

Using Chatbots to Approach Individual Learning Trajectories in Physics for Foreign Students

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Abstract

This paper presents the chatbot as the way of learning individualization and individual work organization for high education applicants. Authors consider the methodology of teaching physics to foreign students in High Maritime Institution with national, psychological, linguistic and cognitive aspects examined. For the analysis to be done data from Kherson State Maritime Academy was used.

Furthermore, functions and areas of usage in everyday life, professional and educational environments are defined in this paper. Likewise, a comparative analysis of platforms and their potential for the implementation of chatbots was held. Based on the Telegram platform, 'Your Physics Trainer' bot was created for implementation into the educational process of future sailors of Kherson State Maritime Academy.

An experimental research was conducted to test the effectiveness of the chatbot application in the learning process delivering evidence of the expediency of its use.

Keywords

Learning technologies, interactive teaching tools for physics, training of sailors, chatbot, teaching methods of physics.

1. Introduction

1.1. Formulation of the problem.

Nowadays the world is noticed to be significantly constrained in all spheres of life by the COVID-19 pandemic. Such strict limitations are sure to be noticed to be accommodated in social and educational spheres. The educational environment is inclined to be switched to distance learning because of a great need for lockdowns. Classes happen to be conducted online and digital technologies are sure to be turning out to become a key player in the modern learning process.

The digital technologies quantity in education is constantly increasing. The most well-known tools used for conducting educational processes are considered to be Zoom, Google Meet, Microsoft Teams, Skype and BigBlueButton. These tools are noticed to be widely used by teachers for video calls, online lessons and are said to be convenient for screen sharing. Such platforms as Google Classroom, Moodle, iSpring, WebTutor, Teachbase turn out to be the most popular tools for placing educational content. Indeed, these issues allow teachers to test and evaluate students' results providing the possibility to publish and store all the educational material in one place.

However, all the platforms mentioned above seem to have been used rather as a way to convey already existing information, content and pedagogical methodologies. Unfortunately, their flaw is vividly seen in inability to create individual feedback communication. As long as services like Moodle, iSpring, etc. keep grading students' activity on the course's page, they are highly likely to be motivated

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to be reading a lecture mostly for the sake of having a grade rather than for absorbing knowledge purposes. Meanwhile, these services have a time limit for interactions in the same vein i.e. a duration of the web-conference or limitation in trying to interact with content.

This paper embraces the questions of the possibility of a chatbot being used as a tool for providing individual support in the educational process for students. The aim of this item is deemed to be to interact with the student 24/7 in a Q&A format covering physics theory as delivering answers to typical questions, to train students' typical problem solving skills and to act by the way of a cheating sheet before tests.

1.2. Analysis of recent research and publications.

A possible use of chatbots in the educational process has always been an issue found to be appealing to many authors during the last decade. Thus, this topic was thoroughly investigated and coped with in works having been taken into consideration before completing this paper.

O. Zahour, E. H. Benlahmar, A. Eddaoui, H. Ouchra and O. Hourrane [1] managed to have examined the question of application of the bot algorithms and techniques of the Natural Language Processing (NLP) for managing a students' educational system and professional orientation for graduate students.

A. Kerly¹, P. Hall and S. Bull [2] happened to have described an opportunity to use the Intelligent Tutoring Systems for creating a dialog chatbot and to include it into the Open Learner Model to support students while learning.

P. A. Tamayo, A. Herrero, J. Martín, C. Navarro and J. M. Tránchez [3] chanced to have implemented a chatbot as a virtual assistant for a distance learning of a subject of introduction to Microeconomics organization.

F. Colace, M. De Santo, M. Lombardi, F. Pascale, A. Pietrosanto, and S. Lemma [4] turned out to have rendered a process of chatbot prototype development to the use of natural language processing techniques being able to be used to support students while completing particular courses.

J. Grossman, Z. Lin, H. Sheng, J. T.-Z. Wei, J. J. Williams and S. Goel [5] have been noticed to have created a MathBot basing Intelligent Tutoring System applying it in mathematics delivering to adults.

