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COMPUTATIONAL THINKING: MOTIVATION TO LEARN IN TERTIARY EDUCATION

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Abstract: *The paper presents an educational case study – investigation of motivation towards learning computing and computational thinking in tertiary education. In the first part of the paper background of the study is presented – why it was necessary to try to measure motivation. The second part describes the three motivation surveys known in the literature - Motivated Strategies for Learning Questionnaire (MSLQ), Academic Motivation Scale (AMS) and Model of Academic Motivation Inventory MUSIC. The next part describes a survey in which the Model of Academic Motivation Inventory was used. Statistical results of MUSIC Inventory are presented and answers to one of the five open-ended questions are discussed. Preliminary cluster analysis is performed which is the part of ongoing research. Final remarks include an open question – is it possible to increase students' motivation and, if it is, how to do this?*

Keywords: motivation, learning, computing, computational thinking.

INTRODUCTION

Teaching Applied Computer Science Course (Computing and Computational Thinking Course) dedicated to students not specialized in informatics (Gajewski, Wlasak, & Jaczewski, 2013) is a very big challenge. All multimedia materials (Gajewski, 2016b), flipped classroom technology (Gajewski & Jaczewski, 2014) and the automatic flowcharting tool (Gajewski, 2018) used in this course did not improve the quality of learning and learning outcomes and caused cheating problems (Gajewski, 2016a). Lack of motivation towards studying Computer Science among students could be the main reason of this situation. In order to help to design a course that more engages students in learning a survey of academic motivation was prepared and conducted.

1. COMPUTING AND COMPUTATIONAL THINKING COURSE

The Applied Computer Science course at the Faculty of Civil Engineering at Warsaw University of Technology was presented in many previous papers. It was mainly based on a book (Dale & Lewis, 2015). Last year there was a shift towards Computing and Computational Thinking in Civil Engineering as presented in books (Riley & Hunt, 2014) and (Wang, 2015). Much more attention and stress were put on such problems as logic, solving problems, modelling solutions, algorithmic thinking and data organization.

Computer labs are divided into three blocks. The first one called first things first (three weeks) is devoted to basic things like file systems and file transfer and effective use of a text processor. The second block, also three weeks long, is devoted to spreadsheet. There are three major points in this block: logical functions and conditional statements, database functions and their usage and Solver. The third block leads towards algorithmic thinking and programming and is devoted to Computer Algebra System Mathcad. The first part of Mathcad classes is devoted to solving classical mathematical problems: symbolic calculations, definition of variables and functions, calculus (integrals, derivatives, limits), matrix and vector operators and functions, solving problems (linear and nonlinear equations, minimization and maximization). The second part is devoted to simple programming, not object-oriented as it was suggested many years ago (Gajewski, 1994), (Gajewski & Lompies, 1996).

2. ABOUT MOTIVATION

Motivation refers to "the reasons underlying behaviour" (Guay et al., 2010). Broussard and Garrison (Broussard & Garrison, 2004) broadly define motivation as "the attribute that moves us to do or not to do something". Researchers often contrast intrinsic motivation with extrinsic motivation, which is governed by reinforcement possibilities. Educators believe intrinsic motivation to be more desirable and to result in better learning outcomes than extrinsic motivation. More publications about motivation can be found in a report with literature review (Lai, 2011) and in a book about motivation for learning and performance (Hoffman, 2015).

2.1 Motivated Strategies for Learning Questionnaire MSLQ

Prior to Motivated Strategies for Learning Questionnaire (MSQL) a lot of research on student learning focused on differences in learning styles. The idea of individualized learning styles became popular in the 1970s and has greatly influenced education despite the criticism that the idea has received from some researchers (Coffield, Moseley, Hall, & Ecclestone, 2004). Theoretical background of MSQL is an adoption of a general expectancy-value model of motivation (Eccles, 1983). The first model created by Pintrich (Pintrich, 1988) proposes three motivational components: an expectancy

component, a value component and an affective component. The first tool for assessing students' motivation beliefs and self-regulated learning strategies consisted of 44 questions (Pintrich & De Groot, 1990). They were used to form the following five scales: self-efficacy, intrinsic value, test anxiety, cognitive strategy uses and self-regulation. The final version of MSLQ (Pintrich, 1991) has 81 questions divided, like the first version, into two parts: motivation scales and learning strategies scales. The first part consists of six scales: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning & performance and test anxiety. The second part consists of nine scales: rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time/study environmental management, effort regulation, peer learning, and help seeking. Reliability and predictive validity of the motivated strategies for learning questionnaire was later studied in (Pintrich, Smith, Garcia, & McKeachie, 1993). A validity and reliability study of the motivated strategies for learning questionnaire was presented in (Ilker, Arslam, & Demirhan, 2014). Review of MSLQ using reliability generalization techniques to assess scale reliability was presented in (Taylor, 2012).

