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Master Program Students Experiences in Robot Operating System Course

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***Abstract*—After a long period of stagnation in the last decades of 20th Century Russia started investing into development of IT and engineering education. In 2017 Kazan Federal University launched a novel master program in Intelligent Robotics, which was established based on the analysis of curriculums of world leading universities in robotics field and is being taught in English language. The paper presents result of surveys that were conducted among first year students of Robot Operating System (ROS) course, which serves as a basic backbone of the program. We analyzed dynamics of English language comprehension, self-efficiency, and active learning strategies among students within a semester while highlighting their attitude and motivation to study ROS as a part of robotics education. Special language environment was created during the class that allowed students to obtain positive results of material comprehension in English language. Additionally, a significant increase of motivation in studying robotics was observed among the students.**

Keywords*—*engineering education, robotics, master program, Robot Operating System, engineering

I. Introduction

Employers need young and flexible professionals who are able to adapt quickly to a new working environment and make a positive impact in their professional field. Therefore, higher education faces new challenges in preparing specialists with a research mindset, ability to self-development and leadership. On July 28, 2017 the Government of the Russian Federation issued a resolution, which approved the program “Digital Economy of the Russian Federation”. The program defines basic directions, which cover normative regulation, education, personnel, research competencies, IT infrastructure and cybersecurity [1]. Therefore, the emphasis is placed primarily on a person [2], so one of the key priorities of higher engineering education is to provide students with deep knowledge in area of their interest and prepare highly qualified professionals for research activities in academia as well as in industrial companies or government agencies. Robotics is one of the most demanding fields of modern engineering education, which includes wide range of directions such as mathematical modeling, computer science, machine learning, mechanical design, electrical engineering, psychology, and many other disciplines [3],[4],[5]. According to Presidential Decree №623, dated December 16, 2015 robotics is among the foreground areas for Russian science and technology development [6].

The master program in Intelligent Robotics at Kazan Federal University was established in 2017 to educate and prepare skilled roboticists who will be able to take a leading role in the development of science and robotics technologies and systems. During admission process, we have selected 11 students who have a wide variety of backgrounds. Our mission as educators is to inspire students to develop their ability to conduct research activities and practical tasks. During the first year, students defined their research projects that are supposed to be completed by the end of their educational program and presented as their master theses. Currently there are ten different projects carried out by our students in such fields as humanoid robotics (biped robot locomotion; graphical user interface development for a small-size humanoid robot; anthropomorphic gripping manipulators), machine vision (environment 3D modelling based on robot’s stereo-vision), mobile robotics (path planning for a crawler robot, new mobile robot platform R&D), and healthcare robotics (body tissue modelling for robot-assisted surgery).

Before running the master program in Intelligent Robotics at KFU, we started our research on exploring students’ motivation and their vision on profit to take robotic courses and build their career in this field. In [5] we presented our analytical results that were obtained through the surveys among 37 bachelor students who were attending robotics elective courses. To diversify our analysis data, we continued our investigation by surveying bachelor and master students within the context of their robotic courses, such as Introduction to Robotics [7], [8], Sensors and Sensing, Robot Operating System (ROS) and Machine Vision. Through the set of such surveys, we intend to receive useful feedback that would extend our understanding of further development of the robotics education at KFU.

This study presents our survey research results on students’ experiences and motivation to become professional roboticists. We have involved 11 master students and conduct two surveys within the context of the ROS course: after the first class and at the end of the first semester. Collected data gave us an opportunity to compare participants’ expectations before starting the course and their attitude to robotics after the course.

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The rest of the paper is organized as follows. Section II contains a description of our practical oriented approach in developing the educational program. In Section III we briefly outline the ROS course implementation. Section IV describes the research method and presents the comparative results of our survey. In Section V we analyze data of the surveys. Finally, we conclude in Section VI.

II. Practical-oriented educational program

Starting from the 2017/2018 academic year we have launched a novel educational program in robotics for master students. The curriculum consists of a number of general IT courses and a set of specialized core robotics courses, elective courses and a long-term research project, which runs from the beginning of the program and will be presented as a student's master thesis after 4 semesters.