L. K. Fryer, D. Coniam, R. Carpenter and D. Lăpuşeanu [6] are said to have represented working and learning with chatbot experience as having a substantive foreign language learning partner.

P. Smutny and P. Schreiberova [7] are supposed to have been involved in inquiring and depicting possibilities of Facebook Messenger to create an educational chatbot coupled with estimation of bots already existing there and carrying out the classification of them by Language, by Subject, by Platform matters with the aim to create a chatbot on it.

I. M. Tsidylo, S. I. Samborskiy, S.-I. V. Mazur¹ and M. P. Zamoroz [8] are noticed to have presented a chatbot design in Telegram Messenger being possible to be applied in learning academic disciplines.

1.3. Goal

The goal of this paper embraces the carrying out of a comparative analysis of a platform being able to be used for chatbot implementation and project purposes delivering experimental evidence of 'Your Physics Trainer' chatbot application being beneficial in the process of teaching foreign students in High Maritime Institutions.

2. Main body

2.1. Chatbot roles

Chatbots are biased to be referred to as widely used programs for sending automatic replies to users on social media and websites. Furthermore, they are known for making the communication process

between clients and business simplified, gaining from Artificial Intelligent and/or Machine Learning usages.

Chatbots are known to succeed in dealing with CRM systems, leads, business requests, and e-commerce in general. Hence, there is an enormous vastness of them starting from the easiest interactive forms and ending with the most advanced ones with Artificial Intelligent being capable of a real-person dialog imitation.

In business and professional routine chatbots might seem possible to be used to accomplish next tasks according to the survey held [9], [10]:

- E-commerce and business support;
- Automate routine work;
- Collecting personal information (emails, numbers, reviews).

Nowadays, chatbots are becoming integral contributors to education for business employees and all levels of education institutions i.e. from primary school to universities. For instance, this issue is highly likely to be sufficient with a target to support students during studying as an e-tutor [4] for Open Learner Modelling [2] and for managing learning systems and vocational guidance [1].

It goes without saying that a widespread range of teaching aspects occurs to be existing allowing educational chatbot to be successfully applied [11], [12]:

- Administrative support to teachers: chatbot takes off all administrative load of teachers, if trained well and answers natively to questions like ‘where, when, how, etc.’;
- Students’ engagement: students’ attention is drawn to being reminded to follow the deadlines or to participate in discussion;
- Teaching: using the Artificial Intelligent bots are noticed to be self-educated providing learners with answers, guides, pieces of advice according to the context imitating a real-person dialogue;
- Audio converters: chatbots might be capable of transforming the text into speech and vice versa;
- Feedback: through the course chatbots are being able to collect students’ feedback as a result of various tests and turn to be likely to correct the mistakes with repetitive solving of typical problems;
- Anonymity: students are to feel free to ask any questions making fear of the personality being exposed disappear;
- Knowledge review: bot does not seem to cope with delivering answers to students as a way of teaching but to handle with problem solving and critical skills enhancement reviewing students’ knowledge;
- Fostering critical thought: bots made on the Artificial Intelligent and Machine Learning basis are expected to act as a real tutor, to look for evidences of student's critical thinking skills in his/her answers and to foster it with mistakes correction and prompts;
- Universal teacher: unlike a human, a bot could be an absolute expert in several fields and play an administrative role likewise.

2.2. Analysis of chatbot constructors

It is worth mentioning that there is a great variety of services possible to be used for chatbot creation. Most issues demand medium or proficient knowledge of programming although not many of them are viable enough being of service.

We would like to have services highly likely to be applied investigated. The best option to start with is chatbot constructors – special services that are used for chatbot creation on a messenger basis without any programming skills applied. They are easy to operate with the user being whole way guided with simple and clear instructions. Moreover, there is the only need to create such attributes as bot name, bot id, bot commands and answers.

The most popular platforms among the users are Facebook, Telegram, Viber, Instagram and WhatsApp. Many chatbots are said to be using these platforms, including educational ones. For example, 47 educational bots have already existed on the Facebook base. They are used for learning languages and economy-related topics [7].

