The Role of Lectures and Factors Affecting Individual Working Competency of Students at Thai Nguyen University, Viet Nam through Mathematical Modeling Process

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Abstract

For university training, all teaching processes aim at developing and perfecting occupational compentencies for learners. In the study of teaching mathematics at Thai Nguyen University, Vietnam, we consider mathematical modeling as a way to help students solve problems mathematically. Accordingly, the main role of teachers in these situations mostly include: to build learning environment, conduct research and practice, introduce methods and guarantee accurate content of mathematical theory. Through the process of implementing mathematical modeling, independent working compentency of students is influenced by two basic factors named psychological factors and individual compentency factors. The research results show that the main psychological factors include attitudes, motives and willpower while individual compentency factors include the compentence to recognize occupational situations, the compentence to switch between the practice and mathematics, the compentence to use supportive technology in the process of working with mathematical models and randomly opening data sets and critical thinking.

Keywords: Independent working compentency, mathematical modeling, the role of lecturers

Introduction

Economic development entails structural changes and capacity requirements for workers. Students at higher education institutions, primarily and qualified human resources, always need to equip themselves with new skills and knowledge as this is very important for them to meet the current occupational situations (Dam, 2004), (Forrier, 2003). Therefore, education and training with the goal of developing competencies and meeting occupational requirements will be a fundamental element of students’ career awareness (Berntson, Sverke, & Marklund, 2006). Moreover, in higher education, all teaching methods are aimed at helping learners to participate in social life as an independent and responsible citizen (Aebli, 1985), (Blum, 2015).

Mathematical modeling can be used in teaching processes at many levels and in many parts of the world. For undergraduate level, mathematical modeling has connected mathematics with almost all fields: science, computer science, engineering, economics, medicine and pharmacy, etc. Hence, mathematical modeling process is supposed to be taught in open situations, researches, analysis, and prediction of issues which will be appropriate for students' level and apprenticeship (Caldwell & Ng, 2004), (Galbraith, Henn, & Niss, 2007), (Kaiser, Blum, Ferri, & Stillman, 2011). When participating in the mathematical modeling process, the basic goal is to activate learners’ cognition, then stimulate to carry out their own activities. However, it is important to keep a balance between the independent work of learners and the guidance of instructors in this teaching methodology.

Thai Nguyen University aims to be a center for training high-quality human resources for the midland and mountainous areas of Northern Vietnam and across the country. In this study, we consider the independent working capacity of Thai Nguyen University students under the impact of relevant factors considered in the implementation of the mathematical modeling.

Literature Review

Mathematical Modeling Process

Mathematical modeling process is a process of building a conversional model between practice and mathematics (Pollak, 1979), (Blum, 1988), (Schichl, 2004). There are plenty of ways to represent a modeling cycle of mathematical modeling process and to describe that cycle taking place in different stages but all start from a practical situation/ problem, come to the result-generation phase (building model - understanding in reality) and continue the cycle if the conclusions are inconsistent with reality (John Berry, 1995), (Coulange, 1997), (Peter Galbraith, 2006) (Greefrath, 2011).

