ISSN 1803-1617

2009 ERIES JOURNAL

Journal on Efficiency and Responsibility in Education and Science

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An international peer-reviewed journal published by
Faculty of Economics and Management
Czech University of Life Sciences Prague

contact: editor@eriesjournal.com
www.eriesjournal.com

ISSUE 1

ERIES Journal

JOURNAL ON EFFICIENCY AND RESPONSIBILITY IN EDUCATION AND SCIENCE

Aims and Scope

The Journal on Efficiency and Responsibility in Education and Science aims to publish perspectives of authors dealing with issues of efficiency and/or responsibility in education and related scientific disciplines. The focus is on topics such as:

- theory and methodology of pedagogy and education;
- theory and methodology of science;
- human resources and human relations management;
- knowledge management and knowledge engineering;
- systems engineering and information engineering;
- quantitative methods.

The journal accepts quantitative, qualitative and experience-based full research papers, short communications or review studies. Applications and case studies introducing and describing impacts of new theoretical approaches in real conditions of practical case are also accepted.

All papers passed a double-blind peer review process.

Published by the Faculty of Economics and Management, Czech University of Life Sciences Prague

ISSN 1803-1617 (electronic version)

Journal on Efficiency and Responsibility in Education and Science
ISSN: 1803-1617

DSS AND GIS IN KNOWLEDGE TRANSFORMATION PROCESS

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Abstract

Knowledge is an important resource for successful decision-making process in the whole society today. The special procedures of control and management of knowledge therefore have to be used. In the area of knowledge management and knowledge engineering basic terms of these disciplines are data, information, knowledge and knowledge transformation.

The knowledge can be defined as a dynamic human process of justifying personal beliefs. Knowledge is a product of successful decision-making process.

Knowledge transformation is a spiralling process of interactions between explicit and tacit knowledge that leads to the new knowledge. Nonaka and al (2000) show, that the combination of these two categories makes possible to conceptualise four conversion steps: Socialisation, Externalisation, Combination and Internalisation (SECI model). Another model of knowledge creation is the Knowledge Transformation Continuum (BCI Knowledge Group) that begins with the articulation of a specific instruction representing the best way that a specific task, or series of tasks, should be performed.

Knowledge modelling and knowledge representation is an important field of research also in Computer Science and Artificial Intelligence. The definition of knowledge in Artificial Intelligence is a noticeable different, because Artificial Intelligence is typically dealing with formalized knowledge (e.g. ontology). The development of knowledge-based systems was seen as a process of transferring human knowledge to an implemented knowledge base.

Decision Support Systems (DSS), Geographical Information Systems (GIS) and Operations Research/Management Science (OR/MS) modelling process support decision-making process, therefore they also produce a new knowledge. A Decision Support Systems are an interactive computer-based systems helping decision makers complete decision process. Geographic Information Systems provide essential marketing and customer intelligence solutions that lead to better business decisions. Operational Research and Management Science (OR/MS) is methodology based on system theory and theory of modelling. The OR/MS models serve for better quantification and precision of decision-making process.

In this contribution the role of DSS, GIS and OR/MS models in the process of knowledge creation will be explained. The tacit or explicit character of this knowledge and the process of its creation will be explained and discussed.

Key Words

Tacit and explicit knowledge, SECI model, Operations Research and Management Science Models, Decision Support Systems, Geographical Information Systems, Models

Klimešová, D., Brožová, H. (2009), "DSS and GIS in Knowledge Transformation Process", Journal on Efficiency and Responsibility in Education and Science, Vol. 2, No. 1, ISSN: 1803-1617, pp 1-15, [on-line] www.eriesjournal.com/_papers/article_58.pdf [2009-06-30]

Introduction

Knowledge as a meaningful resource of decision-making process has changed the society and economy, today. The nature of knowledge in contemporary society is so specific that special procedures of control and management have to be used. In the area of knowledge management and knowledge engineering basic terms of these disciplines are data, information, knowledge and knowledge transformation.

Data can be explained as the product of research or the raw material of information. A single piece of data has no meaning unless the context is understood. Data with its explanation can be transformed into information. because information is a flow of messages. The relationship in the data is pointed out and discussed.

Knowledge is a multifaceted concept with multi-layered meaning. The traditional epistemology adopts a definition of knowledge as "Justified True Belief". In the theory of knowledge creation, knowledge is seen as a dynamic human process of justifying personal beliefs as part of an aspiration for the "truth". In this process information can add to, yield, restructure or change knowledge (Machlup and Mansfield 1983, Dretske 1981).

Knowledge is often not explicitly describable, not easy to explain and to formulate and formalize. The knowledge is recognized as explicit or tacit. Nonaka and Takeuchi (1995) and Bernbom (2001) stress the importance of the distinction between tacit and explicit knowledge in their definition:

Explicit knowledge is knowledge that is already extracted and consumable in books or other media. Tacit knowledge is not present in explicit form, and cannot often be articulated by a person who possesses the knowledge.

However, the specific introduction to the term knowledge creates a different viewpoint: it is no longer sufficient to deliver huge amounts of information to users, instead it is important to support them in doing their knowledge work.

Knowledge management today recognizes the need to exploit intellectual capital, but many practices fall short by only concentrating on individual knowledge components. Knowledge Management is the art of making Money out of immaterial assets.

What is very important - how the knowledge can be captured and processed, what technology areas can help us to realize a knowledge management strategy, and what kind of knowledge is managed in fact.

Integrated knowledge has structure (it's process centric), links (it integrates parts into a dynamic, cohesive whole), relevance (it's meaningful to execution of the task at hand), and is accurately delivered in a critical time and critical environment. An integrated solution is more effective from a process improvement, decision support, training, and risk management perspective than a focus on just storing and accessing information from a central repository.

Knowledge Management is a holistic approach, which can be analysed from different viewpoints. For this reason, it is difficult to give an exact definition. Davenport and Prusak (1988) define this process:

Knowledge Management is a formal, structured initiative to improve the creation, distribution, or use of knowledge in an organization.

Knowledge management can substitute the loss of stable procedural knowledge by explication and formalization through internal information management systems and to solve customer-related or project-related experiences and know-how

by establishing best-practice or lessons-learned databases (van Heijst et al, 1997, 1998). Also the middle management information analysis and routing services through new IT solutions, e.g., DSS, GIS, intranets, data mining, or data warehouses (O'Leary, 1998a) can be advantage.

Together with the globalisation of businesses, an enormous market pressure enforces ever-shorter product life cycles. On the other hand, modern information technologies allow to create worldwide geographically dispersed development teams, virtual enterprises (Ribiere and Matta, 1998) and close cooperation with suppliers, customer companies, and outsourced service providers. All these factors require complex communication and coordination flows, complex both in technical and in conceptual terms. The role of IT is to support the information and document distribution, to enable worldwide communication and synchronization.

Further more, new customer-oriented management, quality principles and new information technologies promote new styles of communication and decision-making in company departments.

This requires complex communication and collaboration by many people with different educational backgrounds, skills, personal goals and perspectives. It also requires a combination of document types, data and information flows, and decision-making processes or changes in previously separated groups of people.

All these business phenomena produce knowledge-related activities comprising (Abecker et al, 1997, Leibold et al, 2001):

- Better exploitation of already available but insufficiently used documents,
- Formalization of business rules in workflows,
- Better usage of human skills and knowledge, application of new information technologies and competency databases, and
- Explication of experience and know-how in best-practice databases, and much more.

Most of these activities can also be supported by information technology, and are in fact already partly supported by conventional Information Systems (IS) (Davenport, 1996, Bullinger et al, 1997, Tiwan, 2002), Decision Support Systems (DSS), Geographic Information Systems (GIS) and Operations Research/Management Science models (OR/MS models) (Brožová and Šubrt, 2006, Klimešová and Brožová, 2006, Klimešová and Vostrovský, 2008, Šubrt and Brožová, 2007).

Material and Methods

Knowledge Creation or Transformation - SECI Model

Knowledge creation is a spiralling process of interactions between explicit and tacit knowledge (Nonaka, 1995, 2000). The interactions between the explicit and tacit knowledge lead to the creation of new knowledge. The combination of these two categories makes possible to conceptualise four conversion steps (Figure 1):

- Socialisation
- Externalisation
- Combination
- Internalisation

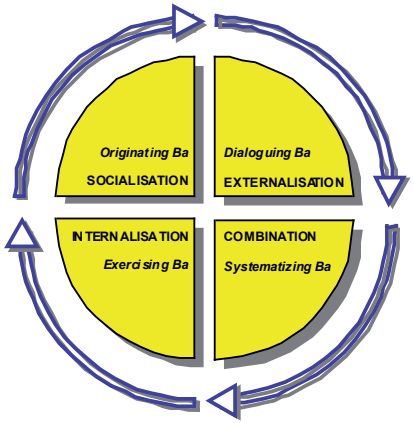

Figure 1: SECI model (source: Nonaka et al, 1995, 1998)

Socialisation enables the conversion of tacit knowledge through interaction between individuals. One important point to note here is that an individual can acquire tacit knowledge without language. Apprentices work with their mentors and learn craftsmanship not through language but by observation, imitation and practice. In a business setting, on job training uses the same principle. The key to acquiring tacit knowledge is experience. Without some form of shared experience, it is extremely difficult for people to share each other's thinking process.

The tacit knowledge is exchanged through join activities – such as being together, spending time and living in the same environment – rather than through written or verbal instructions.

Externalisation requires the expression of tacit knowledge and its translation into comprehensible forms that can be understood by others. In philosophical terms, the individual transcends the inner and outer boundaries of the self. During the externalisation stage of the knowledge-creation process, an individual commits to the group and thus becomes one with the group. The sum of the individuals' intentions and ideas fuse and become integrated with the group's mental world.

Combination involves the conversion of explicit knowledge into more complex sets of explicit knowledge. In this stage, the key issues are communication and diffusion processes and the systemization of knowledge. Here, new knowledge generated in the externalisation stage transcends the ground in analogues or digital signals.

The **internalisation** of newly created knowledge is the conversion of explicit knowledge into the organization's tacit knowledge. This requires the individual to identify the knowledge relevant for oneself within the organizational knowledge. That again requires finding oneself in a larger entity. Learning by doing, training and exercises allow the individual to access the

knowledge realm of the group and the entire organization.

Nonaka and Konno (1998) also adapt the concept of Ba and suggest different Ba's which facilitate the knowledge conversion for his SECI knowledge creation model. Ba can be considered as a shared space that serves as a foundation for knowledge creation. Ba can be thought of as a shared space for emerging relationships. This space can be physical (e.g. office, dispersed business space), virtual (e.g., email, teleconference), mental (e.g. shared experiences, ideas, ideals) or any combination of them. Ba provides a platform for advancing individual and/or collective knowledge.

There are four types of Ba that correspond to the four stages of the SECI model (Table 1). Each category describes a Ba especially suited to each of the four knowledge conversion modes. These Ba offer platforms for specific steps in the knowledge spiral process. Each Ba supports a particular conversion process and then each Ba speeds up the process of knowledge creation. The four Ba's proposed (Nonaka and Konno, 1998) are as below:

- **The Originating *Ba***: a locale where individuals can share feelings, emotions, experiences and perceptual models.
- **The Dialoguing *Ba***: a space where tacit knowledge is transferred and documented to explicit form. Two key methods factors are through dialogue and metaphor creation.
- **The Systematizing *Ba***: a virtual space, where information technology facilitates the recombination of existing explicit knowledge to form new explicit knowledge and;
- **The Exercising *Ba***: a space where explicit knowledge is converted into tacit knowledge.

SECI Element	*Key Elements*
Socialisation and Originating Ba	Focus on potential barriers to personal knowledge exchanges, Employ face-to-face systems across organisations.
Externalisation and Dialoguing Ba	Creative development of systems to aggregate tacit knowledge
Combination and Systematising Ba	Develop multi-organisational outines Solidify shared commitments and mental models
Internalisation and Exercising Ba	Creation of shared expertise and routines Mentoring across organisational boundaries

Table 1: Summary of SECI Implementation Across Organisations (source: Nonaka and Konno, 1998)

Knowledge Transformation Continuum

The Knowledge Transformation Continuum (KTC) is seen as a continuum that begins with the articulation of a specific instruction representing the best (or optimal) way that a specific task, or series of tasks, should be performed within the context of a business process (BCI Knowledge Group) An explanation of each of the components in the cycle and their relevance to the whole is as follows: This specific instruction in reality represents the implicit knowledge resident in the minds of the members of an organization converted to explicit knowledge. This process can be explained by five phases:

- Instruction
- Action
- Measurement
- Collaboration
- Transformation

The articulation of an **instruction** is the first critical step in the transformation of implicit knowledge and experience to explicit knowledge, which can be mined and shared across an organization in the form of process based best practices. Implicit knowledge is defined as the accumulated experience and values of an individual. As such, it resides with the individual and it is of little value to the organization, except as reflected by the action of the individual possessing the specific knowledge. However, once transformed into explicit knowledge by means of an instruction, that knowledge is available to the organization as a whole and will remain an asset of the organization even after the original individual is no longer involved in the process or has departed the organization.

The purpose of a preceding instruction is to provide the basis for a future **action** and to guide an individual performing a specific task on how best to complete the task. Tasks are organized within the tool following the four-tier architecture. Beginning with the overall process, the tool recognizes the sub-process, task and sub-task levels in an effort to provide the flexibility necessary to achieve a significant degree of information granularity so that people can get answers to questions without searching through a series of key word hits, web pages and documents. These answers are based upon the most up-to-date and approved knowledge. In addition to being used as decision support, these actionable instructions are also leveraged as tactical training for the purpose of job certification.

Each action should have a predefined result associated with it. It is by **measuring** the result of an action that an organization is in a position to evaluate its performance, either against a pier group or internal thresholds set by management. Quantification and qualification of results is a critical part of the continuum. The marriage of process centric knowledge and measurement ultimately enables the organization to proactively drive the decision making process towards implementing the highest potential improvements.

The collaboration represents the collective participation of the members of the organization with the specific intent of improving and achieving best possible results from the application of people and technical systems involved in critical business processes. Providing visibility and access to a process centric body of instructions and an elaboration of the measurements and what they mean to the welfare of the organization has, in our experience, resulted in a significant amount of participation by the staff in a continuous improvement process. When proper incentives are tied to the collaboration effort, the results have been spectacular.

Transformation is the last phase. Through collaboration a new way of doing things emerges. Process components are improved and a new best practice is set in place. It does not stop here, it continues and develops its own momentum reaching levels previously unimaginable.

Table 2 shows parallels between SECI and KTC processes.

SECI Element	*KTC Elements*
Socialisation	Instruction, Action
Externalisation	Measurement
Combination	Collaboration
Internalisation	Transformation

Table 2: Parallels between SECI and KTC processes (source: autors)

Knowledge in Computer Science and in Artificial Intelligence

The area in Computer Science that is most influenced by the concept of knowledge is Artificial Intelligence (AI). Figure 2 derived from Aamodt and Nygard (1995) serves as a basis for understanding the use of knowledge in Computer Science. There is no fundamental difference in the representation of data, information and knowledge: everything is based on symbols.