To determine a platform for chatbot development a social survey was managed to be held among the target audience - Kherson State Maritime Academy cadets. The participants of the survey were asked to look through the list of the most popular social networks and messengers and answer two questions: “What social networks/messengers do you use?” and “What messenger do you prefer for studying/working purposes?”. Therefore, according to the survey results, Telegram, Facebook, Viber, Instagram, and WhatsApp appeared to be the most well-liked messengers among cadets. For the representation of cadets` preferences among the most popular messengers, please, check Figure 1.

What messenger do you prefer for studying/working purposes ?

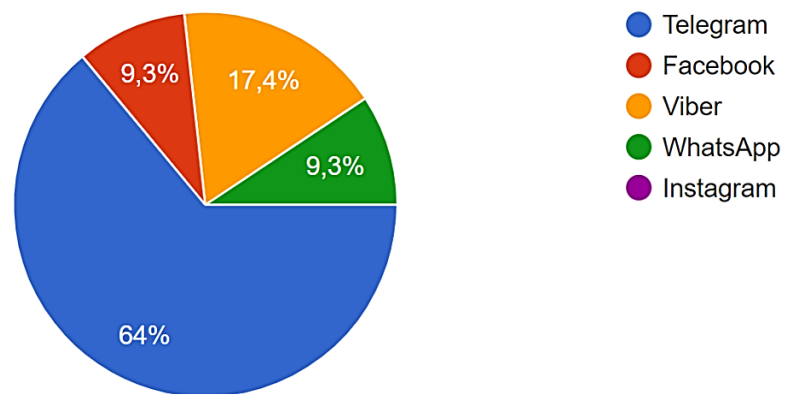


Figure 1: The results of cadets survey

It is worth mentioning that chatbots constructors known to be used for simple bot creation failed to have Artificial Intelligent and/or Machine Learning. On the one hand, such a constructor could be accessed by the user of any level without any specific software or application being installed. On the other hand, the creation of a complex multi-tasking bot or a bot with technologies of Artificial Intelligent/Machine Learning is impossible to be done with these services [8].

Table 1 shows a comparative analysis of the constructors highly likely to be used for creating a chatbot.

As illustrated on Table 1, we have chosen six constructors to be examined: BotMother, BotFather, SendPulse, Flow XO, ManyChat and Chatfuel. As it can be seen on the table, constructors have an opportunity to collaborate with Facebook, Telegram and other platforms. The key features of chosen constructor are noticed to be mobile version availability, option to schedule messages and option of gallery attached to a message.

According to having been compared services possible to support several messengers it is to be noted that a social survey held has proved Telegram to be the leading platform for chatbot (results are given above, please, check Figure 1).

Analysing a comparison on Table 1 it can be vividly seen that BotFather possesses all the features needed to become the tool we have used.

Table 1 Comparison of chatbot constructors

Criteria	BotMother	BotFather	SendPulse	Flow XO	ManyChat	Chatfuel
Free platform	Base plan	+	+	Free trial	Free trial	Base plan
Limit in users	-	-	-	-	-	+
Option of creating predefined answers using photo/video	One file in a message	+	+	+	+	+
Option of sending messages to subscribers	+	+	+	+	+	+
Supported scheduled messages	+	+	-	-	-	-
Collecting users` answers	+	+	-	+	+	+
Mobile version	-	+	-	-	-	-
Supported platforms	Facebook, Telegram, etc.	Telegram	Facebook	Facebook, Telegram, etc.	Facebook	Facebook
Interface language	Russian, English	Russian	English	English	English	English
Option to handle a few bots	In subscription	+	+	+	In subscription	+

2.3. Tutoring chatbots in education and business

Having thoroughly analysed educational chatbots` roles and presence on the market it was concluded that there is a distinct lack in a chatbots` variety. There is a strong presence of linguistic (for language learning) [6], [2], business and economy focused ones [3] rather than equal representation of bots for different needs. Bots that are likely to be used for fundamental natural science educational purposes have been poorly represented.

However, there are few examples of educational bots found that do not seem reasonable to be eliminated in this paper.