An important factor of robotics education is that theoretical knowledge has to be tested within real experiments involving hardware and programming skills [9], [10]. Such approach gives a valuable experience and prepares students for solving real-world tasks. KFU has provided the robotics program with a valuable set of robotic equipment that is actively used in educational and research projects: Mindstorm EV3 LEGO kits, full-sized humanoid AR-601M [11], small-size humanoids ROBOTIS OP2 and OP3 [12], crawler mobile robot Servosila Engineer [13], wheeled UGVs Unior race [14] and PMB2 [15], DJI Phantom IV UAVs [16] and a broad selection of sensors.

During the program every student conducts a particular research under an academic advisor supervision. We have divided students into three thematic groups: urban search and rescue (USAR) robotics, heterogeneous robotic teams and swarms, and humanoids. Students of these groups carry out their research using a particular set of hardware.

For the past decade the Robot Operating System (ROS) is recognized worldwide as a very successful and convenient open source framework for robotics software development [17]. For this reason, we had selected ROS as a backbone for all developed in the laboratory software and teach it through 3 semesters as a core course. The next section briefly describes the implementation of the ROS course in the first semester.

III. Curriculum of the Robot Operatiing System I course

ROS-I course was taught in the first semester along with Introduction to Robotics [8] and Machine Vision courses.

The course includes the following topics:

- *Introduction to ROS* familiarized students with core concepts such as ROS Master, nodes, services, messages, actions and guides through ROS installation and catkin assembling. Further, students were taught to develop ROS applications with Eclipse and Qt Creator, to launch and debug nodes, to utilize Roslaunch functionality. Additionally, there was an essential overview of topics mechanism including senders/listeners explanation, and message creating for a robot.

- *Gazebo simulator* covered receiving data from sensors of a robot, simulation of Wander-bot type robot, mapping in ROS and map adjustment. Topic on *Rviz simulator* was a brief overview of the simulator and ROS services in simulators.

- *Stack navigation in ROS* explored transformation system in ROS and a localization of a robot. Additionally, *Stack navigation* topic included explanations of robot local and global path planning algorithms, maps of Costmap type, command target (from a code), and creating navigation plans.

- *Robot modelling in ROS* introduced use of URDF и Xacro files, modelling by utilizing SDF files and spawning robot to Gazebo simulator.

- *Robot vision in ROS* discussed integration of OpenCV and ROS functionalities, robot vision in ROS, creating of a driven robot.

The course was based on ROS tutorials and during the course a number of existing models of robots in ROS were used. Additionally, ROS Indigo and ROS Kinetics were used for training. During the course students were given 8 home assignments, which were based on obtained in the class knowledge. Teaching was conducted using C++ programming language, but students were allowed to use Python language while preparing their home assignments.

IV. Research method

The data in this paper present analysis of students' attitude and motivation to study ROS in the first semester of the master program. Master students had two classes per week, which in total compiled 3 hours, and were conducted for 18 weeks. We ran an initial survey after the first class and a final survey in the end of the course before a final test.

In total 11 students were accepted to the master program and participated in ROS course, however, unfortunately, not all participants volunteered to respond each of the surveys. 11 students responded to the initial survey and 10 students responded to the final survey. To consistently observe dynamics of the students' progress we selected responses of 10 students, which participated in both surveys. Additionally, we excluded one more respondent with a BA in Public Policy as we target to evaluate students with only technical background, thus decreasing the respondents number to 9. Among the selected respondents 5 students had BSc degree in Applied Informatics, others had BSc in Physics, Information Security and Gas-Turbine Engineering.

