the model
later using more rigorous approaches.

Business Simulators in Education
Although the usage of computer simulators to
support learning has a tradition long nearly 50 years (Faria, 2001; Tonks, 2005), it seems that the basic terms are used in a confusing manner. We may find several synonyms for nearly the same – like
management flight simulators, microworlds, interactive learning environments (ILEs) etc.

In this paper we would like to use for clarification our own
earlier definition (Heskova and Vojtko, 2007). The main points of the definition are that business simulators have three different layers – (1) model providing needed simulations, (2) user interface allowing
input and output, both quantitative and qualitative, and (3) learning environment introducing problem, supporting process of knowledge construction and feedback for it.
Our definition is in the general sense similar to earlier definitions of Davidsen (2000), distinguishing just two components – model and user interface – and Maier and Größler (2000), who assume
“that computer simulations have three key aspects, the underlying model, the human-computer interface and various functionalities.”
These authors also provide a very comprehensive taxonomy of computer simulators built for educational purposes. They classify business simulators under the category of gaming simulation which is in our
opinion inappropriate, especially from the constructivist point of view.

Nevertheless, this taxonomy shows another interesting point in division between
modelling (transparent box) vs. gaming approaches to the use of simulators (black box or semi-transparent box). Modelling approach then provides a possibility of changes in underlying model
structure by users themselves. This approach is usually based on system dynamics and systems thinking, multiagent approach or discrete modelling
The modelling approach is from our experience the most valuable one for a new knowledge discovery because the model structure can be changed in any particular moment of learning to reflect
other assumptions and point of view of the user. But on the other hand there is a serious shortcoming in the need of users’ abilities to change the structure of the model accordingly, not just
parameters. This limits the applicability from this point of view.

The second, gaming approach is very common in business education. The underlying
model is set and just its parameters can be changed. This limits also the possibilities of learning because there is finite number of assumptions and preset embedded knowledge. On the other hand
this may be very simple for the user to just use the prepared model – and various user interfaces may be provided reflecting different contexts.
Both approaches are viable but under different conditions. Both may provide very helpful experience reflecting the real world complexity. And both are capable to provide logical consequences of various
actions under different circumstances.
Also, according to Anderson and Lawton (2009, p. 195) “to be effective, simulations require a substantial time commitment from participants.”
Consequently, the literature suggests that business simulations are an inefficient pedagogy for teaching terminology, factual knowledge, basic concepts, or principles [...]. The basics of a
course can be covered more quickly in lectures. It may be an open debate as to whether students will be able to retain or implement some of these basics if lecture is the sole method of delivery, but few
will dispute that lectures are much faster.”

Constructivism – A Missing Theoretical Link between Education And Simulation?
Lainema (2009, p. 50) suggests that “a comprehensive theory about learning and knowing through simulation and gaming is missing.” The majority of interest has been devoted to the experiential aspects of
simulators’ supporting role in learning (e.g. by Kolb, 1984; Kayes, 2002) and grounding in the theory of education is not employed well in this sense.
Fortunately, the roots of constructivism and often used experiential learning approaches are according to Lainema (2009) very similar and have a lot in common. Thus it is possible to use this
paradigm as a starting point of our inquiry.

What are the most important principles of constructivism? We will now summarise them according to the highly
referenced to authors Duffy and Cunningham (1996):

- All learning is a process of construction of knowledge.
There are many possible ways of knowledge construction and thus also multiple perspectives and meanings.
Knowledge is always context dependent and learning should occur in appropriate contexts.
- Learning is mediated by tools, signs and symbols.
- Learning occurs in social setting, is based on discussion and
communication with others.

- Learning also means an engagement in the community of practice.

- We are able to reflect our own learning and
understand the way we know or know not.

We may add that this all is in concordance with many thoughts of Jan Amos Comenius, famous Czech
teacher and educator from 17th century. Just to mention one of his sayings within this context: “pupil is not a jar to be filled but a torch to be lit.” In other words, it is not sufficient just to deliver pure knowledge
through education. Also feelings and attitudes are important.