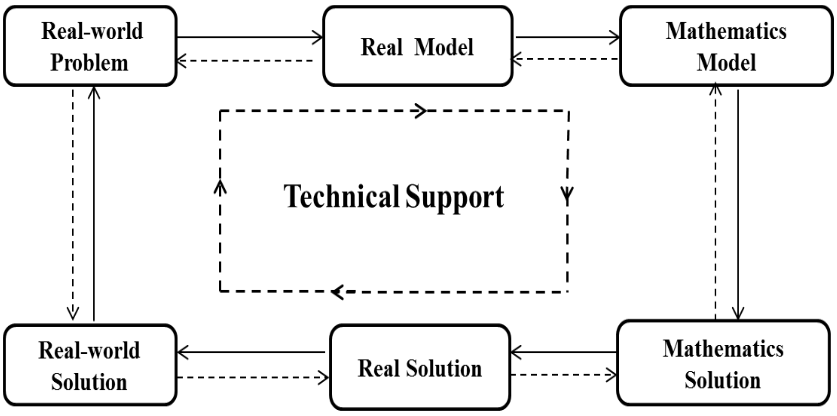

Figure 1. Mathematical modeling process supported by Information Technology

The Blum's mathematical modeling process is considered to be the basis for most mathematical modeling activities because it shows all three factors: the application of mathematics, linguistics and cognitive psychology (Blum, 2015). However, the process of mathematical modeling continues to be extended to one more field, the technological environment. When implementing the mathematical modeling, it is realized that there are many ways of solving problems through built models, and the use of mathematical techniques and tools is also different. Except for simple models which do not need much information technology (IT) support, IT is of great help for all other more complicated models (Borba & Villarreal, 2005), (Henn, 2007), (Geiger, 2011), (Greefrath, Siller, & Weitendorf, 2011), (Ang, 2010). IT support tools can be used for experiments, surveys, simulations, visualization or calculations. Therefore, it is no longer difficult to find ways to process data and calculate large data with the help of IT, the implementers of mathematical modeling will focus on finding optimal solutions to the problem.

For a growing and ever-changing data set, mathematical modeling process also begins to focus on the existence of reflection, meaning that in any step of the mathematical modeling process, it is important to review, test and be able to revert to implementation, if necessary (Galbraith, Stillman, Brown, & Edwards, 2007). In a modeling cycle, there can be many different representations and solutions but they will be sorted, selected or integrated. These representations are then analyzed, interpreted and tested so that they can be adjusted, modified or removed from use in the next steps of the mathematical modeling cycle (Kang & Noh, 2012), (Lesh & Doerr, 2003).

The teaching method at a university attaches great importance to promote learners' self-study and research as well as effectively mobilize the role of modern teaching facilities, techniques and technologies. Meanwhile, lecturers at a university are mainly high-level scientists and specialists who are attached to scientific researches. Therefore, the main task of teachers is to create a learning environment and conditions for learners to have opportunities to learn in a positive and creative way. The teacher's role must move from a catalytic and coordinating one to learner guiding and learner-centered function in the teaching process. In the new era, the value of lecturers is not only to convey knowledge but also to guide and support students in self-direction in learning, and they also need to help students adjust the orientation of quality and the meaning of information sources (Su & Wood, 2012). The foundation of teachers at the university level is the level of scientists combined with teaching competence (Đức, 2010), (Trang, 2018).

Consequently, when participating in the mathematical modeling process, students need to have specific competencies corresponding to each step or each stage of implementing a cycle. Lecturers at university level play a supporting, helping and guiding role for students to implement the process in order to develop the required competencies of the individual.

The effectiveness of teaching and learning process requires adequate facilities. This element is an essential component in ensuring successful education. The availability and use of school facilities has an important impact on student learning outcomes and development (Saeed & Wain, 2011), (Oliver, 2002), (Snipes & Thomson, 1999). External manifestations of facilities include classrooms, teaching equipment, learning materials, etc.

Independent Working Competency

Competency is a set of characteristics or qualities of individual psychology, acting as an internal condition to facilitate the implementation of a certain type of activity. Competency is perceived to be related to the attitudes, motivations, and abilities that an individual meets the requirements of certain activities/ jobs in different situations, while at the same time guaranteeing the operation or the performance of working optimal (Burgoyne, 1989), (Greefrath & Vorhölter, 2016). Competency is individual characteristics, so there is a difference between the competencies of each person, expressed in actions and towards the working efficiency (Boyatzis, 1982), (Hoffmann, 1999), (Brophy & Kiely, 2002).

According to the assessment of students and employers, they all consider the ability to work independently and how to cope with the working pressure which is one of the important competencies to get a job and achieve results in working process (Robinson & Garton, 2008), (Rauner & Maclean, 2008), (Murray & Robinson, 2001), (Duoc & Metzger, 2007). Competency is both a premise and a result of activity. Competency is not only a condition for the activity to achieve results but also it develops within the activity itself.

Independent working competency also expresses through independent thinking and learning. Therefore, the ability to work independently can be considered in terms of readiness, motivation, activity participation and assessments (Tait & Knight, 1996). This competency represents the ability to set goals for working, clear planning, collect information, prepare resources, implement working and report, assess results independently and efficiently (Knowles, 1986). It includes some components:

(i) Ability to know what needs to be done and targets need to be achieved. This means that students can determine when they do their jobs, what their working goals are, what their results will be, how they do it.