Firstly, ‘PhysicsBot’ claims to be an educational tool rather than to be what it is – a calculator with a step-by-step solution shown. It can be successfully applied to the learning process as well as for cheating issues instead of being a usual engineering calculator. Moreover, this application is possible to be downloaded only from Play Market which cuts off almost a half of the target audience.

Secondly, MathBot created at Stanford University [5] seems to be a shining example of technologies used for education. The main challenge being faced was to create a text-based tutor that explains math

concepts and guides students through problem solving. This bot continually checks users' understanding with questions, splits problems into subproblems when an incorrect answer is received and provides personalized feedback. It is possible to be carried out due to bot's specific conversation graph that is a detailed set of if-then rules.

To sum up written above, finding freely available physics chatbots with a required simplicity and possibility to achieve educational goals have turned out to be a challenging and demanding task, but not impossible one. Taking into consideration all these peculiarities, the decision to create an educational physics chatbot was taken.

2.4. Essential aspects of teaching physics to foreign students

Physics is a fundamental course that deals with the preparation of applicants for high maritime education (AHME) to solve professional problems related to ship theory and design, navigation and ship management as well as ship equipment operation. Physics theory profitably contributes to professional competencies of future officers.

Specification of minimum standard of competence for seafarers is able to be easily tracked in International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) [13]. Based on it, model courses were developed by the International Maritime organization (IMO) to train future seafarers with significant professionalism possessed [14].

Physics course in High Maritime Institution is being taught according to the syllabuses compiled with aspects of further professional activities taken into consideration. This course covers chapters that are necessary to acquire in-depth knowledge for qualifications described in Tables A-II, A-III and A-IV of the International Convention on STCW and STCW Code. These Tables regulate the following competences at the operation and management level: knowledge, understanding and proficiency, methods for demonstrating competence, criteria for evaluating competence.

Hence, the physics course's training material has to be standing together with the knowledge of professional disciplines and to be developing professional problem solving. Teaching with such an approach to the course structure is sure to be leading to the formation of direct logical links between disciplines which provides an opportunity to use the educational material unlocking the potential to its full degree while forming professional competencies of future seafarers.

Furthermore, the competency «Ship manoeuvring and handling» is highly likely to be taken as an helpful example to be considered. The achieving of given competency demands the following set of material to be known: the effects of deadweight, draught, trim, speed and under-keel clearance on turning circles and stopping distances; the effects of wind and current on ship handling; squat, shallow-water and similar effects [13]. In addition, this in turn implies an in-depth understanding of certain physical phenomena such as relative motion and relative velocity, Pascal's principle, Archimedes principle, equation of continuity, Bernoulli's equation, rotational motion of solid body, uniform circular motion of particle, forces and their characteristics, magnetic field and its influence on the measuring equipment, course pointers etc.

This very knowledge acquisition seems accomplishable enough while having the course of physics being immediately used to solve applied problems as an example of its widespread usage in a professional environment.

However, taking into account the foreign students contingent's features it was decided to individualize the learning process with 'Your Physics Trainer' bot.

2.5. Contingent

Foreign students from 19 countries are known to be studying at Kherson State Maritime Academy. That is why the educational process for foreigners is carried out in English language. The contingent of foreign Physics learners in 2020-2021 as a percentage is shown on the following Figure 2. As it can be seen, for the majority of foreign students English is not a native language. However, the Physics course, as a fundamental one, demands all students to be familiar with definitions, laws and their applications especially in a professional environment. Hence, a great language barrier between students and teacher

from one side and student and physics from another one similarly appears to be the first peculiarity of foreign students` teaching.

Besides, the miscellaneous level of students` basic knowledge in Physics is the second peculiarity to be mentioned. The students` age range between 20 and 33 years old. Due to this fact future seafarers are supposed to have graduated from school previous year, the year before last and up to 10 years ago. In addition, some of them already have completed a bachelor degree rather than in Economics or Humanities. The teacher is faced with a mission to not only refresh or deliver knowledge and skills of Basic Physics but to complete the Marine Physics course.

Last but not least, difficulties in social and academic adaptation are to be kept in mind. Future seafarers` educational process is organized according to KSMA statute which claims obligatory muster calls (in the morning and after classes), strict schedule of lessons, simulators and watch as a necessity. However, such an agenda might seem to confront with national and religious traditions of foreign students.