In this paper we utilized the same research method we applied in our earlier papers on robotics education [5,7,8] and designed two questionnaires for the initial and the final surveys. The students received questions and statements that are relevant to such categories as English language comprehension, self-efficiency, active learning strategies and significance of studying robotics. As previously the surveys were provided in Russian language to assure the respondents were able to fully understand the content of each question and statement. The initial survey included 49 questions that basically were designed to observe students' expectations from the course in the beginning of the classes. The final survey included 39 questions and contained almost identical questions that are related to the experience, which was obtained by the end of the course. Providing identical questions in both surveys gave us an opportunity to observe dynamics of English language, and motivation to study robotics. The surveys were conducted on-line via Google forms in the following way: each question appeared on a separate page, a new question became available only after a submission of a previous question's reply, and, moreover, there was no opportunity to return to previously answered questions.

The questions were divided into statements, open-ended questions and multiply choice questions. Each statement was presented on a 5-point scale with optional answers - (1) SD, Strongly Disagree; (2) D, Disagree; (3) NO, No opinion; (4) A, Agree; (5) SA, Strongly Agree – which appear along X-axis in Fig. 2-6. Y-axis of Fig. 2-6 indicate percentage of the respondents that selected the corresponding options.

According to the data of the initial survey all students possessed skills of programming before entering the program. However, the experience of programing languages was diverse and 55,55% of the student possessed programming skills of more than 3 languages. The two dominating languages among students were C# (66,66%) and C++ (44,44%) (Fig.1).

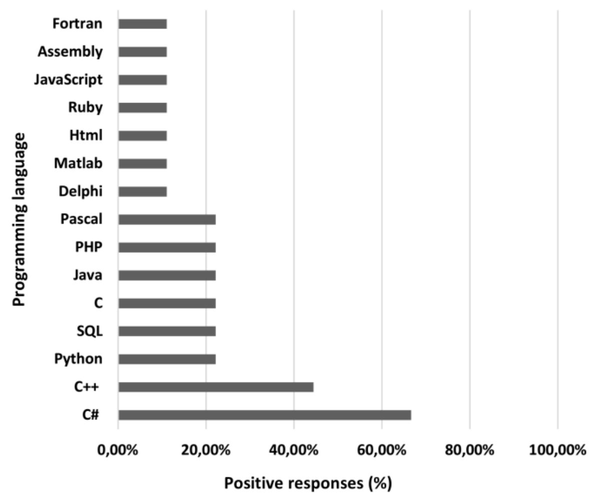

Fig. 1. Programming skills before entering the program.

Almost 78% of the respondents did not have experience working with ROS before the course (Fig.2), while only one student out of 9 possessed skills of ROS programming. The experienced student gained this experience while doing his previous research in our Laboratory of Intelligent Robotic Systems (LIRS) as a volunteer prior to his entrance to the master program. Another student (answer "D") had a limited experience with ROS during her BSc thesis research at LIRS.

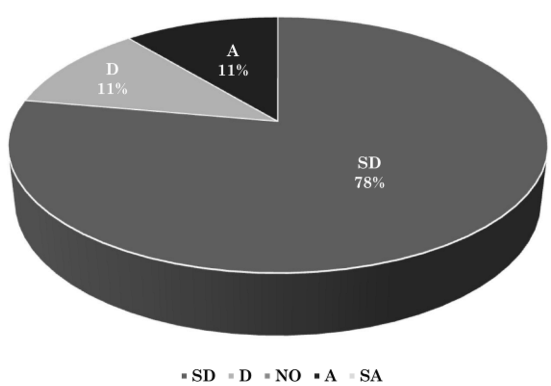

Fig. 2. Experience of working with ROS before the course.

V. Analysis

This section focuses on comparison of the students' expectations in the beginning of ROS course against their experience after they participated in the classes for one semester and before taking the final test. Based on survey data we analyzed English language comprehension, self-efficiency, active learning strategies and motivation to study robotics.

A. English language comprehension

Comparing to the initial survey where 55,55% respondents (A-44,44% and SA-11,11%) thought they would not be worried while speaking English, by the end of the course 88,88% (A-44,44% and SA-44,44%) of the students felt confident when speaking English at the class. To make robotics students feel more confident in material comprehension in the foreign language, expressing their opinion or asking questions, teachers created a special environment where during the class the participants had an opportunity to ask for additional material explanation in Russian if they did not understand the content in English (Fig.3).