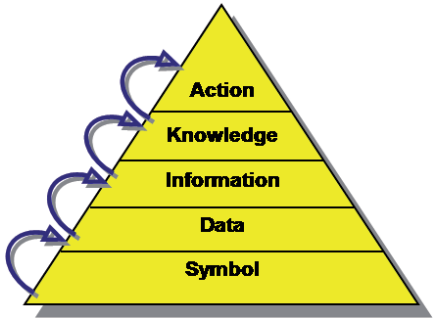

Figure 2: Knowledge pyramid (source: Aamodt and Nygard (1995))

In AI concepts such as Knowledge Based Systems (KBS), knowledge level, knowledge modelling, and knowledge representation were invented and discussed (Studer et al, 1999, 2000). In the early 1980s the development of a KBS was seen as a process of transferring human knowledge to an implemented knowledge base. This transfer was based on the assumption that the knowledge, which is required by the KBS, already exists and only has to be collected and implemented (Musen, 1993). It is interesting to note that research in AI indeed used the early definitions of knowledge in philosophy. It followed the ideas of Plato that knowledge is something inherently true.

It was recognized that the assumption of the transfer approach (that knowledge acquisition is the collection of already existing knowledge elements) was not correct due to the important role of tacit knowledge for an expert's problem.

- Some observations can be made about modelling view of the building process of a KBS.
- The model is only an approximation of reality.
- The modelling process is a cyclic process. The model may guide further acquisition of knowledge. New observations may lead to a refinement, modification, or completion of the already constructed model.
- The modelling process is dependent on the subjective interpretation of the knowledge engineer. Therefore this process can be faulty and an evaluation of the model with respect to reality is indispensable for the creation of an adequate model.

Since this control knowledge is specified independently from the application domain, reuse of this strategically knowledge is enabled for different domains and applications. Besides knowledge modelling also knowledge representation is an important field of research in computer science and AI.

McCarthy (1989) explains an interesting idea:

Expressing information in declarative sentences is far more modular than expressing it in segments of computer programs or in tables. Sentences can be true in a much wider context than specific programs can be used. The supplier of a fact does not have to understand much about how the receiver functions or how or whether the receiver will use it. The same fact can be used for many purposes, because the logical consequences of collections of facts can be available.

More we can see about knowledge representation in Erdmann (2001), Erdmann and Studer et al (2001), Fensel (2000), Staab and Schnurr (2000) and Sure et al (2000), about information retrieval

and information articulation in Mitra et al (2000), about Web catalogues in Labrou and Finin (1999), and about meta-data based search engines in Heflin (2001).

According to Nichols and Twidale (1999) computer supported cooperative work is a research area that examines issues relating to the design of computer systems to support people working together. The type of knowledge managed by computer supported cooperative work systems is usually informal and document centred.

Thus, it is requested to design systems that allow users to collaborate more effectively. Such systems can open up opportunities for collaboration and knowledge sharing that has previously been impossible. People can collaborate in the same place (co-located) or in different places (remote) but also collaborate at the same time (synchronous) or separated in time (asynchronous) (Nichols and Twidale, 1999).

The definition of knowledge in AI is a noticeable different, because AI is typically dealing with formalized knowledge (e.g. ontology, business rules represented in logic, etc.) (Decker et al, 1999, Decker, 2002, O'Leary, 1998b). In a computer supported cooperative work context, knowledge formalization is very difficult and costly, so the formalization of knowledge contained for example in documents is usually not done. In order to enable the usability of AI techniques in computer supported cooperative work this difference will need to be overcome. One possible way is to develop cost-effective techniques that help to formalize knowledge especially knowledge contained in documents (Fensel et al 1998a, Fensel et al 1998b).

Effective management of knowledge requires hybrid solutions of people and technology. Some task human better does, others are better done by technology. Using knowledge to make a decision is usually more successful effected by humans. On the other hand transformation and storage of information is effective done by an appropriate technology.

Results

Decision Support Systems, Geographical Information Systems and OR/MS Models

A Decision Support System (DSS), Geographic Information System (GIS) and Operations Research/Management Science models (OR/MS models) play really important role in knowledge transformation process. We study, explain and discus these facts in our previous work (Brožová and Šubrt, 2006, Klimešová and Brožová, 2006, Klimešová and Vostrovský, 2008, Šubrt and Brožová, 2007) and we synthesise our result in this section.

A Decision Support System (DSS) is an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions (Power, 2002). Also, DSS refers to an academic field of research that involves designing and studying DSS in their context of use. In general, DSS are a class of computerized information systems that support decision-making activities. Five more specific DSS types include:

- Communications-driven DSS
- Data-driven DSS
- Document-driven DSS
- Knowledge-driven DSS
- Model-driven DSS.

The DSS and their construction are based on the models. These models are an approximation of reality and are dependent

on the subjective interpretation of the knowledge. It means that new observations may lead to a refinement, modification, or completion of the already constructed model. On the other hand, the models may guide further acquisition of knowledge and the knowledge is the base for decision support. Moreover, besides knowledge modelling also knowledge representation is very important field of DSS.

A large group of these models is a group of Operations Research/ Management Science models (OR/MS models). These models are obviously mathematical, so each model can be represented as an equation, inequality, or system of equations or inequalities, which describe certain aspects of the modelled physical system. Models of this type are used extensively in the physical sciences, engineering, business, and economics.

Geographic information system (GIS), as the second group of mentioned systems, provides essential marketing and customer intelligence solutions that lead to better business decisions. Geography is a framework for organizing our global knowledge and GIS are a technology for being able to create, manage, publish and disseminate this knowledge for whole society. GIS strengthen the welfare of a nation's citizens. With GIS, it is possible to analyse:

- Site selection and location analysis
- Customer segmentation, profiling, and prospecting
- Demographics and customer spending trends
- Potential new markets and so on

GIS allow visualizing and interpreting data in ways simply not possible in the rows and columns of spreadsheets. GIS can help your business saving time and money, while improving access to information and realizing a tangible return on your GIS investment.

OR/MS methodology is based on system theory and theory of modelling. The basis of OR/MS approach is to build a model for the problem being studied. Practical problems are often unstructured and the definition and clarification of problems, as well as the building of models, is an important part of the OR/ MS methodology. Most people discover that the understanding created by building a model is a very valuable part of the OR/ MS projects. Once a model is built, algorithms often have to be used to solve it. An algorithm is a series of steps that will accomplish a certain task. The study, understanding and invention of such algorithms is also an important part of OR/ MS modelling for decision-making. The decision maker might incorporate some other perspectives of the problem such as cultural, psychological, etc., into the management scientist's recommendations. Finally, communicative and political skills are needed in implementing the results of an OR/MS model in a real-life situation. OR/MS models are aimed at assisting the decision-maker in his/her decision-making process.

OR/MS modelling process helps to improve operations in business and government through the use of scientific methods and the development of specialised techniques. Operations Research is not "research"; it is the cyclic process of re-searching for an optimal (or desirable) strategic solution to the existing decision problem/situation. OR/MS modelling process provides systematic and general approaches to problem solving for decision-making, regardless of the nature of the system, product, or service. The approaches and tools used in OR/MS models are based on analytical methods, simulation and qualitative or logical reasoning. Many of these tools and approaches depend on computer-based methodologies.

Models in Phase of Knowledge Socialization

Knowledge socialization involves capturing knowledge through physical proximity. The process of acquiring knowledge is largely supported through direct interaction with people.

OR/MS models, particularly mathematical models are important part of organisational decision making systems. Development and spread of model applications and organisational information systems were called into existence of DSS. These systems represent a large portfolio of models, which represent tacit knowledge. With database and communication module DSS are worked up to help the organisations to make the rational decisions on different management levels.

Using GIS is about sharing what you know and setting new courses that will sustain our world in the years to come. Standards and interoperability are extensively important elements in our overall software development and support efforts. GIS technology provides essential information tools for many levels of society. As developers, you need to be able to

- Develop applications using the language of your choice
- Deploy applications on a variety of platforms
- Access and manipulate GIS data in multiple formats

To use DSS and GIS needs not only technical skills (explicit knowledge) but also especially good experience and craftsmanship (tacit knowledge). The best way of its application needs to start by apprentice work and practice, because sharing of this tacit knowledge involves joint activity and direct interaction with experienced people. DSS and GIS give the tools to be able to:

- Make informed decisions
- Know where, when, why, and how to take action
- Share knowledge with others
- Help better understand real-world problems using data analysis
- Share information across multiple disciplines and promote a holistic approach to learning

Models in Phase of Knowledge Externalisation

Knowledge externalisation is based on the articulation of tacit knowledge.

The conversion of tacit knowledge into explicit knowledge involves techniques that help to express one's ideas or images as words, concepts, figurative language (such as metaphors, analogies or narratives) and visuals. Dialogues, "listening and contributing to the benefit of all participants" strongly support externalisation. Translating the tacit knowledge of people into readily understandable forms may require deductive/inductive reasoning or creative inference (abduction).

The DSS and OR/MS models are applications that help business data analysis and presentation so that users can make decisions more easily. It is an "informational and knowledge application" to distinguish it from an "operational application" that collects the data in the course of normal business operation.

The model and the way of its application as well as results interpretation may be used for solving many similar problems and this will be a typical pattern of decision-making. The selected model and its application to problem solving represent explicit knowledge that is created as the best practice and can be understood beyond its linguistic, organisational and cultural context.

Also GIS plays a significant part in the way in which the information is distributed to other agencies and organizations

and how it is disseminated to the public. Across government and agencies GIS software solutions are integrated into decision-making processes. By integrating into government or organisations processes, GIS can:

- Create an information base that shares information resources, reduces data redundancy, and increases data accuracy
- Perform joint project analysis and provide decision support
- Streamline processes to increase efficiency, automate tasks and save time and money

With the development of the Web services architecture GIS are becoming more open, robust and interoperable. Web has a unique ability to integrate diverse data through shared location and specially GIS Web services offer real potential for meeting the demands of users and will bring significant benefit to knowledge-based society. Web provides universal and rapid access to information at a scale that has never been seen before and GIS technology has become easier to use and more accessible and make possible to think about large context of processed data.

Models in Phase of Knowledge Combination

The next step of knowledge conversion involves the social process to combine different bodies of explicit knowledge held by individuals. The reconfiguring of existing information through the sorting, adding, re-categorising and re-contextualising of explicit knowledge can lead to new knowledge. This process of creating explicit knowledge from explicit knowledge is referred to as combination. The knowledge combination phase relies on three processes.

First, capturing and integrating new explicit knowledge is essential. This might involve collecting externalised knowledge (e.g. public data) from inside or outside the company and the combining such data.

Second, the dissemination of explicit knowledge is based on the process of transferring this form of knowledge directly by using presentations or meeting. Here new knowledge is spread among the organizational members.

Third, the editing or processing of explicit knowledge makes it more usable (e.g. documents such as plans, reports, market data).

In the combination process, justification – the basis for agreement – takes place and allows the organization to take practical concrete steps. DSS and GIS allow disparate data, information and explicit knowledge to be brought together to create a complete picture of a situation, because GIS and DSS technology have the specialized tools focused on:

- Knowledge identification
- Knowledge sharing/ dissemination
- Knowledge acquisition
- Knowledge preservation
- Knowledge development
- Knowledge utilization.

The focus on single process steps allows the structuring of the management process. Detection of problems in this process and detection of problems, which interfere with the overall knowledge management process, is simplified. Explicit knowledge about future development of solved problems in case of different initial situations is obtained at the end of this stage.

Models in Phase of Knowledge Internalisation

In practice, internalisation relies on two dimensions:

First, explicit knowledge has to be embodied in action and practice. Thus, the process of internalising explicit knowledge actualises concepts or methods about strategy, tactics, innovation or improvement. For example, training programs in larger organizations help the trainees to understand the organization and themselves in the whole.

Second, there is a process of embodying the explicit knowledge by using simulations or experiments to trigger learning by doing processes. New concepts or methods can thus be learned in virtual situation.

Adaptive mechanism of DSS can served as a training tool in organisational systems of training and education. These systems are also used as a simulation tool for experiments with possible decisions and their consequences.

The internalisation capabilities of GIS allow including the new data, information and knowledge into organisational knowledge system. GIS provides essential information tools for many levels of society. IT professionals need those tools to be able to:

- Coordinate and communicate key concepts between departments within an organization
- Share crucial information across organizational boundaries
- Manage and maintain a central spatial data infrastructure, often within a service-oriented architecture (SOA)

The process of exploitation of OR/MS models, GIS and DSS is included into organisational knowledge base as a new specific process and can be used by other members of staff in similar decision situations as a standard. Because these specific processes can be shared mainly by experience, by cooperative action of people, the standards become a set of tacit knowledge.

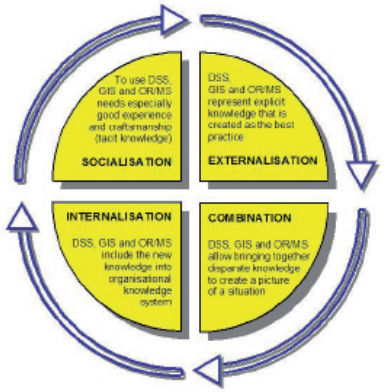

Figure 3: DSS, GIS and OR/MS in SECI spiral (source: autors)

Conclusion

In this contribution the role of DSS, GIS and OR/MS models in the process of knowledge creation and tacit or explicit character of this knowledge were explained and discussed. In the frame of the SECI model it is possible to conclude that

- To use DSS, GIS and OR/MS needs especially good experience and craftsmanship (tacit knowledge), it means knowledge socialisation.
- DSS, GIS and OR/MS represent explicit knowledge that is created as the best practice that is knowledge externalisation.
- DSS, GIS and OR/MS allow bringing together disparate data, information and explicit knowledge to create a complex understanding of a situation (problems and so on), which is knowledge combination.
- DSS, GIS and OR/MS include the new knowledge into organisational knowledge system as a tacit knowledge; it is a process of knowledge internalisation.

Acknowledgements

The following paper was supported by a grant project of the Ministry of Education of the Czech Republic No. MSM6046070904 – "Information and Knowledge Support of Strategic Management".

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Journal on Efficiency and Responsibility in Education and Science
ISSN: 1803-1617

THE ISSUE OF RESPONSIBILITY AND EFFICIENCY IN THE CONCEPT OF TOP MANAGER LIFESTYLE

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Abstract

The article focuses on the top manager lifestyle. The author describes a structure of time allocation by a top manager to individual activities in both professional area and non-work activities it in the context of responsibility towards himself/herself, his/her family and the company in which he/she functions. Simultaneously, it describes the mutual interaction between efficiency and managerial lifestyle models. The research has been carried out by means of questioning using a questionnaire prepared by the author for this occasion which included closed and semi-closed questions, by means of document analysis method, i.e. the technique of assignment content analysis under the Personal Effectiveness and Managerial Task module (MBA Senior Executive Programme) and by means of questioning using a semi-standardized interview. The exploration technique mentioned as the last one was selected to provide for more detailed information concerning the issue researched. The author has come to a conclusion that the time spent in the working environment is identical for both sexes. The male/female managers differ with regard to the time structure and allocation to individual activities in the area outside the working environment, in particular in children and household care. Female managers spend more time on these categories at the expense of recreational activities, self-education and individual studies. Male managers have a greater part of the time pie dedicated to sporting activities, study and self-education and participation in public affairs. Top managers have high competencies which come with obligations and responsibility for an effective decision-making process, measures and efficient provision of processes related to the set objectives which are in keeping with the company strategy. This responsibility is carried out under the following relationship structure: manager – company, manager – family and manager – him/her self. The ability to coordinate private and working life has a positive impact not only on the psychological and physical sides of the individual in question but also has a significant influence on the efficiency of his/her managerial decisions and productivity of his/her performance at work.