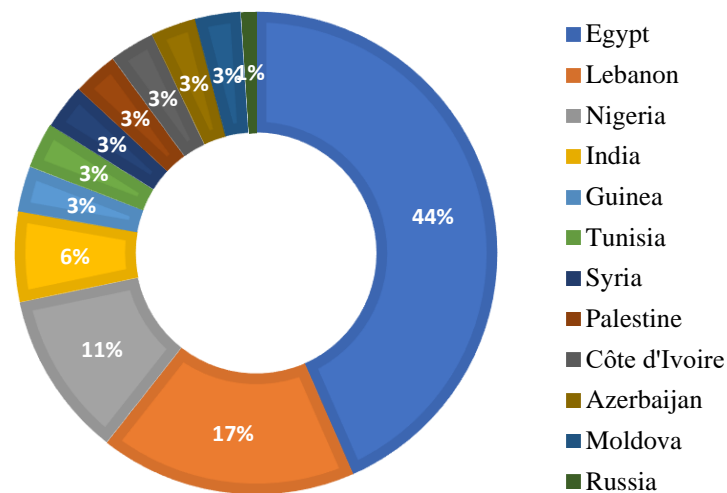


Figure 2: Contingent of foreign students

Summing up, teaching Physics requires an individual approach to work as well as a must-to be-done students` self-study. This problem partly may be solved with `Your Physics Trainer` chatbot.

2.6. Chatbot usage sample

Chatbot `Your Physics Trainer` is created on the Telegram basic using a special constructor (please, check Figure 3 and Table 1) without any AI and ML technologies applied. It`s frontend is a Telegram chat window between bot and a student.

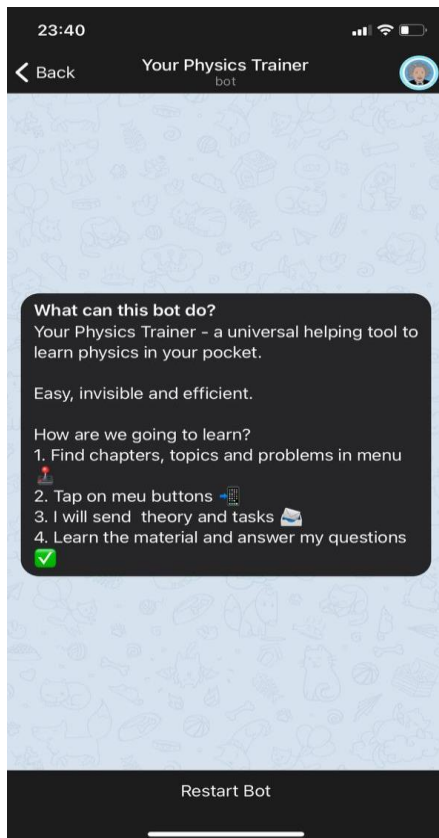
At the beginning the bot shows a starting message to students explaining the way it works and giving short instructions (see Figure 3a). When pushed a button, bot is queried for the material, navigating through its content. All bot`s answers are uploaded beforehand by admins and organised in its structure as a tree.

Students are proposed to navigate through chapters being provided with mini lessons (consisting of images, text, GIFs and videos) as well as being asked to solve problems and to type in answers. A `Go Back` button solves a problem of switching between parent and child nodes making bot interface and structure look user-friendly. Students can scroll through conversation history to review some essential concepts or other material. To encourage students' learning, bot presents answers in a friendly tone. Different emojis are used to emphasize chapters (📁 and 📖), topics (📌), problems and tests (❓ and 📝).