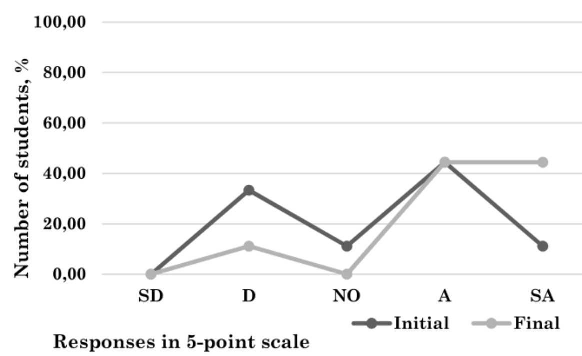

Fig. 3. I do not worry when speaking in English during the class.

To double-check this results, we observed the data of another question where the same number of 88,88% respondents (A-33,33% and SA-55,55%) reported that they had felt confident while speaking in English with Russian native speakers (Fig.4).

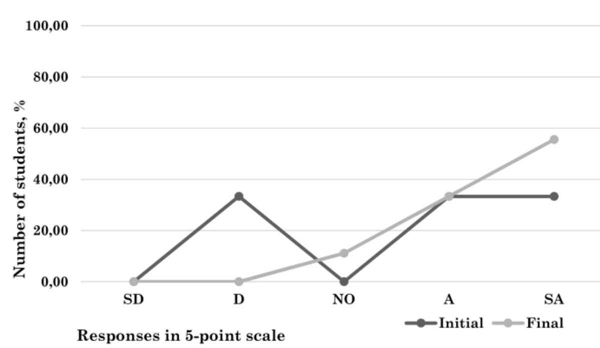

Fig. 4. I do not worry when speaking in English during the class with Russian native speakers.

B. *Knowledge gained before and after the course*

In the initial survey predictably 55,55% of students had no opinion on whether ROS course is difficult comparing to other courses as they just had started to participate in the classes and only 11,11% agreed on the statement that ROS course is the most difficult one (Fig.6). While by the end of the course the number of SA increased by 22,22% and in total 33,33% thought that ROS was a difficult subject. Nonetheless the subject was assumed as a difficult one for 1/3 of the students (as shown in Fig.6), the number of respondents who strongly agreed on the statement that they were sure they would be able to pass a final test in the ROS course increased by the end of the course and reached 44,44% in total.

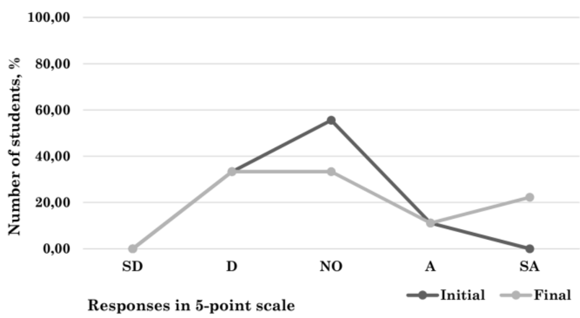

Fig. 6. Comparing to other courses I think that ROS is the most difficult one.

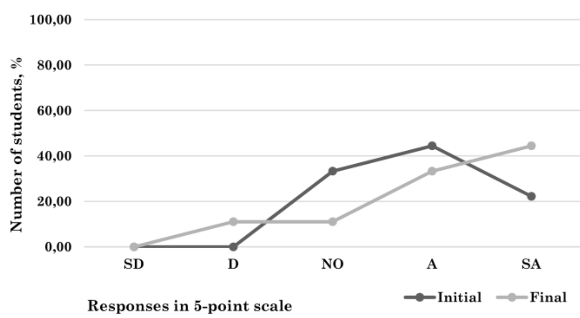

Fig. 7. I am sure I will be able to pass a final test in ROS course.

