

SELF-DIRECTED LEARNING OF UNIVERSITY ENGINEERING STUDENTS IN CONTEXT OF FOURTH INDUSTRIAL REVOLUTION

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Abstract. Students' self-directed learning (SDL) is analysed as a means to promote the development of professionals in the conditions of the 4th Industrial Revolution (4IR). The aim of the study was to analyse the components of SDL and to find out SDL results from the students of the Latvia University of Life Sciences and Technologies (LLU) and the Ural Federal University (URFU) in the context of skills topical for 4IR, and assess their mutual coincidence. The problem whether the students' actual SDL skills meet the 4IR skill reaching demands is assessed in the study. The method of questionnaire was used to investigate the students' self-assessment on their SDL focusing on purposefulness, responsibility, motivation to reach learning outcomes, interest, cognition need, understanding of knowledge and skills usage, implementation of effective learning strategies, control assessment of learning progress, critical thinking, problem solving, time management, co-operation and appropriate usage of IT. The results of the study were obtained from 43 LLU and 28 URFU engineering students. SDL can be effective, if it corresponds to the indicators of professionalism and learning outcomes; that is why labour market and professionalism traits should be followed up constantly. Learning outcomes and SDL should be revised regularly, because they depend on the development of 4IR technologies and labour market demands. The study results also indicate that more attention should be paid to students' time management skills and learning abilities. As SDL is a complicated process consisting of various indicators, affecting factors should be analysed and assessed in further investigations in comparison with 4IR skills.

Keywords: self-directed learning, engineering students, the fourth industrial revolution, skills.

Introduction

The idea of person's improving and technological progress now more than ever takes root in our minds – to be competitive, you need to be able to do what you will need to do tomorrow [1].

Interaction of higher and postgraduate education is a factor in professional formation and development of a young specialist, as evidenced by the tasks solved at the various stages of this development. It is the university that forms in a young person the need of "lifelong" education. Today they have already started talking about the "ahead of time education". The main task of ahead of time education is to focus not only on the production developing at this stage, but also on the expected future. In this regard, it is important to improve a social partnership "enterprise – university (college) – young employee" for development of young specialists [2].

Engineering students' self-directed learning (SDL) topicality is analysed from four perspectives in the study. The first perspective covers the concept of SDL and its components in the latest investigations. The second one refers to the fourth industrial revolution (4IR) demands relating to university graduates and stakeholders. The third perspective shows actual results of engineering students' SDL skills. The fourth perspective reflects the assessment of the engineering students' SDL in relation to skills important for 4IR.

The World Economic Forums raise the topicality of future profession development substantiating skills needed in the 4IR conditions where dynamics of technology progress is significant. Key findings on the future of labour market in the frame of the World Economic Forum 2020 are collected in a report where digital and human factors, and professional clusters and jobs of tomorrow are analysed [3].

That is why the aim of the study was to analyse the components of SDL and to find out SDL results from the students of the Latvia University of Life Sciences and Technologies (LLU) and the Ural Federal University (URFU) in the context of skills topical for 4IR, and assess their mutual coincidence.

Materials and methods

Theoretical studies of SDL development and findings on skills significant for 4IR had been carried out.

Significance of SDL for the 21st century is investigated and assessed by higher and adult education researchers [4; 5; 6; 7; 8], and in today's situation it is a tool how a person can adapt flexibly to labour market in the conditions of 4 IR. SDL covers such aspects, as ability to plan, work autonomously, assess, to be interested in learning and to be able to learn. Precise indicators are derived from the mentioned aspects and measuring is reflected in the "Results and discussion" part of the article.

The newest data about emerging jobs and top skills in the field of engineering are concentrated in the World Economic Forum 2020 reports. Engineering jobs will develop in the clusters of Green Economy Engineering and Cloud computing, and they will be: methane/landfill gas generation system technicians; wind turbine service technicians; green marketers; biofuel processing technicians; solar energy installation managers; water resource specialists; wind energy project managers; chief sustainability officers; refuse and recyclable material collectors; sustainability specialists; solar photovoltaic installers; water/wastewater engineers; forest fire inspectors and prevention specialists; fuel cell engineers; nuclear power reactor operators, Python developers, full stack engineers, Javascript developers, back end developers, frontend engineers, Software developers Dotnet development specialists and technology analysts [3].

The above mentioned professions will be in tight relation to AI and it means that the future engineer should be ready to deep, computer and machine learning, as well as TensorFlow practice [3].

B. Ślusarczyk stresses that "the fourth industrial revolution differs from the previous ones with the fact that it relates to all fields of life. Within its framework, the industry processes and commercializes the exchange of information between people, between people and objects and also between objects themselves" [9].

The rate of 4IR including new jobs and professional skills puts forward also a demand for top skills which will be topical in every profession after 2022. They are: analytical thinking and innovation; active learning and learning strategies; creativity, originality and initiative; technology design and programming; critical thinking and analysis; complex problem-solving; leadership and social influence; emotional intelligence; reasoning, problem-solving and ideation; systems analysis and evaluation [10].