The main relevance of constructivism regarding the business simulators’ usage in
education is in much higher involvement of free will on the side of students, i.e. learner-centered learning – in providing them relevant problems, safe environment for experiments and surprises
from discoveries, interaction with others in social setting or possibility of their own planning of learning etc. This all should lead to more realistic and holistic learning experience in comparison with
traditional objectivistic approaches.

But on the other hand a problem of motivation of students arises, because there is also a shift in the role of
teachers. They are not the only right authority delivering knowledge but rather facilitators of individual knowledge construction.
Knowledge, Heuristics And Learning
If we look to the Merriam-Webster OnLine dictionary (2009), the word knowledge is defined as: “(1): the fact or condition of knowing..."
something with familiarity gained through experience or association (2): acquaintance with or understanding of a science, art, or technique.”
It is obvious that by using knowledge it is possible to answer three basic questions – what, how and why. The question what is related to the awareness of concepts and their meaning in particular
situation (declarative knowledge). The question how deals with procedures and methods of change of the situation (procedural knowledge). And finally, the question why is focused on the
underlying structure of the situation and broader context (structural knowledge). All these questions may be answered differently by different people as we have
shown before in relation to the constructivism. Also, as because we are not just conscious but also unconscious in many ways, Polanyi’s explicit vs. tacit knowledge distinction needs to be considered
(Nonaka and Takeuchi, 1995). The tacit knowledge relates to the unconscious and cannot be articulated unless made explicit, i.e. realized.
Another approach is of Baumard (1999), who is adding implicit knowledge. This knowledge could be made explicit but no one wants to express it.
We have mentioned heuristics earlier. As we might see the process of their use by the students has much to do with the tacit knowledge.
For the needs of this paper we would like to define heuristic according to the Principia Cybernetica Web (2009) this way: “An aid to discovery, any device or procedure used to reduce problem-solving effort,
a rule of thumb.” The problem is – are we able to tackle the heuristics properly in the education?

It has important consequences for business education because
in so complex world purely analytical decisions are not in many situations feasible and the students should cope with this accordingly. On the other hand, heuristics should not be misleading and confounding
like we occasionally experience.

But of course, knowledge cannot be considered static. We use it everyday in a changing world. We create it everyday
through our own actions, discoveries, communication with others and encountering our knowledge boundaries.

A very important perspective on knowledge change is given
by Bloom’s taxonomy (Bloom, et al., 1959). This taxonomy classifies the output of learning, i.e. acquiring of new knowledge on individual level, into three main domains: cognitive (knowing), affective
(feeling) and psychomotor (doing). This framework broadens the perspective because emotions and actions are taken into account.
In this sense, there are several levels of learning objectives in the cognitive category (Bloom, et al., 1959) – (1): basic knowledge, (2): comprehension, (3): application, (4): analysis, (5):
synthesis, (6): evaluation – which should be supported by different tools and methods and also assessed differently.

A lot of research in the area of business simulation
involvement in cognitive learning has been undertaken from the perspective of original Bloom’s taxonomy (e.g. Keys and Wolfe, 1990; Faria, 2001; Gosen and Washbush, 2004). Unfortunately, it seems that
especially at higher levels of cognitive learning the evidence of significant contribution of simulations’ usage is weak and nearly the same as 20 years ago (Anderson and Lawton, 2009).
We think that because the original Bloom’s taxonomy has been revised by Anderson, et al. (2000), it should be helpful to shift also the research of simulations’ usage for learning
in this direction. The main reason is that the new revised taxonomy may be more disambigous and better grounded in the area of cognitive psychology. Which also means that further
research focused on assessment of the simulators’ contribution to the higher levels of cognitive learning may be easier and less confusing due to this clarification.
The beforementioned Anderson, et al. (2000) taxonomy classifies the learning objectives in a little bit different way than the original one: (1) remembering, (2) understanding, (3) applying,
(4) analyzing, (5) evaluating, and (6) creating (synthesis).