Key Words

Lifestyle, Professional Area, Non-Work Activities, Personal Responsibility, Work Efficiency

Staňková, D., M. (2009), "The Issue of Responsibility and Efficiency in the Concept Of Top Manager Lifestyle", Journal on Efficiency and Responsibility in Education and Science, Vol. 2, No. 1, ISSN: 1803-1617, pp 16-27, [on-line] www.eriesjournal.com/_papers/article_65.pdf [2009-06-30]

Introduction

Lifestyle

Lifestyle is an aggregate category which characterizes the life of a person as a whole and in terms of mutual interrelatedness of individual components. Simultaneously it depicts a character of life in terms of its content and structure. Lifestyle may be looked at from several aspects by monitoring its content (i.e. activities carried out by people, making use of individual types of means or time structure) or by monitoring the facts which shape it (i.e. means serving to meet objectives, their determination and assessment of their level).

Certain communities form their lifestyle on the basis of individual and group behaviour models. It is a social process in which all individuals participate.

From the standpoint of social activities of humans, the lifestyle can be understood as a kind of synthesis of two basic areas - the professional area and non-work activities (the latter includes a subcategory concerning leisure time) (Nový and Surynek 2006)

Professional area

Professional area is one of the most significant structural parts of lifestyle, it is closely related to it and it represents a key issue for most top managers. Work includes social, psychological, cultural and other functions (Yost 2004). From the point of view of an individual, the trend of the current social/economic development is marked by gradual rapprochement of the professional and non-professional world while the prior absorbs the latter (Nový and Surynek 2006). In the professional area, lifestyle is determined by the level of education achieved, kind of an employment and status in the company and social hierarchy.

The status at work and type of an employment are closely related to one's career. The following types may be distinguished: the *bureaucratic career*, i.e. anticipated movements towards an employment with a higher social status as part of a single profession or an organization; the *professional career*, i.e. personal growth on the basis of competencies acquired which come with more demanding tasks) and the *entrepreneurial career* which concerns building and development of one's own company and creating valuable outputs (Arnold et al 2007). Generally, the term "successful career" is widely spread. However, how can success be measured and do all individual see it the same way? The most marked criterion may be the status achieved in a particular company hierarchy and simultaneously the level of remuneration. These indicators serve as good driving force in the traditional concept of bureaucratic career but are not as prominent in the other two career types. Earnings and promotion are often stated as the objectives of career success. Attitudes and feelings of a particular individual could be, on the other hand, considered the subject. For these reasons, other criteria for successful career evaluation are available. These are criteria in terms of satisfaction with one's career progress, remuneration or personal influence and balance between the professional area and non-work activities, i.e. also the family life.

Recently, there has been a great interest in the last career success criterion in the list, the work-life balance. The relationship between family life and career must be looked at in the context of global viewpoints which are: job market functioning and state measures and simultaneously subjective components: individual ideas, values and need and distribution of responsibilities and roles within a family (Hajná 2006).

The professional area is closely tied to the issue of workaholism which stands for a psychological disease manifested by excessive working, pathological manifestation of one's will to manage everything on his/her own (Furnham 2005). In the Czech Republic this diagnosis does not officially exist, however, experts recognize it and consider it to be a serious issue of working hours (Pauknerová 2006) This strong obsession by work is related to the personality type. However, not every individual is capable to keep on working in this fashion without endangering his/her psychological and physical health (Fassel 2000). His/her working results do not necessarily have to correspond to the work effort.

Non-work activities

Definition of non-work activities is in the framework of the current economic development rather difficult. This is in particular given by the fact that a number of traditional ways of working which require strict separation of working time from non-work activities looses its efficiency and is being substituted by ways in which this separation is almost non-existent. Simultaneously, the possibilities to make use of free time have been modified as a result of economic growth and the activities which individual people choose are often closely tied to the performance of work-related activities. Area of non-work activities is characterised by activities which an individual carries out outside his/her working hours: *activities connected with his/her employment* (transportation to work, preparations for work), providing for *physiological needs* (sleep, food, body care, relaxation), providing for *functioning of household* (shopping and meal preparation, cleaning, cloths washing), *family life* (education of children, contacts between individual family members), focused on *recreation, entertainment or culture* (walks, meeting friends, performances), *study and self-education* (e.g. MBA, MSc studies), *active physical development and sport* (running, fitness, golf or tennis) and participation in *public affairs* (charity, membership in political parties, representation in employer association).

Leisure time

Leisure time is a subcategory of non-work activities. It is that portion of time devoted to non-work activities which remains after subtracting the time of work the individual is paid for and activities connected to its performance and after subtracting the time connected with reproduction of human beings as a species, i.e. after satisfying the physiological needs of oneself and one's family. The leisure time category is often one of the indicators of a developed society, keeping in mind that managerial work places an individual before the task of organizing his/her social life (Nový and Surynek 2006).

Material and Methods

To obtain the background material necessary for purposes of this research, the method of questioning was selected using a questionnaire which included closed and semi-closed questions. The questionnaire contained an introduction, justification for the research and identifiers for the respondents (age, sex). The main section contained thematic blocks consisting of the following: "Work Area", which delved into not only time devoted to work but also a second significant indicator in the form of education level attained. At the same time, the extent of risk for dependence on work was assessed, along with the use of support resources. In another section, "Non-work Activities", the amount of time for individual activities in particular areas was mapped out, e.g., family life, study and self-education, sporting activities, etc. The return rate for the questionnaire, which stood at 68%,

was increased by a so-called "follow-up" 14 days after sending the questionnaires. This addressed respondents who had not yet returned the questionnaire.

The "Successful Career" area was researched using the 100 assignments under the Personal Effectiveness and Managerial Task module by a document analysis method and a further technique, structured semi-standardized interview with 96 respondents, focused on the same areas as those contained in the questionnaire, this time with the goal of getting deeper insight into the issues.

The exploration technique mentioned as the last one was selected to provide for more detailed information concerning the issue researched. Collection of empirical data, continuous analyses and subsequent evaluation of information was carried out from June 2008 to February 2009.

The research group included 225 individuals who work as top managers in the Czech Republic and who were selected on the basis of quota - age (30-50), working at a top managerial position (min. 3 years) from the base file containing students, graduates and contact information provided by a private university. The research group included 28% men and 7% women aged 30-40; 51% men and 14% women aged 41-50.

The objective of the paper is to describe the time structure and content of both work activities and non-work activities of top management (such as time devoted to family life and child care, study and self-education, sport and recreational activities of participation in public affairs). In a more general context, the objective is to find out about manager lifestyle in the framework of the efficiency of work outputs and the responsibility towards oneself, one's family and company in which he/she works at a managerial position.

Results

Time devoted to professional area

In the professional area, there are two key indicators for mapping the top management lifestyle. The first one is the extent of time spent work.

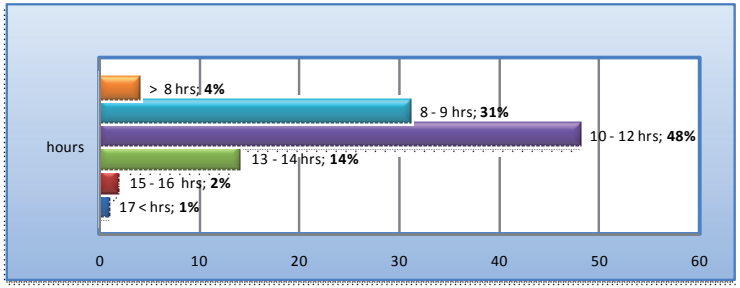

Fig. 1 The extent of time spent daily in the professional area (in %)

48% of top managers state ten to twelve hours spent on work-related activities. To this amount of time (10-12 hours) the time spent at home, however used for activities connected to work must also be added to. Simultaneously, it must be kept in mind that if, in the context of this paper, we talk about working time, it does not mean the "classical" working time model, i.e. performance of work from Monday to Friday, but the time devoted to weekend work must be considered as well. This period of time should, from the standpoint of psycho-genetics, be used for relaxation, strengthening and development of interpersonal relationships within the family, one's surrounding and friends. Due to the excessive time demands for managerial activities (47% of respondents report working also at the weekends) the said interpersonal ties are being neglected together with time spend with family members, friends and oneself.

31% of respondents indicated they worked between eight and nine hours when asked about the "standard" workday. Thirteen to fourteen hours was indicated by 14% of respondents. Extreme values of between fifteen and seventeen hours daily were reported by 3% of top managers polled.

	Men	Women
Secondary school education	**5**	**6**
University education - Bachelors Degree	**16** (79 Bc., 21 BA (Hons)	**16** (67 Bc, 33 BA (Hons))
University – Master's degree	**67** (35 Mgr.,51 Ing., 14 MSc)	**62** (26 Mgr.,61 Ing., 13 MSc)
Post gradual education	**12**	**15**

Table 1: Education completed (in %)

The second significant indicator in the professional area is the level of education completed. At the managerial position, most persons have completed a master's degree of university education and 44% were awarded in particular the title Ing. Attaining the Mgr. title is represented by the difference of 18% The ration between male managers and female managers in terms of attainment a certain university degree is almost identical.

The level of dependency on work (53 points)	12
Light form (54 – 63 points)	26
Moderate form (64 – 84 points)	15
Severe form (85 and more points)	5

Table 2: Workaholism test evaluation (in %)

Table 2 lists the results of the test concerning the risk of dependency on work which was written by Prof. B.E. Robinson from the University of North Carolina (Nešpor 1999). Based upon the sum of points obtained as part of 25 questions, it is possible to categorize dependency on work. On the basis of results of the said test, a high percentage share of work-dependent managers is obvious, namely in 58% of cases. This is an alarming fact since workaholism has a negative influence not only on the health of the particular individuals but also impacts, in a destructive way, the psychological side of people as well as their private lives.

Alcohol	8
Coffee	94
Energy drinks	31
Food supplements	19
Marihuana	9
Cocaine	1

Table 3: Making use of supporting substances (in %)

A serious problem of using alcohol as a supporting substance for stress release, for relaxation and stimulation is mentioned in 8% of respondents. Other supporting substances which are frequently used include in particular coffee 94%, (i.e. 212 respondents) - (84% from them [i.e. 178 persons] up to 5 cups a day, 15% from them [i.e. 32 persons] up to 10 cups a day, 1% from them [i.e. 2 persons] more than 10 cups a day), energy drinks – Redbull, Semtex, etc. 31% respondents (i.e. 70 persons) - (57% from them [i.e. 40 persons] stated consumption

1-2 a week, 17% from them [i.e. 12 persons] 3-4 a week, 11 % from them [i.e. 8 persons] 5-6 a week, 15% from them [i.e. 10 persons] 7 and more energy drinks a week). In the research group selected (225 respondents) 9% stated that they have experience with marihuana and 1% with cocaine. In spite of the fact that questionnaire research was anonymous, it can be assumed that the low percentage of experiences with cocaine has a low prediction value since it is a very sensitive issue. Other substances stimulating brain activity and higher work productivity include food supplements, in particular lecithin, guarana, ginko biloba (used by 19 % of respondents).

	Men		Women	
	Mon - Fri	Sat - Sun	Mon - Fri	Sat - Sun
Employment-related activities	27	13	24	10
Physiological needs	48	33	49	32
Providing for household functioning	3	4	6	13
Family life (partnership)	7	15	8	19
Child care	3	6	7	10
Recreational activities	2	7	1	4
Study and self-education	5	8	3	6
Active physical development and sport	4	10	2	4
Participation in public affairs	1	4	0	2

Table 4: The extent of time spent on non-work activities area per week (in %)

Employment-related activities

This non-work activity category concerns primarily transportation to the place of employment. Including the time spent travelling to business meeting is disputable. For the purposes of this paper, the time necessary for such work transportation will be considered to be work-related. Results in this category are almost identical (in the case of male managers 27% time (Mon – Fri), 13% time (Sat – Sun) and in the case of female managers 24% (Mon – Fri), 10% (Sat – Sun) of time necessary for preparations for work, transportation to work. In recent months, an increase in preferences for taking a train as opposed to driving one's own car have been noted. An effort to maximally make use of time management and devote the time which was usually spent driving by working on a notebook, dealing with Outlook mail, preparation of projects, and notes for meetings etc. Before the economic recession settled in, a company driver for transportation of a top manager was not rare. The gloomy economic situation has, however, caused radical cost cuts in this area.

Physiological needs

The extent of time, i.e. 48% (Mon – Fri, 33% (Sat – Sun) in the case of male managers and 49% (Mon – Fri), 32% (Sat – Sun) in the case of female managers is devoted to this category of non-work activities weekly.

Providing for household functioning

This is primarily a women's domain (female managers devote 6% (Mon – Fri), 13% (Sat – Sun) of time to this category as part of their non-work activities, while men reserve only 3% (Mon – Fri), 4% (Sat – Sun) of their time for the said activities). During a common working week these activities include basic household cleaning and meal preparation. In the area of household chores the weekend activities also encompass shopping (interviews show preferences for a one-off shopping to provide for the whole week) and cloths washing.

Family life (partnership)

During a working week the top managers devote minimum amount of time to this category. Male managers "invest" 7% of time a working week in this category. Female managers spend slightly more time on family life during a working week then male managers - by 1%. At the weekend, the amount of time spent increases: to 8% for male managers and 11% for female managers. The insufficient amount of time spent with family is currently also greatly impacted by the economic crisis. There are much higher demands made on managers in terms of their performance, efficiency and output productivity, effectiveness of implemented anti-crisis measures within their company. The time spent at work radically displaces the time which could be devoted to family (partner).

Child care

In spite of the fact that female managers are fully occupied at their employment, the research shows a greater amount of time devoted to child care and activities connected with their education compared to the amount of time which male managers devote to their children, 7% (Mon – Fri) 10% (Sat – Sun) female managers, 3% (Mon – Fri), 6% (Sat – Sun) male managers). Child care includes not only providing the basic care but also helping them with their schoolwork, reading and talking, playtime and providing transport to their regular sporting activities, going to see presentations of their activities - school shows, children's theatre and music performances.

Recreational activities

This type of activities takes a minimum share in the framework of the working week time structure for both the male and female managers. Male managers are more likely to take part in recreational activities than female managers, specifically 7% (as part of the non-work activities). Female managers only 4%. If women find time space for recreation, it is interconnected (the same way as sporting activities) with participation by all (or at least the majority) of family members.