(ii) Ability to divide specific tasks and managing time. When students have identified what they need to do, then divide their jobs in the most efficient way and start evaluating the performance level.

(iii) Ability to pursue working objectives when students have set goals in working, they must always stick to their goals to develop themselves.

In the mathematical modeling process, the working competency identical to the mathematical modeling competency of each individual represents the ability of thinking and implementation of the processes. The mathematical modeling competency does not have a particular structure, it consists of many factors, obtained from cognitive psychology, different types of thinking to transition from reality to mathematics and vice versa (Galbraith, Henn, & Niss, 2007), (Özdemir & Üzel, 2012), (Maaß, 2006), (Lesh, Galbraith, Haines, & Hurford, 2013). In the meantime, the willingness to participate in the mathematical modeling process corresponds with an individual's ability to build a model, interprets between the real world and the mathematical world, use supporting tools and work on the mathematical model, have accurate evaluation and reflection of that model in order to have suitable adjustment. That is, students can perform step by step following a cycle of the mathematical modelling process. As a result, the independent working competency of the mathematical modeling process is a synthesis of knowledge, skills, attitudes and willingness to effectively participate in the resolution of the initial issue.

Therefore, in the mathematical modeling process, it is necessary to identify factors that affect the evaluation of students' independent working competency. According to the analysis, the research team divides the competency into two factors: the individual psychological component towards the desire to address the issue, and the element of each individual to achieve the stages of mathematical modeling cycle to solve the problem (individual competency). The research model is suggested in figure 2.

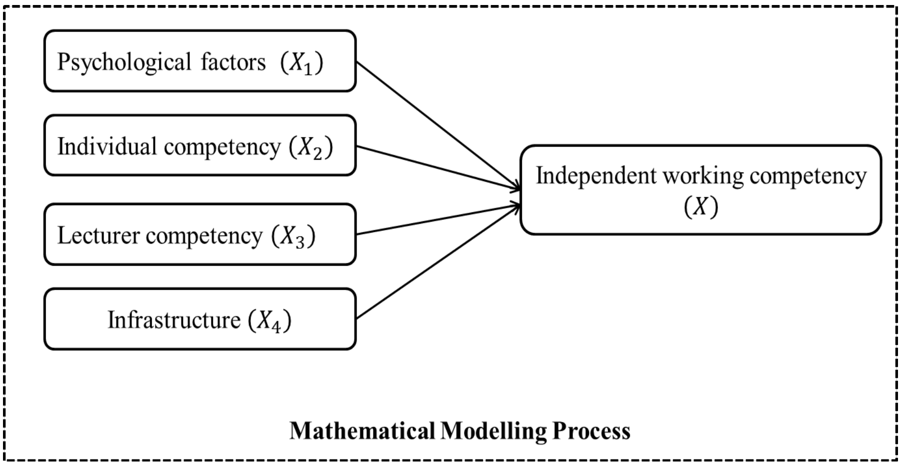

Figure 2. Proposed research model

Research Methods

The study is conducted through 2 steps:

Step 1: Qualitative research by building and developing the concept system/ scale and observed variables and adjusting observed variables in accordance with reality.

Step 2: Quantitative research, using Cronbachs's Alpha reliability coefficient to test how closely items in the scale correlate; exploratory factor analysis (EFA) is used to test influencing factors and identify the factors appropriate; at the same time, using multivariate linear regression analysis to determine the factors and the impact of each factor on the independent working competency of students of Thai Nguyen University through the process of learning.

Research theoretical model of independent working competency of students including 4 groups of impact factors:

Psychological factor (X_1): measured by four observed variables from x_1 to x_5 (see Table 1).

Individual competency factor (X_2): measured by five observed variables from x_6 to x_{10} (see Table 1).

Lecturer competency factor (X_3): measured by four observed variables from x_{11} to x_{14} (see Table 1).

Infrastructure factor (X_4): measured by three observed variables from x_{15} to x_{17} (see Table 1).
In this study, the research team used the Likert scale to score from 1 to 5 to measure observed variables.