It also combines these learning objectives with factual, conceptual, procedural and metacognitive knowledge.
dimensions which help to divide content and methods accordingly. A map of previous concepts is provided on the next figure.

See figure 2 in full PDF online
A Proposed Model of Constructivist Use of Business Simulators in Education

From our perspective we would like to relate our contribution to earlier
attempts focused on efficient use of computer simulators in education (e.g. Hsu, 1989; Davidsen, 2000; Alessi, 2000; Sterman, 2000; Anderson and Lawton, 2009).
Amongst others, we have chosen two of approaches focused on learner not the teacher. Hsu (1989) provides for the use of education simulators this 4-step learning process:
• retaining information,
• organizing knowledge,
• experiencing, and
• firming.
Another way is suggested for example by Sterman (2000). His approach is based on system dynamics methodology, thus it is focused on an ability to explicitly model system behaviour (transparent-box
approach) by users, and could be described in these steps:

- definition of problem and purpose of solution,
- dynamic hypotheses,
- model formulation,
testing of the model,
proposing and testing of policies.

Our model respects previous definition of business simulator (Heskova and Vojtko,
2007), the general 4-step learning process by Hsu (1989) but relates it with the taxonomy of education simulators provided by Maier and Größler (2000) and the taxonomy of learning

We think it is useful now to notice how the higher levels of the taxonomy of learning objectives could be employed
in the scope of business simulators’ usage. These are – applying, analyzing, evaluating and creating. First of all, we need to distinguish between various situations in which we could
use business simulators for the support of learning. Each of them has consequences for the overall learning process.

Their preference in a given curriculum depends on
learning objectives (synthesis of prior knowledge, falsification of incorrect knowledge), learners’ abilities (e.g. are they able to change the model structure on their own?)
and resource constraints (i.e. time and staff availability etc.).

See table 1 in full PDF online
Individual Learning Situations

The simplest learning situation is where every student works with just one business simulator, i.e., three layers – model, user interface and
learning environment. We need to mention that it may mean several runs or more case studies/scenarios involved in the learning process etc. But each student tries to solve given problem individually and
the structure of model itself is not changed although changes of model parameters, e.g. different scenarios, are possible.
In this case, the business simulator may be used both to destruct prior usufficient knowledge using falsification approach (hypotheses testing) or to construct new knowledge using experimenting and
analysis of the underlying model structure.

If we look at this learning situation from the point of view of black box/transparent box approach, we would like to
argue that black box approach is suitable mainly for firming prior knowledge (including synthesis) or falsification – the feedback provided shows inconsistencies in user’s knowledge. But unless at least
the semi-transparent box approach or a specific support on the side of learning environment is used, it is not clear if new knowledge is constructed accordingly – it may be rather tacit.
Nevertheless, it may be easily always falsified again. Another important point is related to the explicit/tacit knowledge distinction. The student’s perception of behaviour patterns during
recurring runs should help to construct both – but our goal is to ensure that the student is aware of the important concepts and relations between them. Thus we think it is important to support setting
and testing individual hypotheses in the learning process. And the hypotheses should of course reflect individual heuristics to deliver surprising outcomes.
Relations of this learning situation to the all of the higher levels of learning objectives from the taxonomy of Anderson, et al. (2000) are shown in the Figure 3. See figure 3 in full PDF online.
We also need to emphasize the transparent box approach in this case because the students are then able to change or build their own underlying models and compare them. This is very promising from the
constructivist point of view but also demanding on the students – they need to be able to use the right modelling language on their own. And of course the business simulators then have to be
opened for changes, which is unfortunately still rather uncommon. But it is possible and we have tried that in several cases using system dynamics methodology and multi-agent modelling. Many
models based on these methodologies are available in the open form, although sometimes without the other business simulator layers. See figure 4 in full PDF online.
For curriculum, this way of using business simulators could for example mean that at first concepts of fixed and variable costs, revenue and profit are shown, then breakpoint analysis, marketing,
controlling, human resources management etc. and finally synthesis is supported.