The method of questionnaire of SDL self-assessment of 43 LLU and 28 URFU first year engineering students had been carried out from November 2019 to January 2020.

Students marked high (h), average (a) and low (l) level of purposefulness to reach learning outcomes, responsibility, motivation to reach learning outcomes, interest, cognition need, comprehension on the usage of knowledge and skills, assessment of one's achievements, usage of learning strategies, co-operation, time management, critical thinking, problem solving, appropriate usage of IT.

There were ranged the data (R) and their distributions got from the first year LLU and URFU student assessments taking the highest level assessments as an accounting point. Chi-Square test was used in the calculation [11].

The results of the study could be an informative basis for promotion of students' autonomous learning and better understanding of their behaviour.

Results and discussion

The questionnaire of 43 LLU and 28 URFU first year engineering students had been carried out from November 2019 up to January 2020. Results are ranged considering the frequency of answers in the highest level (Table 1).

Average assessments dominate in the most of cases. Exceptions are indicators 1; 3; 4; 9; 12 and 13. The differences between LLU and URFU respondents' assessment sum distributions are not statistically significant. It means that the results got in both institutions are similar.

Statistically significant (366 and 557) differences ($p < 0.05$) are identified for the sums **together** and **totally** assessments, for instance 366 in comparison to **average + low**, for instance 557).

Statistically significant ($p < 0.05$) differences of similar indicators are identified to indicators 5 (LLU), 8 (LLU, URFU), 10 (LLU). The assessment of these indicators in comparison to other indicators is the lowest one.

Statistically significant ($p < 0.05$) indicator differences are marked with **bold** – LLU, URFU.

Table 1

**First year students' assessments of self-directed learning
(LLU $n = 43$; URFU $n = 28$) – November 2019 to January 2020**

Indicator		Assessment grade			$\Sigma 2 + 3$	R_i max
		high	avg.	low		
		R_i				
		1	2	3		
Purposefulness to reach better learning outcomes	LLU	19	24	0	24	2
	URFU	14	13	1	14	1
Responsibility	LLU	19	22	2	24	2
	URFU	12	16	0	16	2
Motivation to reach learning outcomes	LLU	16	24	3	27	2
	URFU	18	9	1	10	1
Interest	LLU	19	22	2	24	2
	URFU	21	6	1	7	1
Cognition need	LLU	8	32	3	35	2
	URFU	9	15	4	19	2
Understanding how to use knowledge and skills	LLU	18	25	0	25	2
	URFU	11	16	1	17	2
Assessment of one's successes	LLU	18	22	3	25	2
	URFU	9	17	2	19	2
Implementation of effective learning strategies	LLU	9	26	8	34	2
	URFU	5	21	2	23	2
Co-operation	LLU	27	15	1	16	1
	URFU	9	16	3	19	2
Time management to reach better learning outcomes	LLU	7	25	11	36	2
	URFU	10	15	3	18	2
Critical thinking	LLU	14	28	1	29	2
	URFU	12	13	3	16	2
Problem solving	LLU	18	25	0	25	2
	URFU	15	11	2	13	1
Appropriate usage of IT	LLU	13	27	3	30	2
	URFU	16	11	1	12	1
Together	LLU	205	317	37	354	2
	URFU	161	179	24	203	2
Totally		366	496	61	557	2

Coloring: *dominance*; *statistically significant dominance*

Students were also asked to comment the choice of the indicator assessments. Not all the students commented because they were voluntary. They are summarized in Table 2.

What kind of specialist is expected at a modern industrial enterprise? The results of our previous studies at industrial enterprises of the Urals made it possible to single out the "key qualification" for university graduates of various engineering specialties. These are the following qualities. They are the presence of which indicates the good potential opportunities of a young specialist coming to the enterprise: learning ability, ability to self-development, ability and desire to independently find information; good performance; developed thinking; attention; memory; emotional stability; responsibility; leadership; interoperability. A future production manager should possess such qualities as initiative, enterprise, flexibility and rationality of thinking, the ability to be creative in business, the

ability to make decisions and take responsibility. An important managerial quality is leadership, the ability to use human and other resources to obtain a result [12].

Table 2

**First year students' assessment comments of self-directed learning
(LLU $n = 43$; URFU $n = 28$) – November 2019 to January 2020**