Table 1. Variables in the model

x_1	Attitude	x_{10}	Decision making competency
x_2	Demand/ Motivation	x_{11}	Building learning environment
x_3	Volition/ Action	x_{12}	Research and practice
x_4	Cognition	x_{13}	Introducing learning methods
x_5	Personality	x_{14}	Accurate the contents of mathematical theory
x_6	Competency to identify situations	x_{15}	System of lecture halls and classrooms
x_7	Competency to convert between reality and mathematics	x_{16}	System of teaching facilities and technical equipment
x_8	Competency to use supportive technology	x_{17}	System of teaching methodology
x_9	Critical thinking		

Since then, the model of independent working competency of Thai Nguyen University (TNU) students through the mathematical modeling process is established as follows:

Independent working competency of students $X = f(X_1, X_2, X_3, X_4)$;
where X is a dependent variable and X_1, X_2, X_3, X_4 are independent variables.

The research team conducted a survey of students in the second year (students who have studied the mathematics course), the total number of students of 7 member universities under TNU is N = 4900 students with the following allocation

Name of University	Number of students
Thai Nguyen University of Information and Communication Technology	900
Thai Nguyen University of Technology	1400
Thai Nguyen University of Sciences	200
Thai Nguyen University of Economics and Business Administration	1200
Thai Nguyen University of Agriculture and Forestry	500
Thai Nguyen University of Education and Training	200
Thai Nguyen University of Medicine and Pharmacy	500
	4900

After processing the data, the team removed the invalid votes, the remaining sample was 4792 students.

Research Results

The research team used SPSS 20.0 software to support the analysis; the results of implementing the research model are as follows:

First, we used Cronbachs's Alpha model to test the reliability of the scale for measuring independent working competency of TNU students through the process of mathematical modelling with 17 observed variables of 4 factors. After three discovering factors analysis, in terms of variables - total correlation, all 5 variables were excluded from the model because of a value less than 0.3. The five variables are $x_1, x_4, x_5, x_{10}, x_{15}$. The remaining 12 measurement variables used in exploratory factor analysis (EFA), with Cronbachs's Alpha coefficient reaching 0.723; proving that this measurement scale is usable. The results of exploratory factor analysis (EFA) after three tests are guaranteed as follows:

- Reliability of observed variables (factor loading > 0.5).

- Testing the suitability of the model (0.5 < KMO = 0.723 < 1).

- Barlett's test of correlation of observed variables (Sig < 0.05).

- Test of cumulative variance = 65.272% (cumulatine variance > 50%).

Table 2. Rotational component matrix

	Component		
	1	2	3
x_1	.861		
x_2	.789		
x_3	.772		
x_6		.834	
x_7		.806	
x_8		.762	
x_9		.701	
x_{11}			.821
x_{12}			.796
x_{13}			.857
x_{14}			.871
x_{16}			.702

Source: Results of exploratory factor analysis from survey data

According to the rotational component matrix, we have factor loading of variables in Table 2 which are greater than 0.5. Three factors are as follows:

- Factor 1 includes observed variables x_1, x_2, x_3 named *"Psychology"*.

- Factor 2 includes observed variables x_6, x_7, x_8, x_9 named *"Individual competency"*.

- Factor 3 includes observed variables x_{11}, x_{12}, x_{13}, x_{14}, x_{16} named *"Teachers' role"*.

Based on the results of great value coefficients in the above table of component score matrix, we provide the following factor equation:

Factor 1, the factor *"Psychological factor"* are mostly affected by three observed variables x_1 (Attitude), x_2 (Demand/ Motivation), x_3 (Volition/ Action). These factors all have a positive impact on factor 1, of which the "demand/ motivation" factor has the strongest impact on the *"psychological"* factor.

$$X_1 = 0.358x_1 + 0.479x_2 + 0.462x_3.$$

Factor 2, factor *"Individual competency"* are largely affected by four observed variables x_6 (competency to identify the situation); x_7 (competency to convert between practicality and mathematics), x_8 (competency to use supportive technology), x_9 (critical thinking). These factors all have a positive impact on factor 2, in which the "competency to convert between reality and mathematics" has the strongest impact on the *"Individual competency"* factor.