Each of these phases then may be assessed individually. And the assessment is possible not
just on the lower levels of the taxonomy of learning objectives but also on the higher levels using the comparison of explicit conceptual or simulation
models prepared by the students. Both these learning situations mean that the complexity of learning situation is somewhat limited due to mainly rational and abstract focus (higher
internal validity). The main reason is that there is no significant interaction with the other students and thus the experience and affective domain is limited too.
Team Learning Situations

Team learning situations provide another level of experience – interaction with the other team members which raises the overall complexity.
On one hand this is more similar to real-world circumstances (higher external validity) and human-human communication and emotions are involved, on the other hand the relation between shared
team knowledge and individual knowledge is quite difficult to manage and cope with (lower internal validity) from the side of learning process and assessment.
This may be one of the reasons why the before mentioned measurement of business simulations’ impact on learning has so ambiguous results and seems to be so uneasy.
Nevertheless, this team use type of learning situations has a possible specific advantage – in certain circumstances it is possible to bring together teams consisting of students with different abilities, e.g.
older students with modelling or other skills or students with different specializations. Then it could be possible to apply the transparent box approach efficiently. This is uncommon
in business schools yet but it seems to be promising.

See figure 5 in full PDF online.

It is also possible to apply the black box approach but the
problem of relation between individual and team shared knowledge persists.
The Model of Constructivist Use of Business Simulators in Education

We have argued that different learning situations according to the individual/team use,
one/multiple simulators involvement and black box/transparent box approach should have different consequences for learning outcome, its assessment and further research.
This means that it is not possible to easily evaluate the learning outcome of business simulators as a whole group.

Thus our proposed model of constructivist use of business
simulators in education tries to overcome the main obstacles and synthesise the findings in a coherent way. It is presented as an ideal and possibly the most beneficial one but we suppose it could be modified according
to the constraints and circumstances of a given curriculum.

It is clear that to overcome many of the problems mentioned before, use of
multiple simulators from easier to more difficult ones should be recommended to fully uncover their potential in learning. Also, gradual shift from black box/semi-transparent box to transparent box approach and
individual to team use should be promising because it logically goes up in the taxonomy of learning objectives and adds higher levels of complexity too.
The transparent box approach is at the core of constructivist use of simulators because it supports construction of own models, meaning and discovery of new knowledge.
Subsequently, hypotheses setting and testing should be an inherent part of the whole learning process. It should help to falsify own inappropriate knowledge and reconstruct it.
See figure 6 in full PDF online

Conclusions

We have shown that the whole domain of business simulators should be divided to several
learning situations. We think that this categorization is needed and its nonexistence is partially the reason for difficulties in proper evaluation of learning outcomes from
business simulators use as shown in literature.

We have also proposed the model of constructivist use of business simulators in
education based on the beforementioned categorization. This model should provide a coherent and clarifying framework for further application in curriculum and research –
mainly it is possible to consistently compare simulation learning outcomes in right categories. The model should be of course tested. It could be done partially using the
experimental design where independent variables are the categories used in the model. And we are preparing a new subject where this model will be practically applied and tested with students –
hopefully allowing them to discover new knowledge on regular basis.

Acknowledgement
This paper is a part of research project MSMT MSM
6007665806 “Factors of regional development and their influence on a social-economic potential of regions.”
References


Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, 2nd Ed., Allyn & Bacon, USA.
The cognitive domain, David McKay, New York.

Duffy, TM., Cunningham, DJ. (1996) ‘Constructivism: Implications for the design and delivery of instruction.’ In DH. Jonassen, ed. *Handbook of research for educational communications and*
Learning and Education, vol. 1, pp. 137–149.


Kolb, D. (1984) Experiential Learning: Experience as the Source of Learning and
Development, Prentice-Hall, New Jersey.


Maier, FH. and Größler, A. (2000) ‘What are we talking about?—A taxonomy of computer simulations to
support learning,’ *System Dynamics Review*, vol. 16, pp. 135–148.

*Merriam-Webster Online Dictionary.* [Online] [Retrieved May 10, 2009],
http://www.merriam-