Motivated Strategies for Learning Questionnaire was later used by many researchers. The making of MSLQ was presented in (Duncan & McKeachie, 2005) and review of MSLQ in (Artino Jr, 2005). This questionnaire was used in assessing motivation and learning strategies of generation 1.5 Korean immigrant students (Stoffa, Kush, & Heo, 2011). The MSLQ was also used to score validity among medicine residents (Cook, Thompson, & Thomas, 2011).

2.2 Academic Motivation Scale AMS

This measure of motivation towards education has been developed in French as Echelle de Motivation en Education (EME) (Vallerand, Blais, Briere, & Pelletier, 1989). The EME was composed of 28 items subdivided into seven scales. They assess three types of intrinsic motivation - intrinsic motivation to know, to accomplish things and to experience stimulation, three types of extrinsic motivation – external, introjected and identified regulation and amotivation. Some years later EME was translated into English through appropriate methodological procedures and renamed to Academic Motivation Scale (AMS) (Vallerand et al., 1992), (Vallerand et al., 1993).

AMS is still in use. Cokley examined the validity of AMS by comparing scale construction to a self-determination theory (Cokley, 2000) and later performed psychometric investigation of AMS using a United States sample (Cokley, Bernard, Cunningham, & Motoike, 2001). Fairchild evaluated existing and new validity evidence for AMS (Fairchild, Horst, Finney, & Barron, 2005). Hegarty applied AMS to graduate school students (Hegarty, 2010). Kusurkar investigated validity evidence for the measurement of the strength of motivation for a medical school (Kusurkar, Croiset, Kruitwagen, & ten Cate, 2011). Haslofça examined reliability and validity of AMS

for the sports high school students (Haslofça & Korkmaz, 2016). Zhang performed revision and validation of AMS in China (Zhang, Li, Li, Li, & Zhang, 2016).

2.3 Model of Academic Motivation Inventory MUSIC®

The MUSIC® Model of Academic Motivation Inventory (MUSIC® Inventory) is a questionnaire that can be used by instructors and researchers to assess students' perceptions of the MUSIC components for an activity or course. The MUSIC Inventory is a research-based questionnaire that has been shown to produce valid scores. The inventory was developed by Jones to measure constructs related to the five primary components of the MUSIC Model of Academic Motivation (Jones, 2009). More details of the MUSIC® Model of Motivation can be found in Jones' book (Jones, 2017). Validity evidence for the MUSIC Inventory was presented in (Jones & Skaggs, 2016) and other publications – for the elementary school version in (Jones & Sigmon, 2016), for pharmacy students in (Pace, Ham, Poole, & Wahaib, 2016), for Chinese and Spanish speaking university students in (Jones, Li, & Cruz, 2017) and for students of science in Iceland in (Jones, Sahbaz, Schram, & Chittum, 2017).

The MUSIC Inventory measures five primary components of the MUSIC Model of Motivation: empowerment, usefulness, success, interest, and caring (Jones & Skaggs, 2016). The components of the MUSIC model are not directly related to any one specific construct because they are names of categories of teaching strategies that can be used to motivate students. eMpowerment shows the degree to which a student perceives that he or she has the control of his or her learning environment in the course. Usefulness illustrates the degree to which a student perceives that the coursework is useful to his or her future. Success demonstrates the degree to which the student perceives that he or she can succeed at the coursework. Interest exhibits the degree to which the student perceives that the instructional methods and coursework are interesting. Caring reveals the degree to which the student perceives that the instructor cares about whether the student succeeds in the coursework and cares about the student's well-being.