$$X_2 = 0.368x_6 + 0.473x_7 + 0.45x_8 + 0.302x_9.$$

Factor 3, the factor *"Lecturer competency"* are largely influenced by the five observed variables x_{11} (Building learning environment), x_{12} (Research and practice), x_{13} (Introducing learning methods), x_{14} (Accurate contents of mathematical theory), x_{16} (System of teaching facilities and technical equipment). These factors all have a positive impact on factor 3, in which the "Accurate contents of mathematical theory" has the strongest impact on the *"Lecturer competency"* factor.

$$X_3 = 0.405x_{11} + 0.316x_{12} + 0.352x_{13} + 0.464x_{14} + 0.421x_{16}$$

Table 3. Component score matrix

	Component		
	1	2	3
x_1	.358	-.082	-.016
x_2	.479	-.132	-.127
x_3	.462	-.068	-.082
x_6	-.116	.368	-.126
x_7	-.039	.473	-.098
x_8	-.051	.450	-.077
x_9	-.158	.302	-.074
x_{11}	-.018	-.039	.405
x_{12}	-.057	-.065	.316
x_{13}	-.024	-.073	.352
x_{14}	-.011	-.029	.464
x_{16}	-.053	-.061	.421

Source: Results of exploratory factor analysis from survey data

Table 4. Results of linear regression analysis

Model	**Unstandardized Coefficients**	**Standardized Coefficients**	**Sig.**	**VIF**
	B	**Beta**		
(Constant)	1,709	-	,001	
X_1	,302	,528	,000	3,769
X_2	,389	,607	,000	2,124
X_3	,247	,478	,000	1,359
Sig.			0,000	
Adjusted R Square			0,609	

Source: Results of linear regression analysis from survey data

The regression analysis results in Table 4 show that the R^2 coefficient is 60.9%, which means that 60.9% of the variation of the independent working capacity of Thai Nguyen University students can be explained by the factors included in the model; other affecting factors have not been studied. The coefficient Sig.F = 0.000 is much smaller than the significance level of $\alpha = 5\%$ so the regression model makes sense, meaning that the independent variables influence the dependent variable X. Besides, the variance inflation factor (VIF) of the variables in the model is much smaller than 10, so we can conclude that the variables included in the model do not have multi-collinear phenomena. The above analysis results show that all 3 variables included in the model have statistical significance Sig. < 5%. From the above results, the regression equation estimated the factors affecting independent working competency of students of TNU through the process of mathematical representation set as follows:

$$X = 1.709 + 0.302X_1 + 0.389X_2 + 0.247X_3.$$

Based on the regression equation, the three variables included in the model are positively correlated with the independent working capacity of TNU students through the process of learning. In which the factor *"Independent working competency"* is the most influential factor (the non - standard correlation coefficient is 0.389), then the factor *"Psychological factors"* (corresponding to the coefficient) the non - standardized correlation is 0.302), the last is the *"Teachers' role"* factor corresponding to the non - standardized correlation coefficient of 0.247).

The linear regression model using OSL method is done with a number of assumptions and the model only really makes sense when these assumptions are guaranteed. Therefore, to ensure the reliability of the model, the research team also conducted the detection of violations of necessary assumptions.

The first assumption is the linear contact assumption. The method used is a Scatterplot scatter chart with normalized residual values on the vertical axis and normalized predicted values on the horizontal axis. Looking at Figure 3, we see that the remainder does not change in any order for the predicted value.Thus, the hypothesis of linear relation is not violated.

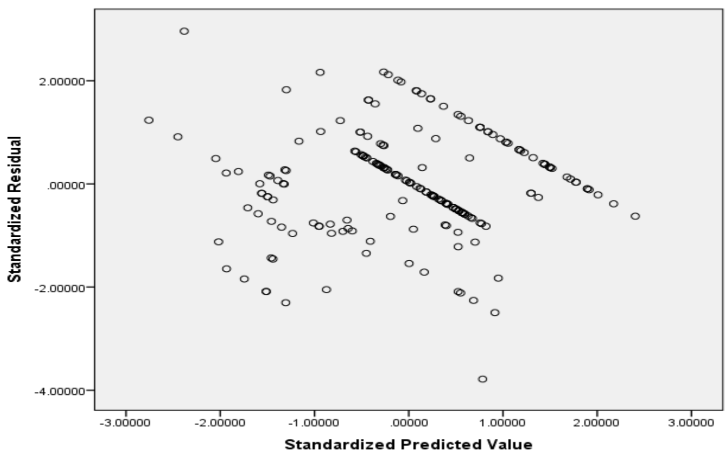

Figure 3. Random distribution graph of a standardized residual
Source: Data processing results of the author

To detect the violation of the normal distribution assumption of residuals, we used two drawing tools of SPSS software: Histogram and Q-Q plot. Looking at the Histogram (Figure 4), we see that the remainder has a normal distribution with an average of almost 0 and its standard deviation is close to 1 (= 0.97034).