Study and self-education

Study and self-education is interconnected with further follow-up studies (in particular university) increasing the credit of a particular manager and his/her competitive ability on the job market. Top managers usually devote their time to studies aiming at a prestigious MBA (Master of Business Administration) title, which is nowadays considered to be the standard for top manager qualification. Respondents in the research group stated male managers 5% of time (Mon – Fri), 8% (Sat – Sun) and female managers 3% (Mon – Fri), 6% (Sat – Sun) devoted to studies. Aside from the mentioned MBA studies, managers take part in seminars in the area of soft skills (e.g. crisis management and crises communication, managerial skills, leadership, process management, time management, stress management etc.) together with the type education which develops their professional expertise.

Active physical movement and sport

The most frequent stated sporting activities such as running, golf and tennis. However, it is complicated to determine a clear category to included sporting activities in which managers participate. At the first sight it could be considered to be a part of the non-work activities, this, however, is not clear. Simultaneously, there exist an interconnection of both the professional world and non-work activities. Top managers often use a connection between sporting activities and business. Compared to male managers, the total amount of time invested in the physical development is significantly lower in case of female managers (- 8%). This is due to the fact that given the time exigencies of a particular profession, female managers give preference to childcare and household duties. The interviews carried out revealed that if female managers include sporting activities in their daily timetable it is usually connected with saturating needs in their roles of mothers or wives and they thus seek activities in which other family members may take part and thus relationship structures within a family unit are reinforced.

Participation in public affairs

Activities connected with participation in public affairs in particular activities in political parties and charity, are the domain of male managers. As part of the non-work activities account for 4% of time per weekend. Female managers devote only 2% of weekend time space.

Discussion

In their effort to achieve success and career growth most managers feel a strong need for self-realization which is often ranked at the top of the value system. The current period of economic recession places greater demands upon error-free and maximally efficient character of all activities connected with managerial work.

Let's focus on selected areas of professional and private lives in the context of top management lifestyle.

Work – life balance

Family or work? Work or family? How much time should be devoted to each of these areas? How often can we encounter this dilemma which top managers have to deal with. It is undoubtedly true that to achieve a psychological balance and feelings of well-being there must be an interconnection between maximum success and satisfaction in professional area and functional family and positive experiences in private life (Jones et al 2006).

The balance between private and professional life is therefore an important aspect in the lives of top managers (Hall 2006). If an individual carries out activities in his/her professional area which he/she regards as positive, this fact is reflected in his/her private life (Johnston and Smith 2001). This is also, of course, true vice versa. Managers also pay attention to the balance between the professional/private life so that they find corresponding amount of time to devote to themselves, their leisure activities and interests but simultaneously (an in particular) their loved ones. It is also very important to be able to rise above work-related problems and do not transfer them to one's environment in their private life. Top managers also state that a balance in the said two areas may be achieved if they manage to think about and experience other things than just their business and avoid seeing it all around themselves, in spite of the fact, that they enjoy it and it enables to saturate their self-realization needs. Responsible setting of priorities and to be able to, on a given scale, divide the time ratio for professional and career values and priorities in private life is a key element for the mutual balance is a responsible setting of priorities. The ability to balance private and professional life has a positive impact not only on psychological and physical areas of a particular individual, but it also has a significant impact upon efficiency of his/her decisions and performance at work.

Aspect of responsibility in professional and private areas

Work brings benefits not only to a particular individual but also to economy of a given country. Top managers have high competencies which come with obligations and responsibility for an effective decision-making process, measures and efficient provision of processes related to the set objectives which are in keeping with the company strategy. This responsibility is carried out under the following relationship structure: manager – company, manager – him/her self. Each of them plays several roles in his/her lives and those that are connected with our professional area (manager, employee etc.) may be counter productive and destructive vis-à-vis roles in the private and family areas of life. Here, the individual in question has a further range of responsibilities, especially in the role of father to his children and partner. The extent to which concrete forms of responsibility are fulfilled depends particularly upon the value hierarchy possessed by every individual, upon the phase of life and the age of the individual. On the basis of knowledge from praxis (especially instruction in the MBA programme), a certain developmental curve may be sought in co-relatedness to the responsibilities and value preferences of the area in question. Managers up to about forty years of age tend to be focused on work, building their careers and attaining the greatest possible remuneration. The priorities at this point are usually career and finances. With managers over forty years of age, however, we may run into a substantial re-evaluation of what is important in life and awareness of the fact that money will buy almost anything -- but not health, love and the most beautiful years

in the role of father and partner. Many times, however, it's too late for a change in the ladder of priorities (in favour of family life) and relationship disharmony, as one of the chief reasons for divorce, does its damage. This shows up in the results of research interviews, which indicate that top managers record a high percentage of divorces (36% of all those polled, with 84% divorced once, 16% divorced twice or more).

Workaholism

Workaholism is a significant phenomenon among top mangers, something which carries no small amount of risk (Johnson and Thorne 2000). Workaholism especially impacts that health status of individuals, primarily due to neglect of a healthy lifestyle, with heightened caffeine consumption impacting physical condition in the form of high blood pressure, cardiac ailments or food intake disorders, digestion, ulcer diseases of a stomach and duodenum but also overall weakness of the immunity system. At the same time, also psychological area is impacted manifesting in depression, sleep disorder, apathy or on the opposite anger outbursts. The issue of workaholism is also destructive in the private area, when permanent neglecting family members, partners and giving preference to clients and work issues is a frequent reason for relationship or marriage break-up. The disagreements due to excessive working, insufficient amount of time for a partner/family and subsequent overall relationship tension is mentioned as the reason for a divorce by 89 % of workaholics – managers.

Top managers who "fell for" workaholism should realise an important fact - that their good psychological and physical conditions is a prerequisite for their maximum performance at work. Only when being in the state of physical and psychological well-being they are able to effectively and efficiently manage activities and time of themselves and their colleagues.

Successful career

Successful career, different concepts and understanding of "success" is a frequent topic for a discussion. What is a successful career, how can it be measured and when a particular individual can say he/she has reached it? On the basis of the interviews carried out a rather fitting description was arrived at using the following words and phrases (total enumeration or their combination):

Achieving one's goals, finances, satisfaction, recognition, prestige, felling of a job well done, pride.

Achieving one's personal goals – people who have an ambition and want to achieve something in life; they have clearly determined goals to achieve; personal and career goals are often closely interconnected. Desire to build one's own big business is frequently listed as a long-term objective as well as the wish to become a CEO of a prestigious company etc. Short-term objectives include, e.g., successful completion of MBA studies. To the feeling of achievement or experiencing a successful career requires meeting both types of objectives i.e. personal and professional.

Finances – to achieve the feeling of successful career a particular individual must receive corresponding remuneration and no financial deficit in terms of the level of lifestyle he/she desires is present.

Satisfaction – the particular manager must be concerned with the executed profession and be happy to do it. Then satisfaction is achieved and aside from the fact that the given profession

is his job, he/she is happy to do it and feels psychological satisfaction.

Recognition – an individual can consider him/herself to be successful if he achieves success in his/her field of expertise, his/her activities so that his/her environment appreciates him and was considered an expert.

Prestige – is understood in the context of carrying one's profession which is perceived and considered prestigious by the society.

The feeling of a job well done – doing maximum so that things are done the best way possible while making use of all knowledge and skills acquired in spite of the fact that the people in the manager's surrounding not always register or appreciate that.

Pride - he/she is proud of him/herself and desire that the loved ones are proud of him/her as well.

Conclusions

On the basis of result found during the research it can be stated that the amount of time devoted to the professional area is for both male and female managers identical. Male and female managers differ in the structure and time devoted to individual activities in the non-work activity area. These are, in particular, the following: female managers devote a greater amount of time to children and household than managers. A greater amount of time devoted to private life comes, in case of female manager, from time space designated to recreational activities, self-education and studies. Managers have a greater time space devoted to studies and self-education, sporting activities and participation in public affairs.

Time must be considered to be a limited resource. Time spent doing activities in the professional area decreases the time available for non-work activities. The lifestyle structure and "time subsidies" for individual areas which is selected by a particular manager influences his/her psychological health, interpersonal relationship quality and overall life satisfaction.

A tendency may be noted with managers in particular, due to the limitations on their time imposed by their demanding profession, to spend the maximum amount of non-work time engaged in sporting and recreational activities with their families. It is entirely clear that a model of the top management lifestyle may be constructed which lays emphasis on the quality of time spent with the family and an attempt to get the most out of the minimal time options at hand.

The professional area and private life are the two interconnected containers which influence each other to a various degree. Unbalance and discrepancies between them impacts not only the professional life of a particular manager but is simultaneously reflected in the working atmosphere of the team and its overall performance.

The ability to recognize the level of urgency and importance of issues along with time management are important helpers in the effort to achieve the maximum possible working efficiency and arriving at a balance with the non-work activities. Setting values and matching them with priorities is among the key managerial abilities. It still holds true that top managers are capable of managing high values in their professional life but many times are not able to deal with priceless values in their private lives. The importance and capital contained in physical and spiritual health, quality of interpersonal relationships and their feedback into the professional area of a given individual must be recognized. Realization, respect and responsibility towards the given values is the key to performance in the professional area and satisfaction in human life.

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Journal on Efficiency and Responsibility in Education and Science
ISSN: 1803-1617

A NEW APPROACH TO THE ACHIEVEMENT TEST ITEMS EVALUATION: THE CORRECTNESS COEFFICIENT

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Abstract

This paper deals with the problem set of an achievement test item scoring. The scoring process is generalized with the help of correctness coefficient – the new concept set up by the author. The paper describes complexly formalization of the scoring process, contextualizes the contemporary used methods to the general context and brings new methods as well. The scoring methods of sorting items and guessing penalty are described in detail. Observations described in this paper can help examiners with more accurate assessment of achievement test results.

In the first part, the theoretical basics of the test item scoring are given. We are going to find out that whole scoring process depends on the teaching objectives, test item types, curriculum taxonomy and achievement test objectives. Then the theory of the test item types is described. After this theoretical introduction the concepts of the total achievement test score and correctness coefficient are set up. Let's emphasize that using of the correctness coefficient is the new contribution of the author. Than the correctness coefficient is used to express the measure of examinee's answer accuracy within the different test item types. Using the correctness coefficient for evaluation of closed multiple-choice items, injective and general relational items, narrow open items, joining items and sorting items are deeply examined and described. Various scoring method for these item types are discussed, especially for the sorting and joining items. Afterwards the theory of penalty guessing is expressed with the help of the correctness co efficient, which strengthens the ability and universality of theory being described.

The main goal of this research paper is to provide the complex theoretical overview of the test item scoring problems, which can be useful for pedagogues, examiners and testing application (or e-learning system) developers to provide more accurate and clear evaluation process of the achievement test.

Key Words

Evaluation Methodologies, Intelligent Tutoring Systems, Media in Education

Foltýnek, T. (2009), "A New Approach to the Achivement Test Items evaluation: the Correctness Coefficient", Journal on Efficiency and Responsibility in Education and Science, Vol. 2, No. 1, ISSN: 1803-1617, pp 28-40, [on-line] www.eriesjournal.com/_papers/article_61.pdf [2009-06-30]

Introduction

Achievement test is considered to be the most objective tool of pedagogical evaluation (Foltýnek 2005), Davis (Davis 1993) adds that *"tests are powerful educational tools that serve at least four functions"* (to evaluate students, to motivate and help them, to give a sort of feedback to teachers and reinforce learning). Particular test questions – items – can be however evaluated – scored – with various methods giving various results. This problem appears especially while working with items of more complicated types, where scoring methods aren't obvious at first sight (Foltýnek 2006). As *the assessment is the integral part of the learning process* (Booth et al. 2003), we are going to generalize the scoring methods and analyze possibilities of their concretization in the following text. The analysis will be done with respect to their methodical suitability depending on the type of examined curriculum, expected deepness of students' knowledge, goal of the test and other characteristics (Payne 1968). The paper doesn't suppose just separate evaluation of particular items, but also *weighting of the items* among themselves (Linrace&Wright 1995). Automated, computer supported testing is gaining importance and achievement test results are considered to be an absolutely reliable indicator of the knowledge of examinees (Segall et al. 2005). A technology usually could be *further dissected into finer grain techniques and methods, which correspond to different variations of this functionality and different ways of its implementation* (Brusilovsky 1999). Therefore it is applicable to devote adequate part to the scoring methods for saving the achievement test objectivity.

In the following text, we are going to set up the formalization of achievement test items with the help of correctness coefficient. This coefficient expresses – depending on the test item type – the rate of students' fault. The test score assessment is therefore much more accurate than in case of considering the boundary values (correct – incorrect) only.

Materials and Methods

Let's consider four different bases:

- Teaching objectives taxonomy (Bloom 1956);
- Curriculum taxonomy (Foltýnek 2006);
- Test item types (Foltýnek 2006) and
- Achievement test objectives (Mužić, 1993).

Therefore we have four-dimensional space of indicators, which are helping us to choose the proper scoring method for the specific test. The relations of particular bases among themselves and to the scoring are illustrated at Figure 1. We shall abbreviate Test Item Scoring to TIS in the following text. Teaching targets or curriculum taxonomy impacts – besides TIS – the test item types choosing too. TIS depends on all four bases.

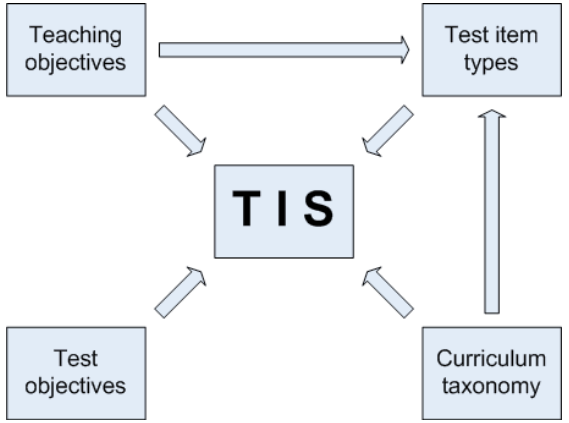

Figure 1: Relation of basis to TIS

Bloom's taxonomy

Bloom distinguishes six levels of knowledge deepness (Hogbood et al. 2004). Construction style of the test items and TIS methods should be adapted to the expected knowledge deepness.

- *Knowledge* – students are asked to remember pieces of information, specific terms and techniques;
- *Comprehension* – students are asked to grasp meaning and to demonstrate understanding by summarizing or explaining;
- *Application* – students are expected to take what they have learned and apply it in a new, real-life situation;
- *Analysis* – breaking down of knowledge into parts and the relation of those parts to the whole concept;
- *Synthesis* – assembling knowledge into a new whole. This means collecting information, then creating a new insight;
- *Evaluation* – students judge the value of the information for a specific purpose.

Knowledge taxonomy

We can classify knowledge according to the way of processing in the human brain and according the application to:

- *Encyclopedic* – knowledge of (isolated) data without deeper relations is important;
- *Relational* – relations between objects are important;
- *Deductive* – knowledge of principles and deduction ability is required;
- *Language* – knowledge and competences about language are important;

Test item types

Test items (more commonly called *questions*) can be divided to many types (Mužić 1993). The crudest division criterion is to *closed* and *open* items. Using closed items, the examinee chooses from given alternatives, events and sorts or joins them. Using open items, the examinee doesn't have any possibilities and he/she is forced to create the answer himself/herself.