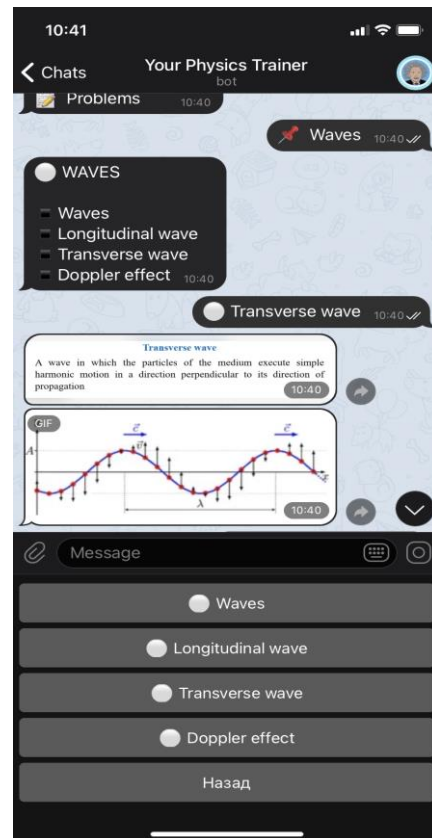
Moreover, a detailed statistic is given to the bot`s administrators. They can see who (username) and when (date and time) uploaded or chose an answer (files, text, tests). When necessary, the bot can send messages either immediately or scheduled.

So, 'Your Physics Trainer' is examined in greater detail using the 'Oscillations and waves' chapter as an example. The educational material consists of two topics – oscillatory motion and waves - and covers the following aspects: periodic motion, simple harmonic motion, mass on a spring, simple gravity pendulum, period of oscillation, compound pendulum, and waves, longitudinal wave, transverse wave and doppler effect respectfully.

To obtain such competencies as 'Monitor the loading, stowage, securing, care during the voyage and the unloading of cargoes' students are required to possess a deep knowledge of these materials. It includes rolling of ships, approximate GM (metacentric height) by means of rolling test and inclining test. The obtaining of 'Manoeuvre and handling a ship in all conditions' competency requires knowing of rolling and pitching of the ship, importance of navigating at reduced speed to avoid damage caused by its own ship's bow wave and stern wave.



(a) Start screen



(b) Conversation with bot

Figure 3: Example of start screen and sample conversation with 'Your Physics Trainer' bot

So, in order to save time at the lesson students are sent a message asking them to pre-learn or review information and characteristics of oscillatory motion and waves before the lesson (in a day or two). Such preparation for the lesson tends to be used for redirection of saved time to more complicated topics. For instance, let us consider waves adding and their interference. The attention is to be drawn that its influence on the moving ship succeeds in being taught on the examples of wave making resistance of ships, the basic wave pattern generated by a moving surface vessel and the interference between the transverse bow and stern wave systems.

3. Experiment organisation and results

Two groups of students of 30 in each have participated in the study. The study process of the first group (control) was held according to usual methodology i.e. all classes were scheduled and students had access to the Physics course resources on Moodle (Learning Management System). The second

group of participants (experimental) has been studied using the same methodology, except they were asked to interact with ‘Your Physics Trainer’ bot. Both groups of students were assigned to be proceeding the ‘Oscillations and waves’ topic.

The control group of students is said to have been explained the material only during classes. When necessary, the teacher clarifies basic terms or concepts, if students are unable to remember them. All students have access to the educational content of the Physics course on Moodle platform by Iryna Bohomolova. The second group learning trajectory was built with the great role of the ‘Your Physics Trainer’ bot as an educational source.

The chatbot contains basic content about oscillations and waves, to be directly short theory paragraphs, definitions, examples of solving elementary problems data. The teacher beforehand sends a message to students (in bot) notifying them to learn or refresh a particular topic. In the class the basic material explanation tended to be skipped and only a control quiz (from 5 to 10 minutes) appeared to be done. Thereafter, students learn the material described in the syllabus using examples related to their future professional activity. In addition, the bot can send a reminder with a home task. Participant’s answer is allowed to be uploaded to chatbot and feedback is available to be received before the next lesson.

After the study participants of both groups were supposed to deal with the final test. The results proved that knowledge quality in the experimental group was higher than in the control one which is illustrated on the Figure 4.