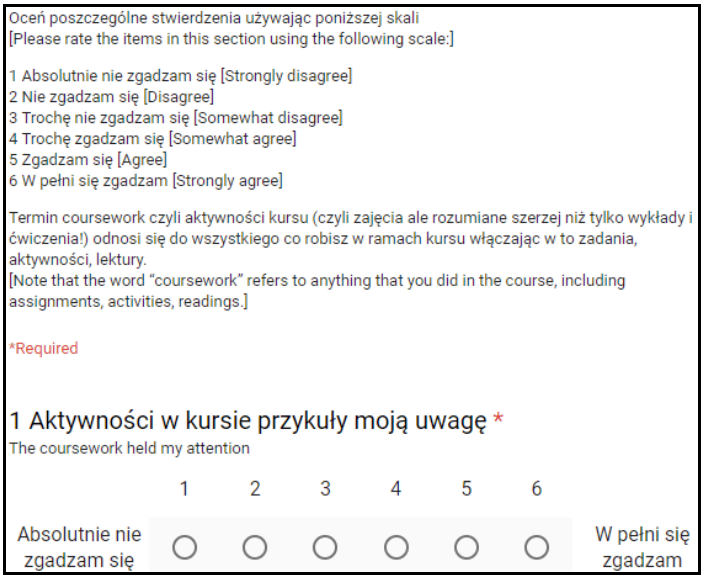
3. SURVEY AND ITS RESULTS

Surveys based on the MUSIC® Model of Academic Motivation Inventory took place at the end of January 2018. Questionnaire consisted of two parts – first with 26 questions where answers were based on six-point Likert (Likert, 1932) scale and second with open-ended questions. The first one was filled by 166 students out of 196 participating in the course (85%), the second by 112 out of 196 (57%). Difference in numbers of answers is perhaps caused by the fact that the second questionnaire was more time consuming and required not only clicking

but also typing. In both surveys Google Forms were used for both parts of the questionnaire (see Figure 1).

3.1 Results of the MUSIC Inventory

Students completed a questionnaire that contained items from previously validated instruments presented in (Jones, 2010). The questionnaire was titled generically as an "Applied Computer Science Questionnaire" and was part of a larger study that examined students' motivation-related perceptions about their current computer science classes. The items were scaled using a 6-point Likert-type format with the following descriptors: 1 strongly disagree, 2 disagree, 3 mostly disagree, 4 mostly agree, 5 agree, and 6 strongly agree.


Oceń poszczególne stwierdzenia używając poniższej skali
[Please rate the items in this section using the following scale:]

1 Absolutnie nie zgadzam się [Strongly disagree]
2 Nie zgadzam się [Disagree]
3 Trochę nie zgadzam się [Somewhat disagree]
4 Trochę zgadzam się [Somewhat agree]
5 Zgadzam się [Agree]
6 W pełni się zgadzam [Strongly agree]

Termin coursework czyli aktywności kursu (czyli zajęcia ale rozumiane szerzej niż tylko wykłady i ćwiczenia!) odnosi się do wszystkiego co robisz w ramach kursu włączając w to zadania, aktywności, lektury.
[Note that the word "coursework" refers to anything that you did in the course, including assignments, activities, readings.]

*Required

1 Aktywności w kursie przykuły moją uwagę *
The coursework held my attention

	1	2	3	4	5	6	
Absolutnie nie zgadzam się	○	○	○	○	○	○	W pełni się zgadzam

Figure 1. First page of the MUSIC® questionnaire
Source: Own work

The instruments measured five constructs:

- Five items measured empowerment (I had the opportunity to decide for myself how to meet the course goals; I had the freedom to complete the coursework my own way; I had options in how to achieve the goals of the course; I had control over how I learned the course content; I had flexibility in what I was allowed to do in this course.)
- Five items measured usefulness (In general, the coursework was useful to me; The coursework was beneficial to me; I found the coursework to be relevant to my future; I will be able to use the knowledge I gained in this course; The knowledge I gained in this course is important for my future.)

- Four items measured success (I was confident that I could succeed in the coursework; I felt that I could be successful in meeting the academic challenges in this course; I was capable of getting a high grade in this course; Throughout the course, I felt that I could be successful on the coursework)
- Six items measured interest (The coursework held my attention; The instructional methods used in this course held my attention; I enjoyed the instructional methods used in this course; The instructional methods engaged me in the course; I enjoyed completing the coursework; The coursework was interesting to me.)
- Six items measured caring (The instructor was available to answer my questions about the coursework; The instructor was willing to assist me if I needed help in the course; The instructor cared about how well I did in this course; The instructor was respectful of me. The instructor was friendly; I believe that the instructor cared about my feelings.).