Indicator		Assessment grade		
		high	average	low
		1	2	3
Purposefulness to reach better learning outcomes	LLU	I study to learn specific things and do it as much as possible; I am enrolled it means that I have to finish; I am focused on getting good results; I always wish to get the best possible outcome; I am a very ambitious person; I wish to finish the University	I am not sure of my goals; I am sometimes tired	-
	URFU	I wish to change a place of work	Self-realisation; shortcomings of basic knowledge; I am not successful in many cases	-
Responsibility	LLU	In a group work everybody should be responsible for tasks; if I am trusted a task I will do it	It could be better because the tasks are completed according to the principle of extinguishing a fire; I fully keep a word but I do not finish works in time; it has to be developed in a group work to avoid slouching by particular persons; I do everything at the last moment; to many things to cope with	-
	URFU	-	I paid for studies and I want to get a positive result; to justify invested funds; I have no debts	-
Motivation to reach learning outcomes	LLU	I want to get good outcomes and knowledge; I am interested in forest education; I agree that motivation is important; I wish to study free of charge	Motivation was high at the beginning (of semester), then it decreased and when the session is approaching, it is increasing; motivation depends on the course content; sometimes motivation is decreased due to teachers' attitude	-
	URFU	To develop career; self-respect; to become an effective leader	-	-
Interest	LLU	I am very interested in studies; because everything is new	It depends on the course; I assess the curriculum positively	The themes in the first-year are not connected with things I wish to acquire
	URFU	Self-development; I am interested in learning; I am interested in a discipline; better career at work	-	Low interest in subjects and getting new knowledge
Cognition need	LLU	-	I do not feel any need for mathematics; often it is difficult to find information	-
	URFU	To get higher category; to improve work conditions	To get higher qualification	No need at all except interest

Table 2 (continued)

Indicator		Assessment grade		
		high	average	low
		1	2	3
Understanding how to use knowledge and skills	LLU	-	Depends on the course content; teaching should be focused on deeper understanding; I don't know yet how and where to use knowledge and skills and I hope that will know it in the future	-
	URFU	-	-	-
Assessment of one's successes	LLU	I have reached my goals for this moment	I assess and despise them because I know that I need to do better; I am proud of what I've done, but it's always possible to do better	I assess my successes too low very often
	URFU	I got a college diploma; I passed a test	I cannot cope with works often; I forget to do home or control works in time because I finished school 15 years ago	-
Implementation of effective learning strategies	LLU	-	I learn how to implement them; I try to dedicate my free time for learning but not always; I am successful in several courses; it's difficult to join learning and free time activities	-
	URFU	-	-	-
Co-operation	LLU	I am open for co-operation with colleagues and teachers; I try to co-operate with everybody without any exclusion; group works are useful; students and teachers co-operation is very good	I don't really trust people therefore my co-operation is mediocre; I prefer individual work; course members are helpful, but several service persons at the University are impolite and surly	-
	URFU	I found a friend and now we help each other; co-operation is only with teachers to complete tasks; it is possible always to ask for help; I find contacts easily	Minimal co-operation with teachers and students	Help from pedagogues and colleagues according to their opportunities
Time management to reach better learning outcomes	LLU	-	I work to this problem; I rest too much; do not plan time and everything happens in self-flow; many works are postponed still; I usually plan everything, but I'm not all right; all too much	It's difficult to combine the useful with the necessary
	URFU	-	Originates various private problems	Everything happens in self-flow
Critical thinking	LLU	I think I have it; I assess everything but a lot of things do not depend on me	Critical thinking causes panic to me; I am able to assess every situation critically	I never thought critically
	URFU	Helps in work process	-	-
Problem solving	LLU	I try to solve problems wisely	I postpone problem solving sometimes; I always solve problems but not always in time; I avoid it very often; I try to solve problems by communication	-

Table 2 (continued)

Indicator		Assessment grade		
		high	average	low
		1	2	3
Problem solving	URFU	Passed tests; meet problems and solve them; try to solve problems immediately and don't postpone them	There are problems I can ask for help to the group; I can't solve everything	-
Appropriate usage of IT	LLU	I use when necessary both at university and home	I know IT except Excel; more IT in the courses; several teachers are not able to use modern technologies; I use IT if necessary	I lack IT skills
	URFU	-	-	-

R. Schmidt et al. substantiate that Industry 4.0 is based on many technologies and will be based on the newest ones. It means that engineers have to orientate and manage all the process of production and use because services are under crucial integration [13]. It means that engineers need appropriate skills of the newest technologies and co-operation as well. It also means that the future engineers need an ability to learn quickly and be on constant process of life-long learning. Developed self-directed learning skills is a tool to be ready for qualitative work in the new 4.0 Industry conditions.

Conclusions

1. SDL is an effective tool to adapt to future demands of Industry 4.0, because it includes such qualities as purposefulness, responsibility, motivation to reach learning outcomes, interest, cognition need, understanding of knowledge and skills usage, implementation of effective learning strategies, control assessment of learning progress, critical thinking, problem solving, time management, co-operation and appropriate usage of IT. These qualities are crucial in the situations, when people have to adapt and learn quickly, depending on the development of technologies and developmental peculiarities of society.
2. Regular investigations of students' SDL help assess which indicators should be improved and what teaching/learning aids to develop. Average results dominate in relation to implement effective learning strategies, cognition need and time management. It means that preferably an electronic aid on learning strategies for the first year students is necessary. The study results also indicate that more teaching methods promoting views expression are of high importance and should be more expanded in the further education courses for academic staff.
3. Voluntary students' comments reflect a situation that the first year students need a unified multisided introductory programme at the beginning of the first semester. Organisational, administrative, psychological and didactical themes should be included in the programme.

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