C. *Self efficiency*

In general, self-efficiency tendency towards the subject was positive (Fig.8) as in both surveys same number of students (100%) thought that they could learn ROS no matter the difficulty level and also SD responses increased by 22,22% by the end of the course.

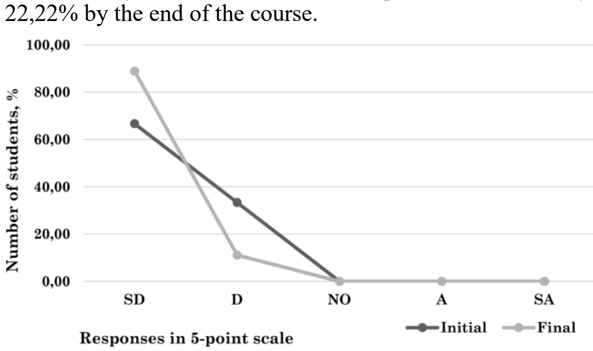

Fig. 8. I think I will not be able to learn ROS no matter efforts I put.

The students were efficient in studying ROS as in the beginning and in the end of all classes still 100% of respondents pursued studying the subject even if the class content was difficult (Fig.9).

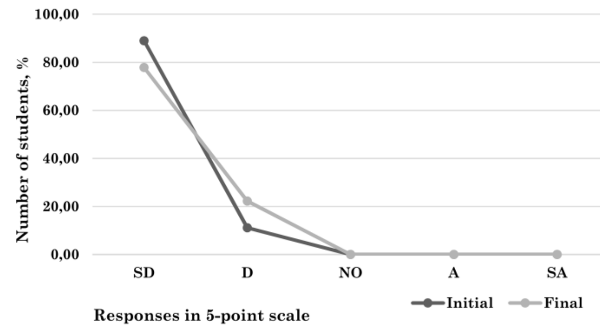

Fig. 9. If the class material is difficult for me I shall prefer not to study it.

D. *Active learning strategies*

Students involved learning strategies in connecting previous background with new material that was provided at the class (Fig.10). Such active engagement of already gained experience could be related to the data indicated in Fig. 1, where all students possessed programming skills before entering the master program and it could allow them more easily to understand ROS.

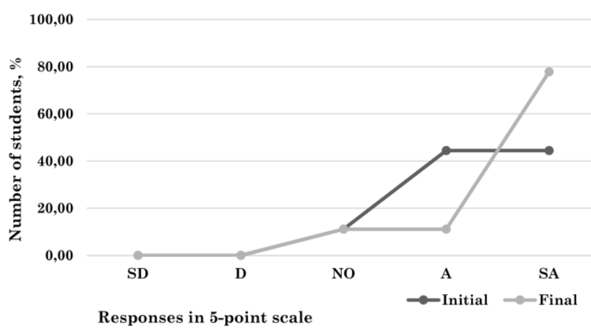

Fig. 10. When I study new material I am trying to connect it with my previous experience.

According to Fig. 11 accumulated knowledge that was gained previously and at other courses was actively used during studying ROS.

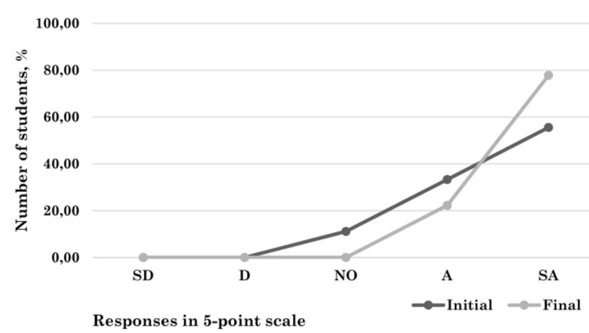

Fig. 11. During ROS classes I am trying to connect new concepts and material I have learned with my background and knowledge I gained at other courses.