The reliability estimates for the scales summarized in Table 1 were acceptable (Guttman, 1945) and (Guilford, 1965), especially Cronbach coefficients (Cronbach, 1951) which are good and one even excellent.

Table 1.

Means, standard deviations and Cronbach coefficients

Component	Mean	Std.Dev.	Cronbach
Empowerment	3.598	1.249	0.879
Usefulness	4.163	1.214	0.908
Success	3.526	1.272	0.897
Interest	3.667	1.194	0.869
Caring	4.167	1.268	0.821

Source: Own work

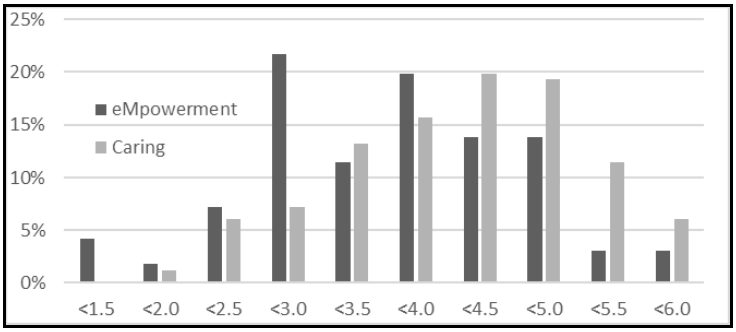


Figure 2. Comparison of the results obtained for eMpowerment and Caring
Source: Own work

The greatest differences in results are observed for empowerment and caring (see Figure 2). Perhaps it is due to the fact that the course is too much constrained and there is too little control given to students.

Generally, the results show central tendency bias (Douven, 2017), (Olkkonen, McCarthy & Allred, 2014), typical of Polish students. Figure 3 presents an average of all results for all constructs.

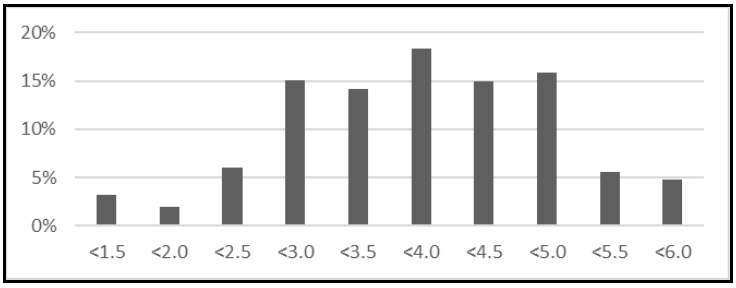


Figure 3. Central tendency bias.
Source: Own work

3.2 Open-ended questions

In addition to the inventory five open-ended questions based on (Jones, Watson, Rakes & Akalin, 2012) were asked (see Table 2). These questions were used to gain further insight into those aspects of the course that contributed to or detracted from the MUSIC component. From the list of sixteen questions prepared and used by Jones five were chosen.

Table 2.

Open-ended questions for students

Component	Question
Empowerment	What could be changed in this course to make you feel you had more choices in the course?
Empowerment	Which aspects of this course give you control over this course?
Usefulness	What could be changed in this course to make it more useful to you?
Success	What could be changed in this course to help you feel you could be more successful in it?
Interest	What could be changed in this course to make it more interesting and enjoyable?

Source: Own work based on (Jones et al., 2012)

For analysis of the open-ended items a thematic whole text analysis was used (Jones et al., 2012). An initial coding scheme for the item responses

was developed after reading all of the responses. Results of this procedure for the last question - What could be changed in this course to make it more interesting and enjoyable is presented in Table 3.

Table 3.

Answers on the last question – what could be changed...