Open items are further divided to *wide* and *narrow* distinguished by the length of an answer. Closed items are divided to multiple-choice, where generally the examinee is asked to choose some of offered alternatives and relational, where the examinee looks for the relation between offered objects, respectively sets of objects. The scheme of test items division is illustrated at Figure 2.

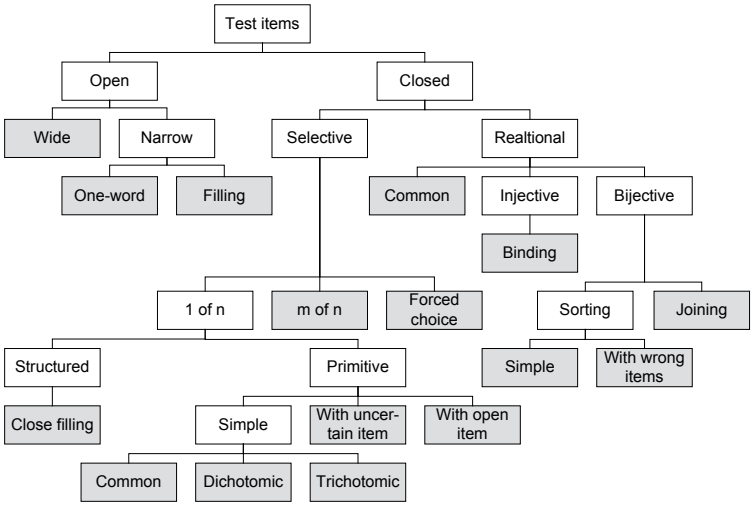

Figure 2: Division of test items types

Achievement test objectives

An achievement test can have many objectives (Foltýnek, 2006):

- *Administrative* – indicates if the student has met given requirements or not;
- *Advisory* – indicates special abilities or disabilities of the student, recommends suitable fields of future personality development;
- *Informational* – indicates performance, output, success, failure of the student, parent or teacher;
- *Motivational* – stimulates the student to increase his/her output;
- *Achievement* – fixes and deeps his/her knowledge;
- *Educational* – forms the student's approach to learning and knowledge;
- *Reflexive* – provides a feedback to the teacher.

It is obviously possible that one achievement test can has more targets. Hardly ever we have a test with just one of the mentioned targets. Always is important to notice that TIS method depends on the test targets.

Total achievement test score

Let's consider test **T**. Let the test be composed of n items denoted $p_1, p_2, \ldots, p_n$. Then

$$\mathbf{T} = \{p_1, p_2, \ldots, p_n\}$$

Let $b_1, b_2, \ldots, b_n$ is a point evaluation of items, thus their weights. During the scoring process, we will find so called particular item score, thus the real number from the closed interval <-1,1>, which will be denoted σ_i. This number is serving as a base for computation of item score, which will be denoted s_i. The weights are taken into account during computation of the item score. Obviously is

$$s_i = \sigma_i \cdot b_i$$

Therefore total test score S_T is

$$S_T = \sum_{i=1}^{n} s_i = \sum_{i=1}^{n} s_i \cdot b_i$$

Values $b_1, b_2, \ldots, b_n$ assesses examiner during the preparation of the test. Values σ_i for $i = 1, 2, \ldots, n$ are computed from the examinees´ answers during the scoring process.

Results and Discussion

Correctness coefficient κ

To the most common generalization of TIS formalism, we have to decompose the scoring of each type to the most fundamental elements.

In open items, let's consider text strings.

In multiple-choice items, let's consider particular alternatives

In injective and general relational items let's consider members of Cartesian product A × B (thus ordered pair (a,b), where $a \in A$ and $b \in B$).

In pairing items, let's consider particular one-to-one pairings between the sets A and B. In the following text, we will denote the set of all one-to-one pairings by the symbol $B_{ij}(A,B)$.

For each of these elements, let's define its correctness coefficient, denoted by κ, which is going to be the base for the particular item score computation. The correctness coefficient has the same range as the particular item score, and, as we will show

later, in some cases these values are equal.

From the methodic aspect, in correctness coefficient the rate of correctness (event. the rate of incorrectness) of every particular answer is hidden. Let's explain the semantics of correctness coefficient in particular groups of test item types.

In open items, the correctness coefficient is assigned to every text string. It is obvious that for most of the strings $\kappa = 0$, these are generally incorrect or nonsense answers. For absolutely correct answer $\kappa = 1$. In the case of existence of more correct answers, all of them will have the correctness coefficient equal to one. There can also be even partly correct answers. In this case, the values from the inside of interval (0, 1) gain their importance. These values indicate how close the examinee's answer was to the correct one. We can also consider existence of answers indicative of a blunder. In this case, and supposing much restrictive TIS methods, we can also consider values $\kappa \in <-1, 0)$, which will indicate the rate of incorrectness of these answers. Open items serve as an example of items where correctness coefficient and particular item score are equal.

In multiple-choice items, the correctness coefficient is assigned to each alternative. This is independent from the multiple-choice item subtype. We have to notify that multiple-choice items type *m* of *n* are de facto sets of dichotomy items, which are special cases of multiple-choice items type 1 of *n*. We need to elaborate the numeration of TIS just for the multiple-choice items type 1 of *n* and apply gained knowledge to the other types.

Let's have the set of alternatives. The examinee has to choose just one of them. In the most simple case, we assign to the only correct alternative $\kappa = 1$ and to other alternatives $\kappa = 0$. Now we have to consider the case, where distinguishing the mistake following from choosing particular incorrect alternatives is suitable to consider. Not all of them can be equally incorrect and sometimes some of them can be "almost correct". In that case, similarly as in the open items, we should consider even values from the inside of the interval (0, 1). Moreover, some of alternatives can indicate rough ignorance which should be penalized by the negative score. Therefore, we can consider values from the interval <-1, 0).

Negative values of the correctness coefficient gain their importance also when guessing penalty (penalization of incorrect answers) is employed. In that case let's set $\kappa = 1$ for correct alternative and

$$\mathsf{k} = \frac{-1}{n-1}$$

for the incorrect one.

Due to the fact that the items type *m* of *n* are – as we have mentioned above – sets of the items type 1 of *n* with two (eventually three) constant alternatives, in items of this type we have to define the correctness coefficient both for the case if the examinee has chosen the given alternative and for the case if not.

Injective items are de facto sets of items type 1 of *n* with constant set of alternatives equal to B. Correctness coefficient is defined for every pair (a, b) from the Cartesian product $A \times B$ and its semantics lies in the evaluation of validity of formatting object a from the set A to the group $b \in B$. Values 0 or 1, respectively values from the inside of interval (0, 1), respectively negative values, have the same meaning as in the multiple-choice items type 1 of *n*.

We can look at the general relational item as if it was a set of multiple-choice items type *m* of *n*, where the examinee decides in every object of the set A to which groups of the set B given objects belong. As we know that items type *m* of *n* are sets of

dichotomy items, we can look at the general relational item as if it was a set of |A|·|B| dichotomy items. Thus we assess the correctness coefficient particularly for each pair (*a*, *b*), where *a* ∈ A and *b* ∈ B and each of cases chosen or not. This practice is consistent with necessary thinking processes in the examinee's brain, because he/she has to decide whether every independent given object can be member of a given set or not. The examinee considers independently whether to check each pair or not.

According to the correctness coefficient assessment, the most complicated are pairing (connecting and sorting) items. We can't look to the pairing items as if they were a set of multiple-choice items, because these items weren't independent. To place a given object to the proper group is the task of the examinee, equally as in all other relational items, in the case of pairing items we additionally require using of each group just once. The sets A and B are in this case equally potent. The smallest independent element we can evaluate with the correctness coefficient is thus whole one-to-one pairing. Due to their big amount (k! for k = |A| = |B|) we have to choose (besides the correct pairing) those, which indicate certain specific mistakes and to assess them individual correctness coefficient. We have to assess a suitable implicit value to the other pairings (e.g. κ = 0).

Closed Multiple-Choice Items Scoring

At first, let's look at the most simple case of closed multiple-choice items, items type 1 of *n*, where the examinee chooses just one. We are working with the set of alternatives M. The correctness coefficient κ(m) is defined for each *m* ∈ M. Let m_o ∈ M is the examinee's answer, thus chosen alternative. Particular item score is given by formula

$$\sigma = \kappa(m_o)$$

Equal formula is good for singular cases of closed multiple-choice items, thus for dichotomy and trichotomy items.

We can look at the multiple-choice items type *m* of *n* as if it was set of dichotomy items. Let M is the set of alternatives, let's define correctness coefficient for each alternative and each possibility chosen or not (0 – 1). Let Z ⊆ M is the set of items chosen by the examinee and Ž ⊆ M is the set of not chosen items. Inevitable sets Z and Ž are the decomposition of the set M. Thus Z ∪ Ž = M a Z ∩ Ž = ∅. Particular item score is therefore given by formula

$$s = \frac{\sum_{m\in Z} k(m,1) + \sum_{m\in \check{Z}} k(m,0)}{|M|}$$

Injective and general relational items scoring

The task of the examinee is to find a relation between two sets. In the relation as in the subset of Cartersian product is true that a given pair either belongs or doesn't belong to the relation. If we decompose the wanted relation to the particular members and consider each member extra as an elementar dichotomy item, we can apply methods of closed multiple-choice items during the TIS.

Let A, B are sets. In binding items we usually call A as the set of objects and B as the set of groups. Then the answer O ⊆ A × B = {(a, b) | a ∈ A, b ∈ B}. In the most general case we define for each member of Cartesian product A × B and each case chosen – not chosen, the correctness coefficient κ, thus mapping κ: A × B × {0, 1} → <-1,1>.

Particular closed relational item score is in this most general case given by formula

$$s = \frac{\sum_{(a,b)\in O} k(a,b,1) + \sum_{(a,b)\in A\times B\setminus O} k(a,b,0)}{|A\times B|}$$

Narrow Open Items Scoring

Even in the case of open items, we can widen the TIS problems from the classic aspect "correct answer / incorrect answer" to the more general case, distinguishing correctness of particular possible answers. We aren't able to cover the whole set of possible answers, thus all words of given language with the correctness coefficient. Thus we have to assess an implicit value which will be used in cases where correctness coefficient is not defined for the examinee's answer.

The final evaluation of the narrow open item, answered by the examinee with the word s, is therefore given by this simple formula

$$s = k(s)$$

Joining Items Scoring

Let's now deal with pairing items except the sorting ones. The examinee has to find a one-to-one pairing between two sets of equal cardinality. Because solving of the pairing items is from the examinee's aspect quite a difficult mental operation and due to the relation of one member of pairing to another isn't possible to decompose it to the fundamental cases we are able to assess the correctness coefficient for, we have to assess it for each pairing.

Let's remind that A and B are the sets of objects and the examinee looks for a relation between them. The correctness coefficient is defined for every pairing, thus for every member of the set *Bij*(A,B). Then, if the answer of examinee is $O \in Bij(A,B)$, the particular joining item score is given by formula

$$s = k(O)$$

We didn't solve the problem of joining items scoring; we just moved it one level down. Let's now think about counting κ for given one-to-one pairing, which represents the examinee's answer and explicates various methods of computation. In the rest of this part, we will denote the correct answer, thus the correct one-to-one pairing, with symbol P. Then $P \in Bij(A,B)$ and especially $\kappa(P) = 1$.

Number of correct pairs

Let's denote the number of members of the set A, respectively B, by the symbol k. Thus $k = |A| = |B|$. The examinee has to find k pairs. If we use the number of correct pairs as the only criterion, we can assess the correctness coefficient according to the formula

$$k(O) = \frac{|O \cap P|}{k},$$

thus as the ratio of the cardinality of intersection of pairings (thus sets) O and P representing the number of correct pairs, and number of all pairs.

Other methods

The number of correct pairs is the mostly implemented method for correctness coefficient assessment. Furthermore, we can look at the joining items as if they were a special case of relational items and take advantage of the assessment of correctness coefficient for each pair extra. The fact, that it is a pairing item, will serve just to the examinee telling him/her that each member of the group set has to be used just once.

In case of finding the suitable sort of the set A we can look to the pairing items as if they were sorting items and use methods explained in following part.

Sorting Items Scoring

As we mentioned above we assess the correctness coefficient for each permutation of alternative set extra. Let *Per*(M) be the set of all permutation of the set M and O ∈ *Per*(M) be the examinee's answer. Particular item score is given by obvious formula

$$\sigma = \kappa(O)$$

Then, let P ∈ *Per*(M) be the correct answer, thus the permutation representing the proper ordering. Then obviously

$$\kappa(P) = 1$$

Let's now deal with methods for the assessment of κ for various permutation of the sorted objects set.

Permutation difference operation

Now our goal is to define such operation with the set of all permutations of a finite subset of naturals, which expresses the rate of their difference and corresponds with the rate of difference between the examinee's answer and the correct one. It could be suitable to consider such definition of this operation, which satisfies the metric axioms and therefore expresses the distance between two permutations. The test item score was counted from the distance between the examinee's answer and the correct one in this case. Let's call this operation *difference* and denote it by the symbol *d*.

Let's leave the definition of the difference operation now and deal with conversion of its result to the interval <-1, 1>, thus assessment of particular item score. For a correct answer, which isn't distinct of the correct answer, and the operation result will be zero, the wanted function has to be return value 1. Value 0 should represent the maximal possible mistake, thus maximal possible difference of permutations O and P. So we're gaining formula

$$s = 1 - \frac{d(O,P)}{d_{\max}(P)},$$

where d(O, P) is difference of permutations O and P and d_{max}(P) is the difference of the most different permutation from the permutation P.

Now, to define the mentioned operation remains. We can define it by various ways which will correspond with various ways of evaluation. All of them will be suitable for substitution in an equation mentioned above.

Sum method

Let A = (a_1, a_2, …, a_n) and B = (b_1, b_2, …, b_n) are two permutations of the set $\mathbf{N}_n$. Their difference d is defined by formula

$$d = \sum_{i=1}^{n} |a_i - b_i|$$

For B = P = (*1, 2, …, n*) we're gaining more simple formula

$$d = \sum_{i=1}^{n} |a_i - i|$$

This method counts – for each member of the set of alternatives – how far is this member from its correct position. The sum of these differences (distances) then expresses the total rate of correspondence or difference of whole permutations.

We can gain maximal possible value d_{max} for opposite permutations and its value is equal to

$$d_{\max} = \sum_{i=1}^{n} (n - (n - i + 1)),$$

and then

$$d_{\max} = \frac{n^2 - (n \bmod 2)}{2}$$

Sequential method

Let A = (a_1, a_2, … a_n) is permutation of the set $\mathbf{N}_n$. Its difference d from the permutation P = (1, 2, …, n) is defined by formula

$$d = (n-1) - \sum_{i=1}^{n-1} j(a_{i+1} - a_i),$$

where

$$j(x) = \begin{cases} 1 \ for \ x = 1 \\ 0 \ for \ x \neq 1 \end{cases}$$

The result of this method is the sum of lengths of correct subsequences regardless of their position in the sequence. Because maximal possible subsequence length is n – 1, this expression appears at the beginning of the right side of the equation and ensures that for maximal possible subsequence, the result of operation d will be zero. For permutation without any correct subsequence, we'll gain the result d_{max} = n – 1.