E. Motivation to study robotics

In both surveys 100% of respondents thought that studying robotics was important for their future career and by the end of the course the item SA increased to 77,77 % in comparison to the initial survey (Fig. 12)

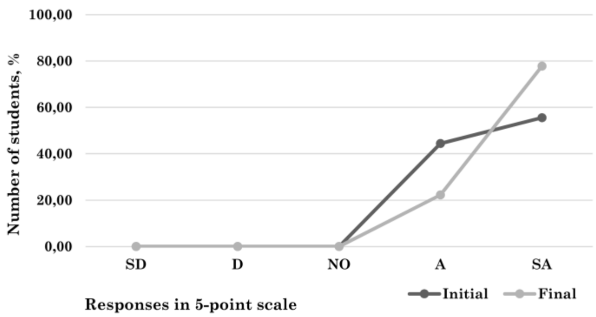

Fig. 12. I think that studying ROS is important for me because I shall use it in my future career.

Significant motivation was observed in the end of the semester when 88,88% (A-11,11%, SA-77,77%) of the students thought that studying of ROS instilled more confidence in them, because the gained knowledge empowered them with a capability to program a robot.

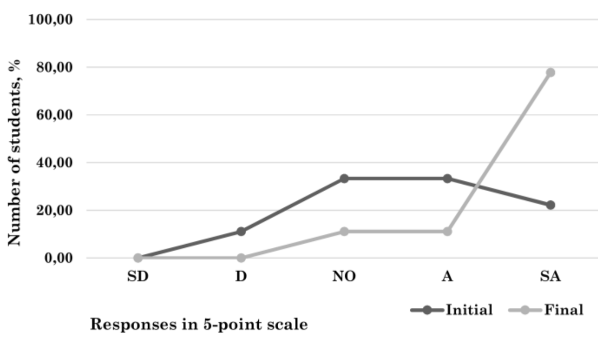

Fig. 13. Studying ROS instills me confidence, because I will be able to program a robot.

Additionally, there was almost no change in considering the course important as 100% of the respondents were eager to participate in the classes voluntary if the course had not been an obligatory course (Fig. 14).

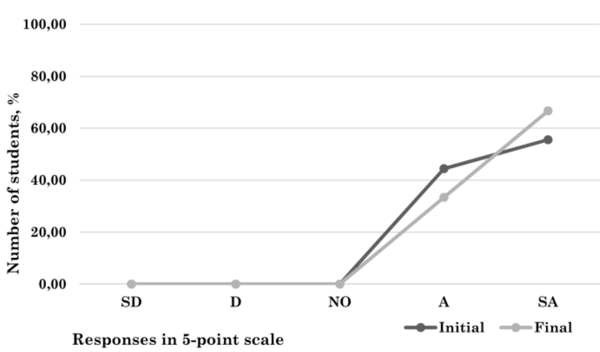

Fig. 14. If it was not an obligatory course, I would participate in it voluntary.

VI. Conclusion and Future Work

In September 2017 we established a novel master program in Intelligent Robotics at Kazan Federal University. In order to improve the program and prepare world competitive specialists, apart from other activities we are conducting regular surveys among students in the beginning and at the end of each course.

In this paper we provided a comparative analysis of the two surveys that were conducted among the students of the master program in Intelligent Robotics in order to evaluate the course on Robot Operating System (ROS). By creating a special language environment during the class which allows students using both English and Russian languages we could obtain positive results of English language comprehension.

Gained before the class knowledge obviously assisted students in acquiring of the new material. However, nonetheless 1/3 of the students thought that the ROS course was the most difficult one, 44,44% of the respondents strongly agreed that they were sure in their capability to pass the final test of the course successfully. The surveys demonstrated an improvement of self-efficiency and active learning strategies by the end of the course. A significant increase of motivation in studying robotics could be related to the fact that it was the practically oriented course in comparison to other, more theory-based, courses.

As a part of our continuous survey work we analyze data obtained from surveys that are conducted in other courses as well. Further we plan to observe students' motivation to study robotics after they start to work with robotic systems and sensors to pursue research for writing a master thesis.

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