Response	% Overall Responses
Lack of answer	29%
Nothing	18%
I do not know	14%
Assessment methods	6%
Lectures and test	5%
More practice	5%
Other responses	23%

Source: Own work

3.3 Preliminary Cluster Analysis

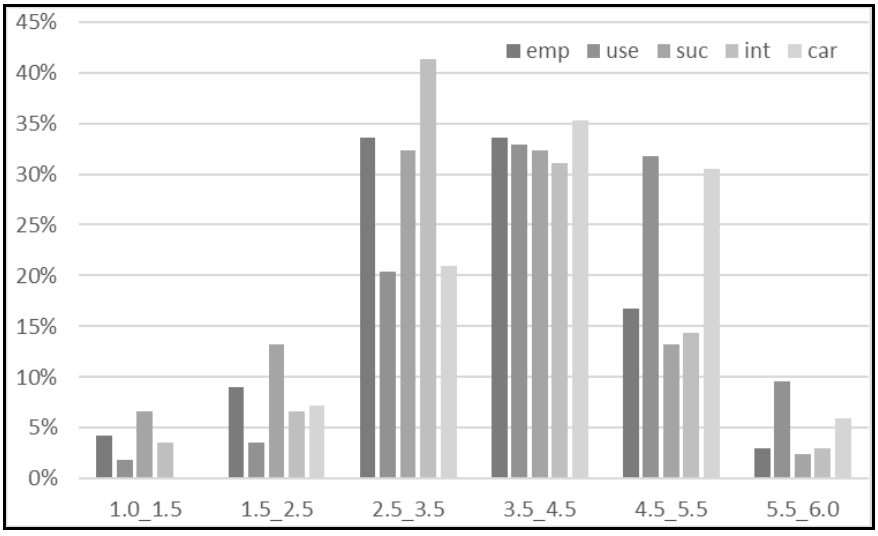


Figure 4. Clusters for separate components.
Source: Own work

The purpose of cluster analysis is to maximize within-cluster homogeneity and between-cluster heterogeneity (Chittum & Jones, 2017). In order to define the cluster profiles, the cluster centres were first organized into six categories that described the students' reported perceptions, per the 6-point scale: very low

(1.0 to 1.499), low (1.5 to 2.499), somewhat low (2.5 to 3.499), somewhat high (3.5 to 4.499), high (4.5 to 5.499), and very high (5.5 to 6.0). Results are presented in Figure 4. The biggest differences are observed for usefulness and caring.

Using the very low to very high categories to explain each variable's cluster centre within the overall cluster membership, initial characterization of the five clusters was as follows (Chittum & Jones, 2017): Cluster 1 - low motivation; Cluster 2 - low usefulness and interest, moderate empowerment, and high success and caring; Cluster 3 - somewhat high motivation; Cluster 4 - somewhat high empowerment, usefulness, and interest, and high success and caring; Cluster 5 - high motivation. Such simplified analysis can also be performed by using of k-means (Macqueen, 1967) (Figure 5) and online k-means clustering calculator.

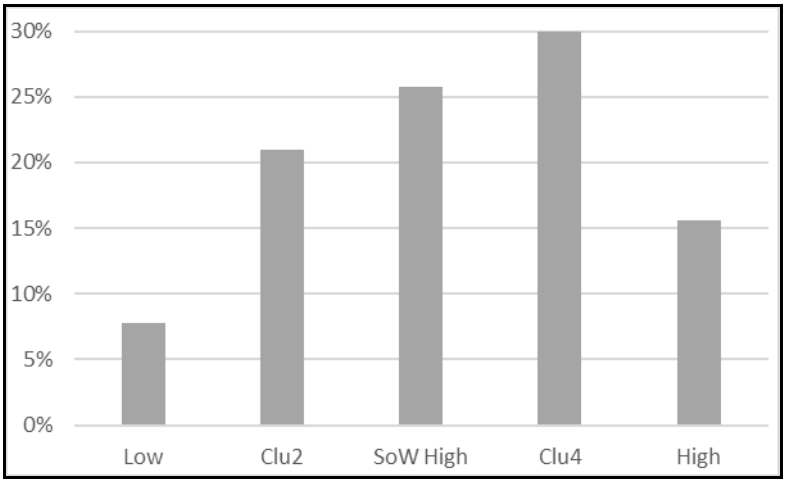


Figure 5. Clusters – simplified analysis.
Source: Own work

CONCLUSION

Outcomes of the first pilot MUSIC Inventory survey show a big difference in the results for empowerment and caring. Answers to the open-ended questions were the most valuable part of the survey. Knowledge about students' motivation will help to design courses that engage students in learning. It also leads to the next question. Is it possible to increase students' motivation and, if it is, how to do that?

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