Euclid method

If we look at the permutation of n naturals as if they were points in the n-dimensional Euclid space, we can express the difference of two permutations as the Euclid distance of appropriate points.

Let again A = (a_1, a_2, …, a_n) and B = (b_1, b_2, …, b_n) are two permutations of the set $\mathbf{N}_n$. Let's define their difference d using the Euclid method by formula

$$d = \sqrt{\sum_{i=1}^{n} (a_i - b_i)^2}$$

Maximal possible distance between points having no coordinate greater than n, is the diagonal of a n-dimensional cube with the edge of length $n - 1$. To simplify, let's omit the fact that opposite vertexes don't represent points appropriate to the sequences O and P. Then we'll gain

$$d_{\max} = \sqrt{n \cdot (n-1)^2} = (n-1)\sqrt{n}$$

Greatest mistake method

This method is based on the difference of position in the sequences in such member, whose position difference is biggest. Let A = (a_1, a_2, …, a_n) and B = (b_1, b_2, …, b_n) are two permutations of the set $\mathbf{N}_n$. Their difference d is then defined by the formula

$$d = \max \left\{ |i - j|; a_i = b_j; a_i, b_j \in \mathbf{M} \right\}$$

The maximal difference in members' position is obviously

$$d_{max} = \text{n} - 1$$

Individual evaluation method

This method is based on the supposal that each permutation represents a specific mistake of different kind and so unique function formula assessing the score just based on the permutations doesn't exist. The evaluation function is in this case defined by the enumeration and is based on semantics of the members of the set **M**.

Penalty guessing in multiple-choice items

One of the most important properties of the multiple-choice items scoring is their restrictivity, thus penalizing incorrect or not totally correct answers. Typical restrictive action is penalty guessing in multiple-choice items, thus simple penalization of incorrect answers. Sometimes it is necessary to distinguish the rate of mistake and decrease (or increase) the penalization.

Using multiple-choice type 1 of n brings the risk that the examinee is guessing correct answers. This risk can be taken out by both sufficient number of alternatives in each test item and sufficient number of items in the test. Using any number of alternatives and any number of items, we can use penalty for guessing during the scoring. This means to adjust the score in such way, than eventual guessing of the examinee isn't displayed in the result, or is displayed as less as possible (Davis, 1993).

During the penalty guessing, we give to the examinee points according to the number of mistakes he/she has made. We result from the fact that those who guess, make mistakes more often than those who really solve the task and answer only in case of knowing the answer (Mužić, 1993). Correction of score can be done according to the formula

$$S_o = S_n - \frac{N}{n-1},$$

where S_o is so called corrected score, S_n is original score, N is number of incorrect answers in the test and n is number of alternatives offered in one item (Stalker, 1968). The mentioned formula is valid for posterior adjusting of the total test score. We can reformulate it for usability during assessment of a particular item score:

$$s = \begin{cases} 1 & \text{for correct alternative} \\ -\frac{1}{n} & \text{for incorrect alternative} \end{cases}$$

If a particular item score is equal to the correctness coefficient of a chosen alternative, we are gaining the formula for counting correctness coefficient of the alternative $m \in M$.

$$k(m) = \begin{cases} 1 & \text{for correct alternative} \\ -\frac{1}{n} & \text{for incorrect alternative} \end{cases}$$

Changing the correctness coefficient value in alternatives representing exceedingly rough mistake (or in alternatives whose choosing is not serious problem to respect assessed targets of achievement test) is the right of the examiner.

Let's stress that penalty guessing can be done even in dichotomy items as a special case of polytomy multiple-choice items. The denominator is then 2 – 1 = 1 and the way of evaluation matches positive points for the correct answer and negative points for the incorrect one.

If we realize the guessing penalization, we have to call examinees' attention to it. In that case, if they don't know the correct answer or they aren't sure, omitting the answer is advantageous for them. If we don't warn the examinees, they can have valid objections. The scoring rules should be known before the test in detail.

The experts dispute about guessing penalty. Theoretical pedagogues feel the base contradiction in the behavior of the examinee who doesn't know the correct answer. Is better to try it or to confess the ignorance? Not even in real life the clear answer doesn't exist. This is the examiner's decision to judge if guessing of ignorance confession is better (Stalker, 1968).

Using correctness coefficient: An example

Due to the length limitations of the paper there is not enough space to describe differences between classical scoring and scoring with the help of the correctness coefficient properly. Let's illustrate new concept on a short test dealing with set theory and propositional and predicate logic, containing 4 simple closed multiple choice questions (type 1 of n).

1. How many elements the empty set contains?
    a. 0
    b. 1
    c. 2
    d. sometimes 0, sometimes 1
2. Choose the set operation which is *not* commutative:
    a. union
    b. intersection
    c. symmetric diference
    d. Cartesian product
3. Which of following sentences can be considered as a *proposition*?
    a. Is this true?
    b. Send this letter!
    c. I'm at school right now.
    d. What time is it?
4. A symbol ∀ denotes
    a. universal quantifier
    b. existential quantifier
    c. common quantifier
    d. logical compound

Let's now discuss suitable values of the correctness coefficient of proposed possibilities.

Question no. 1: Answer "a" is the correct one. Answer "b" represents typical student mistake flowing from the confusion between the number of elements and number of subsets. Answer "c" is total nonsense as well as answer "d" which is nondeterministic. Some pedagogues with tolerance to some type of confusions can then propose κ values for example as (1, ½, 0, 0).

Question no. 2: Answer "d" is the correct one. The uncorrectness of other answers is evident and there is no possibility to lower the penalization in case of choosing one of them. There for κ values will be (0, 0, 0, 1)

Question no. 3: The correct answer is "c", some examiner may be tolerant if an examinee chooses answers "a" or "b". Then s/he may set κ as (¼, ¼, 1, 0)

Question no. 4: The difference between "universal" and "common" may not be clear enough. Therefore the answer "c" can be considered as "almost correct, whereas the answer "a" is totally correct. Answer "b" may show the temporary confusion of an examinee ad answer "d" is nonsense. Therefore we can set κ as (1, ¼, ½, 0)

Let's imagine examinee's answers 1b, 2a, 3c, 4c. Without using the correctness coefficient the total score would be 0+0+1+0 = 1 out of 4. With using the correctness coefficient the total score

rises to ½+0+1+½ = 2 out of 4. The difference would be higher in case of students choosing "almost correct" answers.

Let's emphasize that the assessment of the correctness coefficient values is the examiner's responsibility and that there can be arguments about the values. This was not the goal of the paper, the paper just provide the tool to more accurate achievement test scoring.

The example from mathematics was chosen just due to the author's affiliation. It is obvious that in exact sciences (like mathematics) there is almost no space for middle values. However, in social and human sciences where correct answers are not so clear, the potential is much bigger.

Conclusion

In this contribution, we set up the division of commonly used achievement test items types and summarized theoretical basics of test item scoring (TIS). From this base, we built the formalization of test items scoring based on the correctness coefficient.

Although the found way is very general and provides huge freedom do the examiner, hard work to assess the correctness coefficient in all relevant entities and related error risk is connected with this freedom. Only future pedagogy practices will show if the scoring methods described in this paper are proper or not.

Acknowledgements

The paper is supported by the Ministry of Education of the Czech Republic (the Research Proposal VZ MSM 6215648904/03/03/01).

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Legends to figures

Figure 1: Relation of bases to the TIS

Figure 2: Division of test items types

Journal on Efficiency and Responsibility in Education and Science
ISSN: 1803-1617

EVALUATION OF TEST QUESTIONS USING THE ITEM ANALYSIS FOR THE CREDIT TEST OF THE SUBJECT OF MATHEMATICAL METHODS IN ECONOMICS IN THE MOODLE LMS

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Abstract

The Moodle system has been used within the CULS in teaching for almost two years. This paper deals with its utilization in the subject of Mathematical Methods in Economics II. The Moodle course of this subject provides students with basic and organization information, figures and tasks for exercises, software for solving them if necessary, video-records of methods and, of course, tests. The aim of this contribution is to analyze one of these tests and to summarize recommendations for improving it. The item analysis is used for this purpose. First the definitions of the item analysis indicators are given. Then they are computed using the Moodle system. All of them were very different at particular questions and it means that single questions had a different quality. The quality even depended neither on the topic nor on the form of the question (it often happened that two similar questions were evaluated very differently). The proper analysis is shown on several particular examples of questions. The item analysis has shown to be a very efficient tool for evaluation of test questions and there is no other way how to get some of the information obtainable by this analysis.

Key Words

Test, test question, test item, item analysis, LMS Moodle, mathematical methods in economics

Kucera, P., Kvasnicka, R., Vydrová, H. (2009), "Evaluation of Test Questions Using the Item Analysis for the Credit Test of the Subject of Mathematical Methods in the Moodle LMS", Journal on Efficiency and Responsibility in Education and Science, Vol. 1, No. 2, ISSN: 1803-1617, pp 41-50, [on-line] www.eriesjournal.com/_papers/article_69.pdf [2009-06-30]

Introduction

Since the last academic year the learning management system (LMS) Moodle has been used in teaching at the CULS in Prague. The LMSs are the narrowest part of electronic education support systems, which integrates in itself tools for controlling the teaching, i.e. offers a variable environment for creating and administrating Internet courses. Furthermore, it provides communication tools for all the participants of the course (in addition, with ability to differ single roles of users in a given course).

Currently the Moodle system is utilized in the most of subjects taught within the CULS. The first two of the authors of this paper use it in the subject of Mathematical Methods in Economics II which is concerned in this paper. It is the second semester of a two-semester course of the operations research methods. The topics contained in the subject are various methods and approaches which often occur in practice, e.g. larger models of linear programming, different types of transportation tasks, game theory, decision models, multiple-criteria decision, Markov chains and some of other stochastic systems etc.

The introduction of the Moodle course of this subject contains the syllabus, information about the conditions for obtaining the credit, a forum for sharing news within teachers and students and a software tools necessary for calculations at the exercises (macros in the Visual Basic for Applications specially designed by the members of the department for this purpose). Next the course is divided into 14 thematic units according to the single teaching weeks (lectures and exercises). The typical content of a unit is as follows:

First, figures and tasks for the exercises are available for students. Their amount is sufficiently large to cover all the time of the exercise and some tasks remain for students for their home individual training. They are in the MS-Word document form.

Another regular part is a page of checking questions for students. These questions are made up so that they guide students to the repetition of important parts of the taught problem. In the first year of the utilization of the Moodle system they were originally in the form of a text page, for the second (i.e. last) year the form was changed to the small tests (so called home preparation) which are evaluated and students get points necessary for obtaining the credit.

Some of the units provide also video-records of methods for exercises. They are applied with such topics which are problematic for students.

The structure of testing students consists of two parts. The former one is the home preparation mentioned above. The latter and the main part of testing is a (main) test divided into two parts. The first part takes place in the middle of the semester and the second part in the end of the semester. Both the home preparation and the main test are designed in the test interface provided by the Moodle system and consist of various types of questions: multiple-choice (with both one and more right answers), numerical and true/false.

The minimum number of points necessary for obtaining the credit is approximately one third of the whole possible amount for the whole testing (both the main test and the home preparation) and at the same time approximately one third of the maximum possible amount for the home preparation.

The aim of this paper is to analyze the first part of the main test and to suggest changes, i.e. deletion or modification of unsuitable questions etc. This analysis will be realized using the item analysis.

More information about the Moodle courses on the Mathematical Methods in Economics is in Kučera, Kvasnička (2008a), Kučera, Kvasnička (2008b), Kučera, Kvasnička and Burdych (2008).

Material and Methods

The item analysis is used for exploring the characteristics of single items of the test. It is suitable for judging the quality of each of its questions. It involves two types of analysis: quantitative (e.g. correlation, burdensomeness, time demand) and qualitative (lucidity, content and format adequacy, etc.). The item is the smallest unit of the test according to which it is possible to judge a given test using it.

More information about the theoretical respect of the test results evaluation and the item analysis is e.g. in Vyškovský (1982), Hniličková, Josífko and Tuček (1972), Komenda (2003), Smékal, Švec and Zajac (1973). The Moodle system provides computing the following statistical parameters.

The Ease

The ease indicates how the question is easy for a student. In the case of the dichotomic form of the question (right/wrong answer) this parameter is equal to proportional (or percentage) expression of the right answers of students. This parameter can be clearly described using the formula:

$$ease = \frac{X_{mean}}{X_{max}},$$

where:

X_{mean} is the average number of points obtained by all the students for a given item and

X_{max} is the maximum possible number of points.

The Standard Deviation

The standard deviation (SD) is a commonly and widely used statistical parameter. It determines the dispersion of the students' answers in the whole sample. It shows how much students differ among each other in their knowledge of the given problems. Thus the standard deviation is an indicator of the discrimination ability of the test but it does not identify good and bad students. If all the answers are identical, the standard deviation is equal to zero.

The Discrimination Index

The discrimination index (DI) shows how much (to what degree) an item makes difference between successful and unsuccessful students. Using this index it is possible to compare the result of e.g. this item, or the whole test, and results of all the other items, or other tests, respectively. In general, one can state that a student with good results will write the test well and, on the contrary, a bad student will not succeed. The discrimination index is a rough indicator of the efficiency of each item at a given students group.

For determining the value of this index one third of all the students (no matter whether the evaluated question has been randomly chosen for a student and thus he/she has actually solved it) with the best results and one third of students with the worst results are taken and then it is found out how these groups of students have solved a given particular question. In the ideal case the best students should succeed and the worst ones should fail. For each of these two groups the mean value of the proportional expressions of the results of all its members is computed and the mean value of the latter group is subtracted from the mean value of the former group.

The value of this index ranges in the interval from –1 to +1. Negative values show that the right answer has been given more often by worse students than by the best students at the single question. Such negative values of this index should signalize to the creator of the test that it is necessary to remove or reformulate such a question.

The Discrimination Coefficient

From the statistical point of view the discrimination coefficient (DC) is a correlation coefficient between the score for a given item and for the whole test. It shows how much (to what extent) the results would be different if we differed between clever and less clever students. As in the case of the discrimination index, this index gets values from –1 to +1. Positive values show the difference of the clever students. Negative values indicate items which have been answered wrong by the best students. For the creator of the test it signalizes the necessity of removing the given question.

The advantage of this coefficient is that it uses the data of all the results for computing, and not only the results of one third of the best and the worst students.

Results

The test analyzed here is based on a file of 205 questions divided into 17 categories. As mentioned in the introduction, all the questions are simple (unstructured) and so they form items for the analysis at the same time. Each category contains from 6 to 14 (usually 10) questions. A single test is created by the Moodle system using a random choice of questions, from 1 to 4 questions representing each category. Number of students who solved each question varied from 24 to 142, but at each category this number was similar for each question.