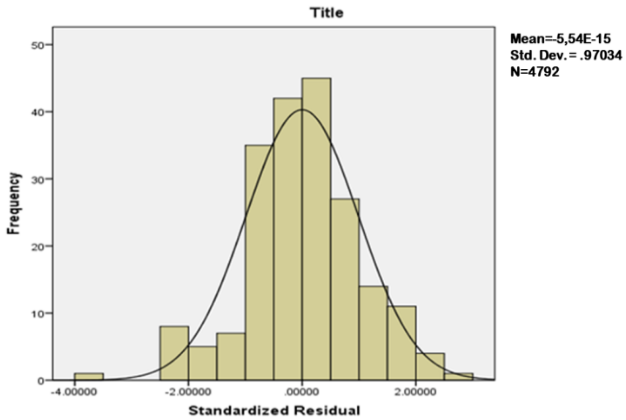

Figure 4. Frequency chart of standardized residuals
Source: Data processing results of the author

Looking at the Q-Q plot (Figure 5) shows the actual observation points that are fairly close to the diagonal of the expected values, meaning that the residual data has a normal distribution.

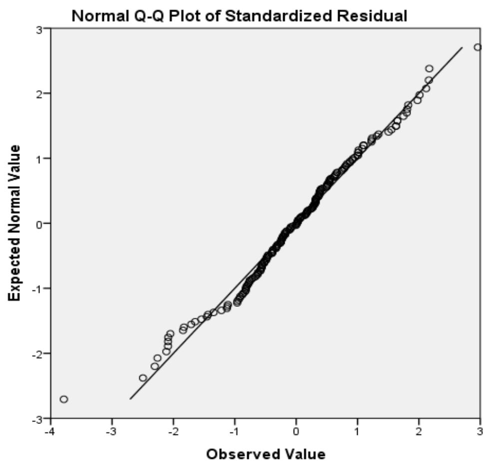

Figure 5. Comparison graph with normal distribution (p-p) of standardized residual
Source: Data processing results of the author

Discussion and Conclusion

Through the mathematical modelling process, some competencies of students are formed, adjusted and developed. According to the above analysis results, in the mathematical modelling process, the independent working competecny of students at TNU depends on both external and internal factors. External factors relate to creating a relationship between lecturers and students (Su & Wood, 2012), and at the same time, building a learning environment with the provision and guidance of students with IT competency is an important factor. However, external factors only serve as a premise for the development of the independent working competency of each individual. It is important to distinguish between students working independently and the support of lecturers and students working alone (Blum, 2015).

The internal element is the capacity and psychology that individual students are affected. Competency requires the right attitude, motivation and experience to develop more deeply (Sydänmaanlakka, 2007). Therefore, psychological factors that affect students' ability to work independently are shown under three observed variables: Attitude, Demand/ Motivation, Volition/ Action. An individual's level of competency increases in the direction of being able to work or work independently (Fernando, 2004). Individual competency is not only the knowledge but also the ability to apply the knowledge gained in practice. Unsurprisingly, the use of technology as an effective assistive tools always prevails in the classroom at an increasingly advanced level (Beare, 1996), (Cheng & Wah, 1999), (Ferrucci & Carter, 2003).

In this study, the given model was only tested on the sample of TNU students. Therefore, it is possible that the model is appropriate in this case and the factors that give the test have an impact on the student's ability to work independently. For other research samples, the model may change and may not even retain the linear relationship among the proposed factors. The nature of higher education is the development of career competencies. All teaching methods should be student-centered. The impact of which factors, more or less on each competency that the teaching objectives specified, depends on the individual who participated in the study, corresponding to certain teaching method, given time and specific circumstances. Therefore, the proposed research model can be tested for different cases.

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