The ease of questions was very different: the lowest one was 5 p.c. and one question had an ease of 100 p.c., i.e. it was right answered by all the students who got it.

There was no item with a negative discrimination index. In the worst case this index was just 0.000. On the other hand, 20 items had the discrimination index equal to 1.

The discrimination coefficient varied from –0.197 to 0.658. There were only 10 questions with a negative discrimination coefficient. Let us remind that for the one question with the 100 p.c. ease the discrimination coefficient is not defined.

Discussion

For demonstration of applying the item analysis 19 questions were selected, all of them being of the multiple-choice type with an offer of four answers, just one of them being right. The following data were taken from the form of evaluation provided by the Moodle system. Because the original table containing these data had too many columns and so it was too large and nontransparent, the data are divided into two parts. In the following part (Text of Problematic Questions) there are given for each question its number from the Table 1, the text (input) of the question and the possibilities given students for choice. In the Table 1 there is the following information about the test and its item analysis results:

In the first column there is its serial number. As all the questions have four answers to choice, the information about each question is contained in four columns. In the column No. 2 the offered answers are labeled by letters from a) to d) and the column No. 3 contains the partial credit for each answer, i.e. 1 for the right one and 0 for the wrong ones. The following column shows how many students have chosen this answer and how many

students have solved this question, so these two numbers form the ratio of students who have chosen this option. The next column contains the same ratios in the percentage form. In the column No. 6 the number of students solving the task is repeated again and the last four columns contain the statistical indices described in the chapter of Material and Methods.

1	2	3	4	5	6	7	8	9	10
Question number	**Answers**	**Partial credit**	**Number/ answers**	**P.c. of answers**	**Num. of students**	**Ease**	**SD**	**DI**	**DC**
1	a)	0,00)	2/90	(2%)	90	6	0,2303	0,071	0,118
	b)	0,00)	1/90	(1%)					
	c)	1,00)	5/90	(6%)					
	d)	0,00)	82/90	(91%)					
2	a)	1,00)	2/37	(5%)	37	5	0,2292	0,111	0,117
	b)	0,00)	21/37	(57%)					
	c)	0,00)	12/37	(32%)					
	d)	0,00)	2/37	(5%)					
3	a)	(0,00)	20/46	(43%)	46	22	0,4170	0,111	-0,110
	b)	(1,00)	10/46	(22%)					
	c)	(0,00)	13/46	(28%)					
	d)	(0,00)	3/46	(7%)					
4	a)	(0,00)	5/44	(11%)	44	25	0,4380	0,182	0,000
	b)	(0,00)	3/44	(7%)					
	c)	(0,00)	24/44	(55%)					
	d)	(1,00)	11/44	(25%)					
5	a)	(0,00)	5/50	(10%)	50	18	0,3881	0,111	0,118
	b)	(0,00)	5/50	(10%)					
	c)	(0,00)	31/50	(62%)					
	d)	(1,00)	9/50	(18%)					
6	a)	(1,00)	6/50	(12%)	50	12	0,3283	0,375	0,388
	b)	(0,00)	28/50	(56%)					
	c)	(0,00)	13/50	(26%)					
	d)	(0,00)	3/50	(6%)					
7	a)	(0,00)	6/56	(11%)	56	29	0,4558	0,500	0,247
	b)	(0,00)	27/56	(48%)					
	c)	(0,00)	6/56	(11%)					
	d)	(1,00)	16/56	(29%)					
8	a)	(0,00)	2/45	(4%)	45	29	0,4584	0,500	0,250
	b)	(0,00)	2/45	(4%)					
	c)	(0,00)	27/45	(60%)					
	d)	(1,00)	13/45	(29%)					
9	a)	(1,00)	15/42	(36%)	42	36	0,4850	0,625	0,258
	b)	(0,00)	15/42	(36%)					
	c)	(0,00)	7/42	(17%)					
	d)	(0,00)	4/42	(10%)					
10	a)	(1,00)	8/44	(18%)	44	18	0,3902	0,375	0,340
	b)	(0,00)	24/44	(55%)					
	c)	(0,00)	10/44	(23%)					
	d)	(0,00)	2/44	(5%)					
11	a)	(1,00)	14/43	(33%)	43	33	0,4741	0,429	0,283
	b)	(0,00)	22/43	(51%)					
	c)	(0,00)	5/43	(12%)					
	d)	(0,00)	2/43	(5%)					
12	a)	(0,00)	9/28	(32%)	28	25	0,4410	0,000	-0,197
	b)	(0,00)	6/28	(21%)					
	c)	(1,00)	7/28	(25%)					
	d)	(0,00)	6/28	(21%)					

13	a)	(0,00)	13/35	(37%)	35	26	0,4434	0,200	0,075
	b)	(1,00)	9/35	(26%)					
	c)	(0,00)	3/35	(9%)					
	d)	(0,00)	10/35	(29%)					
14	a)	(0,00)	5/36	(14%)	36	78	0,4216	0,429	-0,131
	b)	(1,00)	28/36	(78%)					
	c)	(0,00)	0/36	(0%)					
	d)	(0,00)	3/36	(8%)					
15	a)	(0,00)	4/39	(10%)	39	51	0,5064	0,100	-0,097
	b)	(0,00)	3/39	(8%)					
	c)	(1,00)	20/39	(51%)					
	d)	(0,00)	12/39	(31%)					
16	a)	(1,00)	16/36	(44%)	36	44	0,5040	0,625	0,212
	b)	(0,00)	14/36	(39%)					
	c)	(0,00)	4/36	(11%)					
	d)	(0,00)	2/36	(6%)					
17	a)	(0,00)	8/25	(32%)	25	36	0,4899	0,600	0,100
	b)	(1,00)	9/25	(36%)					
	c)	(0,00)	5/25	(20%)					
	d)	(0,00)	3/25	(12%)					
18	a)	(1,00)	13/32	(41%)	32	41	0,4990	0,429	0,009
	b)	(0,00)	2/32	(6%)					
	c)	(0,00)	2/32	(6%)					
	d)	(0,00)	15/32	(47%)					
19	a)	(1,00)	51/53	(96%)	53	96	0,1924	0,818	-0,118
	b)	(0,00)	0/53	(0%)					
	c)	(0,00)	1/53	(2%)					
	d)	(0,00)	1/53	(2%)					

Table 1: Evaluation of Questions by the Moodle System

The first two questions are the most difficult among all. These questions are the only ones with the less than 10 p.c. ease. Their discrimination index and discrimination coefficient are relatively small, too. But there is a significant difference between the evaluations of these two questions. If a question of 5 or 6 p.c. ease solved the same number of both the best and the worst students, its discrimination index might be at most 0.15 or 0.18, respectively. The question No. 1 has a discrimination index equal to 0.071, while the one No. 2 has 0.111 which is relatively close to this boundary. The only problem of the question No. 2 is its burdensomeness. If there were other difficult questions, there would be no reason to remove it from the test. This matter is analyzed thereinafter in comparison to other questions.

On the contrary, the question No. 1 has a small discrimination index also in comparison with its small ease. But first of all, as one can easily see, the most of students have chosen the wrong answer d) (while at the previous question different wrong answers occur, especially b) and c)). Thus the first idea is that this question should be removed or the answer d) should be replaced by more suitable and less confusing one. Let us concentrate on the formulation of this question. This question is on the analysis of the solution of a transportation task and it is the only question where the costs are expressed in monetary units. In all the other such questions tons and kilometers are used. The problem probably is that students are not used to operate with the monetary units and the suggestion how to repair this problem is to concentrate on it more during the exercises and to add other similar questions into the questions database.

The questions with serial numbers from 2 to 11 are the all the questions of the category of the interchange of criterion function and limiting condition. They are selected as an example how much the similar questions on the same topic may differ in their

results of the item analysis. Here is obviously confirmed that the question No. 2 is all right because there are four of all ten questions of this category among ten questions with the smallest ease (less than 20 p.c.). The only question of this category which should be removed according to the item analysis is the question No. 3 because it has a negative discrimination coefficient (and at the same time a relatively small discrimination index) but it is not clear why its parameters are so bad and thus whether it is really necessary to remove it.

The question No. 12 seems to be good if we do not notice its discrimination index and discrimination coefficient. It has ease of 25 p.c. and all four answers were chosen approximately by the same number of students. But both discrimination index and discrimination coefficient are the worst from all the questions and it shows that good students answer this question wrong and vice versa. Thus this question must be removed from testing. Herewith, there exists a similar question No. 13 with a good evaluation again and it is hardly to say what the problem is at the question No. 12.

The question No. 14 is the worst evaluated one of the category of the theoretical questions. Its negative discrimination coefficient indicates that it is confusing for clever students and so it should be modified or removed.

Another question with the negative discrimination coefficient has no. 15. In this case, three other similar questions (on judging which variants in the multiple-criteria analysis are feasible subject to the aspiration levels) follow (from no. 16 to no. 18) with approximately the same ease, slightly higher discrimination coefficient and much higher discrimination index in comparison to the question no. 15 and there is an easily notable difference between the bad evaluated question and the others. The question no. 15 is the only one of these questions where there is offered an answer that there is no variant feasible subject to the aspiration levels and at the same time the right answer is that there are two such variants (in all other questions there is just one such a variant). It seems to be surprising that these facts which make the question more difficult are troubling just clever students. Anyway, this question should be removed.

The last question (No. 19) has also a bad discrimination coefficient. Herewith, it has 96 p.c. ease and its bad discrimination coefficient is caused by only two good students who have answered wrong. It may be only a bad luck of these students. Moreover, the high value of the discrimination index of a question with such a high ease indicates that almost nobody of the students who have got it is a bad student in the whole testing (this fact may even cause the high ease). Therefore, it may be kept in testing.

Text of Problematic Questions

Question No. 1

The cost for the transportation of the optimum amount of the potatoes from the plot of field H2 to the potato store B1 (see model "potatoes - variant B, 1 km cost is 8 CZK) is:

a) 400 CZK
b) 2600 CZK
c) 16000 CZK
d) 32000 CZK

Question No. 2

If the interchange of criterion function and limiting condition to the optimization model with two criteria z1 = 2x1 - 2x2 + 4x3 --> min with the optimum value 33 and z2 = 4x1 - x2 + 4x3 --> min with the optimum value 72 is applied, the following is obtained: e.g.

a) a new constraint 2x1 - 2x2 + 4x3 <= 33 and the criterion z2 = 4x1 - x2 + 4x3 --> min80; 260; 50; 70; 8.9
b) a new constraint 2x1 - 2x2 + 4x3 <= 39 and the criterion z2 = 4x1 - x2 + 4x3 --> min
c) a new constraint 2x1 - 2x2 + 4x3 <= 39 and the criterion z1 = 2x1 - 2x2 + 4x3 --> min
d) a new constraint 2x1 - 2x2 + 4x3 <= 33 and the criterion z1 = 2x1 - 2x2 + 4x3 --> min

Question No. 12

	Vitamin A	Vitamin B1	Vitamin B2	Vitamin C	Price
Cabbage	80	260	50	70	3,70
Cauliflower	90	200	100	70	8,90
Cucumber	1	120	30	6	13,70

In the table single sorts of vegetables are evaluated according to the content of vitamins in mg per kg and to the price in CZK per kg. To which aspiration levels is no variant a feasible subject?

a) 1; 120; 30; 6; 13.8
b) 80; 260; 50; 70; 8.9
c) 90; 200; 50; 70; 3.7
d) 90; 200; 100; 70; 3.7

Question No. 14

Systems analysis is

a) an applied cybernetics
b) an applied systems science
c) the only systems science
d) a closely specialized team science

Question No. 15

	Vitamin A	Vitamin B1	Vitamin B2	Vitamin C	Price
Cabbage	80	260	50	70	3,70
Cauliflower	90	200	100	70	8,90
Cucumber	1	120	30	6	13,70

In the table single sorts of vegetables are evaluated according to the content of vitamins in mg per kg and to the price in CZK per kg. If the aspiration levels are set to the values of 50; 90; 35; 10; 10, then the following variants are feasible subject to the aspiration levels:

a) cauliflower
b) cucumber
c) cabbage and cauliflower
d) no variant

Question No.19

Transportation tasks belongs to the group of tasks called:

a) distribution tasks
b) quadratic tasks
c) balance tasks
d) NP-complete tasks

Conclusion

The item analysis has shown to be a very efficient tool for evaluating the test questions. Applying on the first part of the main test of the subject of Mathematical Methods in Economics II, it determined the burdensomeness (or ease) of each single question which reaches a wide scale of different values. It shows that one question was solved right by all the students and few others by almost all of them.

About 10 p.c. of the whole amount of questions had discrimination index equal to one which means they are answered right by good students and wrong by bad students. On the other hand, about 5 p.c. had a negative discrimination coefficient, i.e. they differ badly between good and bad students. Such questions should be modified or removed from the file of questions. But it is necessary to approach to single questions individually, as shown in the discussion. Thus one cannot simply say that the unsuitable questions are just those with the small discrimination coefficient.

The questions with a bad evaluation were on different topics, i.e. the single topics did not differ in the burdensomeness of creating the questions on them. Two similar questions often differed very much in their evaluation and it is hardly to say why. It means that only the item analysis can check them in such details.

If questions of such a category where more than one is chosen into a single test differ too much in their ease, it is suitable to divide this category into several smaller ones according to the ease of the questions.

The only drawback of the Moodle system item analysis is that it does not inform about the number of good and bad students who answers particular questions. Such information would enable a better analysis of the computed parameters of the item analysis, especially the ease and the discrimination index.

The item analysis was very helpful to analyze the test and according to its results it will be improved for the next year.

Acknowledgements

The paper is supported by the grant No. 2735 of the Found of the Development of the Universities (FRVŠ) of the Czech Ministry of Education, Youth and Sports.

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Journal on Efficiency and Responsibility in Education and Science
ISSN: 1803-1617

MODERNIZING THE PROFESSIONAL CAPABILITIES OF DRIVING INSTRUCTORS AND TRAFFIC SAFETY TEACHERS

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Abstract

The effective traffic safety training is a long process; it starts from very young age and continues throughout life. This is not only a process of acquiring knowledge and skills, but also a matter of social importance. Pedagogical forms of education depend on the position of a man in society, respectively, on abilities to percept the environment. The recent investigations of traffic accidents show, that the young drivers generally have poorer than average self-reflection skills. It is therefore important to foster self-reflection skills and attitudes from an early age, especially in matters that relate to road and driving safety.

All of staff that have career in traffic safety training (mainly instructors for driving and traffic safety teachers) in Europe have their responsibility for decreasing the traffic accidents and incidents by polishing their skills. They work under variety conditions, specific National Lows and Regulations, but the features of their target groups are one and the same. In order to meet the new challenges put by EU Commission they need to have common vision about traffic safety training in Europe, to know what traffic safety means for different age groups, to know what is the best practice of their colleagues, including curricula, methods, training materials, and to be aware their work is very important for traffic safety.

Aim of this paper is to present an approach for non-formal instructors for driving and traffic safety teachers training for modernizing their professional capabilities with students form 0 to 30 years old.

The investigations and main results are based on the theoretical investigation for hierarchical level of behavior, made by Hatakka for instructors for driving training. The students are divided in four age groups: pre-school children (0-6 years), schoolchildren (7-12 years), teenagers (13-17 years) and young adults (18-30 years). For each age group a curriculum is developed according to common EU rules and the Hattakas' investigations. An example for curricula on teenagers' traffic safety training is presented the paper.

Key Words

Traffic Safety, Instructors for Driving, Traffic Safety teachers, continues training

Kolarov, I. (2009), "Modernizing the Professional Capabilities of Driving Instructors and Traffic Safety Teachers", Journal on Efficiency and Responsibility in Education and Science, Vol. 2, No. 1, ISSN: 1803-1617, pp 51-58, [on-line] www.eriesjournal.com/_papers/article_72.pdf [2009-06-30]

Introduction

According to the White Paper, "European Transport Policy for 2010: Time to decide", 40,000 lives are lost in road accidents every year in the EU. An additional 1.7 million people get injured in those accidents. This translates into an estimated cost (indirect and direct) of €160 billion each year. Thus, EU Parliament passed a resolution in 2006 to halve the number of traffic deaths by 2010. Their report calls for coordination, research, awareness campaigns and exchanges of best practices.

Similarly, Framework Programme 7 recognizes the need for drastic changes in surface transport and calls after, for example, greener and safer transport systems. In addition to all the technical and logistical development in the area, the level of persons' behavior takes one of the key places for traffic safety in daily lives.

The recent investigations of traffic accidents show, that the young drivers generally have poorer than average self-reflection skills. It is therefore important to foster self-reflection skills and attitudes from an early age, especially in matters that relate to road and driving safety.

Normally, the driving instructors are professionals that take care about basic driving skills and driving behavior and it is going during their regular training courses for a short time (a few weeks or months) with a student. The instructors pass regularly continues training courses for updating their professional skills according their National low. Other traffic behavior skills are presented before various age groups by traffic safety teachers at kindergartens, at schools during their regular or out-of class activities. Most of them are drivers; they have common pedagogical skills to work with specific group and usually they passed a short pedagogy course on traffic safety.

All instructors for driving and traffic safety teachers in Europe have their responsibility for decreasing of traffic accidents and incidents by quality of their carrier. They work under variety conditions, specific National Lows and Regulations, but the features of their target groups are the same. In order to meet the new challenges put by EU Commission they need to have common vision about traffic safety training in Europe, to know what traffic safety means for different age groups, to know what is the best practice of their colleagues, including curricula, methods, training materials, and to be aware their work is very important for traffic safety.

Aim of this paper is to present an approach for non-formal instructors for driving and traffic safety teachers training for modernizing their professional capabilities with students form 0 to 30 years old.

Theoretical basis of Traffic Safety Education

This approached is based on theoretical investigation made for instructors for driving training (Hatakka, 2002). The following table is a representation of the model as it could be altered to more generally description the skills and knowledge required from all traffic participants.

The idea of this model is that the higher hierarchical levels consist of conscious and subconscious choices that affect a person's behavior in traffic. The highest-level factors, such as one's lifestyle choices relating to traffic (car hobby, sports bicycling, jogging) affect the lower level functions in the model. For example, a young male who builds his identity around his moped hobby and seeks the acceptance of his peer group, will choose his driving routes and traffic behavior as set by the reference group (other young male moped drivers). He will do that even though he could modify his vehicle to go faster than

the legislated speed limit for that type of vehicle. So, the peer and social pressure affects of behavior of an individual traffic participant.

Teaching Principles.

When the training of traffic safety issues is structured into study modules, it gives a chance to focus on specific issues for each course. These modules can then be taught to students in an increasing order of difficulty; starting from basic traffic safety issues and moving onto the training of higher-level meta-cognitive and self-regulatory skills. It is evident that different age groups require different kinds of focus inside the learning modules; small children are less capable of self-regulation than young adults usually are. Therefore, the specific learning assignments and group exercises for these learner groups will be very different.

Here are presented Goals for Traffic Safety Education (GTSE) matrix (Adapted from the Goals for Driving Education in Hatakka (2002)):

- **G**oals for life and skills for living: **Knowledge** of the effects of lifestyle, age, values, group norms and pressure etc. on behavior in and out of traffic and the **skills** to control them.
- **G**oals and context of travel (particular route, trip): **Knowledge** of factors that affect a trip, such as the goals of the trip, choice of route, social pressure on decisions, importance of trip etc. as well as the **skill** to see alternatives to the choices.
- **M**anagement of traffic situations: **Knowledge and skills** related to traffic rules, signaling and safety measures, recognition of traffic conditions etc.
- **T**actile/manual control: **Basic skills and knowledge** of the handling of a vehicle / shoes and their characteristics (anti-skid properties etc.).

Traffic safety curricula

Traffic safety curricula with four different implementation plans are in a process of development in the framework of European project LLP-LdV-TOI-07-FI-160810 "Modernising the Professional Capabilities of Driving Instructors – Future Facilitators of Lifelong Traffic Safety Learning". The students are divided in four age groups: pre-school children (0-6 years), schoolchildren (7-12 years), teenagers (13-17 years) and young adults (18-30 years). For each age group a curriculum is developed according to common EU rules and the hierarchical level of behavior according to Table 1. The first group - pre-school children includes children that have not yet entered the official school system and will receive their traffic safety education from their parents, community and in day-care centers. The second group - schoolchildren - refers to an age group that has entered the education system, but is not yet allowed to drive a moped or other motored vehicles on public roads. In essence, they will move around by walking, on a bicycle, by being a passenger in their caretakers' car or by using public transportation systems. The third group - teenagers - is young children who are allowed to start riding motored vehicles such as mopeds or tractors on public roads. The fourth group - young adults - refers to those who have received their driver's license and participate in traffic in their everyday lives, but are not yet hindered by the physically detrimental effects of old age.

By option, the curricula are recommended and they give common conceptions about advanced features for driving and traffic safety training. The exactly numbers of lessons depends

on the National regulations that every Instructor/Teacher has.

An example of curricula created for teenagers (third age group) traffic safety training is presented below.

An example for curricula Implementation

A detailed investigation of different kind of training of this age group was carried out (Traffic Low etc.) . The most specific features of training in this age are:

- Students get more self-dependant, they go into the streets alone, take part in the traffic as pedestrians, bicyclists, they study in school and out of school lessons (theoretic and practice) advance rules for Traffic safety behavior.
- Students obligatory obtain science knowledge by studding subjects like Physics, Mathematics, Psychology in High School System, where they study Natural phenomena about topics, related to traffic safety, for example, speed, acceleration, power, speed of stopping, reaction etc..
- Students (aged 16 and 17) can study the Traffic Low and obtain practical skills for riding of moppet by courses, in which they obtain driving license "M" if they successful pass the final exam.

These formal trainings are very different and any of them has strictly organization and methodic recommendations. They enlighten a good practice for traffic behavior from specific point of view and all together contribute for higher transport culture. For example, when students master traffic rules, they usually study that the vehicle should move with safety (reasonable) speed that means the driver have be possible to control the vehicle. That us very important obligation, the high speed is one of the main reason for traffic incidents and accidents. A science based answer gives Physics by investigation of Natural phenomena as friction, speed and inertia. It is usual phenomena as acceleration (and suspensory), speed and distance (including distance of stopping) to be mastered in Mathematics and speed of human responding of a signal is studied in Psychology.

Besides these formal activities out-of-class are applicable to increase the traffic behavior skills and education of students, like:

- Competitions on Traffic Safety in sports clubs and schools where in artificially organized traffic where students present abilities to manage the traffic situation and that is one of criteria for evaluation; getting ready for competitions students master their abilities for real life.
- Organization of voluntary student's patrols at school from senior students with a teacher as leader with aims to help juniors to cross streets and to monitor the traffic around the school; during implementation (including preparation as instructive) of these kind activities students create a serious attitude to traffic mater that is supposed to exist when they get drivers.
- Medias for preventive activities to increase traffic safety; nowadays the Medias (newspapers, local and National broadcastings – radio and TV) surround our life and some kind has influence over people behavior. In this sense is reasonable a good driving practice to be visualized and explained as good practice to be followed by students to increase their safety; for example, the use of helmets to prevent serious head injury.

On the base explained forms of education, the followed modules are defined:

MODULES 1.
FUNDAMENTAL THEORETICAL KNOWLEDGE

This module gives basic knowledge and skills related to traffic rules, signaling and safety measures etc. like:

- Common knowledge for available in traffic vehicles and roads as the main stress is put on used vehicles by teenagers, dangerous when they are used in traffic together with other vehicles and how to decrease consequences from traffic accidents.
- Knowledge for traffic management and signals for regulation as the stress is put on mutual connection of traffic safety and strictly consideration of signalization.
- Knowledge for safety participation in traffic: here the content from the Traffic Low is thematically considered with traffic safety. Typical exampled for traffic accidents from practice are investigated.

MODULE 2
RESPONSIBILITIES AND CREATION OF TRAFFIC SAFETY BEHAVIOR

The basic themes here are: Safety riding, controls the risk and duration of running. Tiredness, attention and distraction; Alcohol and drugs influence to driver behavior; Tolerant behavior and traffic safety, rules for tolerant behavior. Aggression as a style of driving; Traffic conflicts. Emergency help; civil traffic behavior; obtaining vehicle/moppet and following responsibilities.

MODULE 3
APPLICABLE KNOWLEDGE AND SKILLS FOR TRAFFIC STRATEGIES

This module gives knowledge and skills for management of traffic situations. Basic areas of study are: Strategies for highway and rural riding; Strategies for participation with the rest drivers. Safety and defensive riding; Strategies for riding in emergency conditions – bad weather conditions, limited and diminished visibility.

MODULE 4
BIKING/RIDING A MOPED

This is a practical module and gives skills for tactile/manual control. After this practice students have to balance the bike/moped along a straight line and to change direction, to pass trough obstacles and restraints. The practice is organized on polygon but imitation of bad weather conditions is implemented by pouring on a section by water, passing on a not good fixed board. Practical skills for technical maintain of a bicycle/moped, emergency medical assistance on the road are mastered as well.

MODULE 5
SCHOOL, DOMESTIC, LOCAL, REGIONAL, NATIONAL AND EUROPEAN LEVELS FOR IMPACT ON TRAFFIC SAFETY.

Here are presented basic fields of education and skills for living by out-of-school forms, like:

- Medias (newspapers, local and National broadcastings – radio and TV) and family surrounding for increasing traffic safety and preventives usage by teenagers.
- Students patrols for safety traffic observation around the school and its influence on teenagers traffic safety.
- Competitions organizing on subject "The youth and traffic safety" – local, regional, National, European levels.

Training content

Typical training materials and tools will help teachers and instructors in order to master their abilities.

There are many tools for use by instructors and teachers. The basic tool is the National Traffic Low and Regulation of its application, which is specific for every country including created for e-learning use. Training materials in the way of articles, dedicated on important mater in traffic safety are important in order to help teacher to organize their lessons and master their skills in the field. A typical example is the speed, which is used in Mathematics to describe different parameters of a movement, but in the same time, it is one of the common parameters of driving. Attracting the student attention on real problems in traffic the teacher will implement simultaneously their professional obligations and will contribute for students' preparation for real life. These training materials will help the "old" drivers to increase their knowledge as well.

There are different National limitations of speeds for urban and country driving. However, the driver should always take in account the concrete road conditions, so to be able to escape traffic accident. It means the driver should appreciate the visibility, passing pedestrians, weather conditions etc.

The usual situation in practice is: a driver run a car and suddenly remarks an hurdle in front of the car. The reasons can be to high speed, distract attention from the road etc. The sequels depend on the speed of driving.

What is going on when the driver brakes in an emergency? First of all the dynamic behavior of a car depends on the interaction between tires and road surface. In is used so-called coefficient of adhesion [10] and it is maximum when slipping is missing. The basic parameters of the car under uniform emergency stop on horizontal surface are: $a = \gamma .g; V = a.t_B; L_B = \frac{1}{2}.a.t_B^2$, where a is deceleration, γ - coefficient of adhesion, g - acceleration of gravity, V - velocity in the moment of press the pedal to stop the car, t_B - duration of braking, L_B - passed length for braking. Speed of the car V_{Bi} will decrease in the process of braking and after time t_{Bi} it will be $V_{Bi} = V - \sqrt{2\gamma .g.L_{Bi}}$ where L_{Bi} is the distance passed from beginning of brake ($L_{Bi} = \frac{1}{2}.a.t_{Bi}^2 = \frac{1}{2}\gamma .g.t_{Bi}^2$). The entire duration t of stoppage can be accepted: $t = t_R + t_B$, where t_R is duration for human wake up to the situation. During this time the car is moving by velocity V and pass length $L_R = V.t_R$. The entire length of stoppage is $L = L_R + L_B$.

Coefficient of cohesion depends on the condition of the tires and the road surface. The maximum value is from 0,7 to 1 when tires contacts with dry asphalt. Increasing of temperature, availability of rain or snow decrease it to 0,4 - 0,5 and to 0,1 - 0,3 if ice and snow.

If a hurdle (or a pedestrian) is available in front of the car on distance L_H, so $L_H < L$ the car will hit the hurdle by speed $V_H = V - \sqrt{2\gamma .g.(L_H - L_R)}$. If $L_H \le L_R$ the car will hit the hurdle without braking and $V_H = V$. The details of shock and sequels depend on concrete conditions but statistics can help for conclusions of mathematical problems.

- Reaction time: when the emergency is expected - about 0,4 s; if it is not expected - about 1 s and more; if the river is angry, distracted, tired, etc. - for more than 2 s.
- Hit at a hurdle: it is equivalent of the impact of free fall of car from a height: 10 meters - at a speed of 50 km/h; 22 meters - at a speed of 75 km/h; 40 meters - at a speed of 100 km/h.
- Impact at pedestrian: the probability for fatal outcome depends on the speed and if the speed is 30 km/h - the risk of fatal injury is low; if 50 km/h - 50% die from pedestrians; if 70 km/h - 100% of pedestrians get killed.

These data can be implemented in the mathematical problems, so students to make conclusions how should drive in concrete conditions. It is obviously, after many times repeating of different variants students will have lifelong memories and that will reflect to their traffic behavior. Because these kind of training materials will be put in web for free access drivers will use them to improve their theoretical knowalidge and driving skills.

Conclusion

The effective traffic safety training is a long process; it starts from very young age and continues throughout life. This is not only a process of acquiring knowledge and skills, but also a matter of social importance. Pedagogical forms of education depend on the position of a man in society, respectively, on abilities of perception of the environment. Combination of different forms of training will improve the fundamental training of participants in traffic and as result will contribute to reduce trafic accidents and incidents.

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Acknowledgment: This work is carried in the frame of the project LLP-LdV-TOI-07-FI-160810 "Modernizing the Professional Capabilities of Driving Instructors – Future Facilitators of Lifelong Traffic Safety Learning" (http://www.procadrin.eu) and supported by European program of vocational training development "Leonardo Da Vinci".