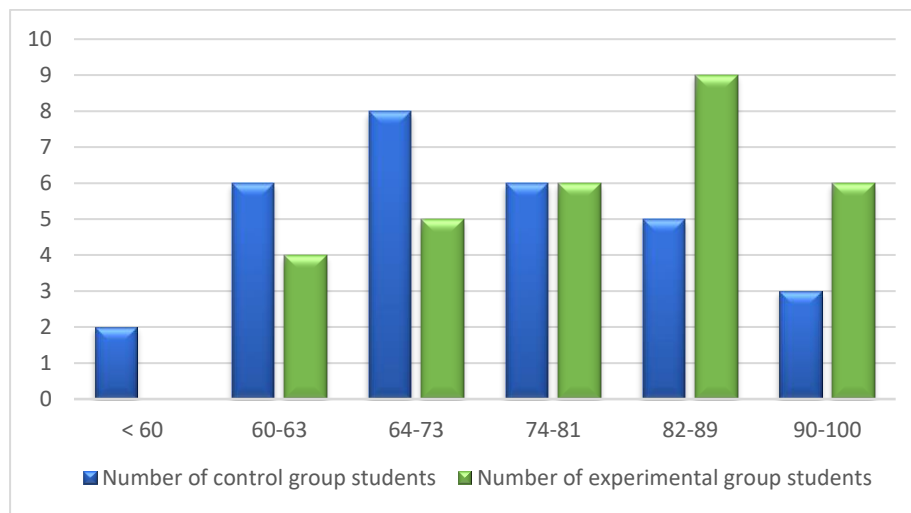


Figure 4: Representation of knowledge quality after the Study

After the study students were faced the task to compare an educational process with and without the chatbot. The survey indicated that a significant fraction of participants considered chatbot and its notifications before the class to be useful and motivating one. Besides, students revealed that quick feedback from the tutor gives a helping hand in overcoming stress as they come to the lesson halfway familiar with the material. Overall, chatbot usage experience is to be definitely going on. For the results of the survey, please, check Figure 5.

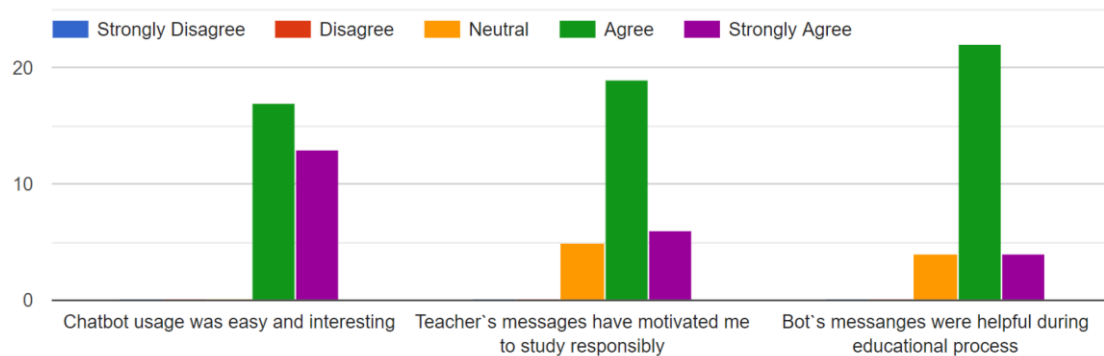


Figure 5: Cadets review of their work experience with chatbot

4. Conclusions and directions for further research

While completing this paper, a comparative analysis of platforms and services available to be used for chatbot development was managed to be held, delivering clear evidence that BotFather is considered to be the most appropriate and requirements-meeting tool becoming a base of 'Your Physics Trainer' bot. A key conclusion of our study to come up is that 'Your Physics Trainer' bot is sure to be contributing to noticeable improvements in knowledge quality as illustrated on Figure 4.

The chatbot is reasonable to be used as an essential component of the educational process for self and distance studying. Therefore, a high-quality communication between the teacher and the students seems available to be effectively organized by this chatbot to reduce fear of making mistakes and, hence, to increase the motivation and self-esteem of the student. Besides, not only can foreign cadets benefit using the created bot but any non-native English speaking cadets are able to use it for memorising the basic Physics definitions, laws and theory in English being favourable enough as it is the language of cadets' further professional environment.

Thus, the creation of this chatbot is certainly to be evaluated as a reasonable one. Further study is required to create a chatbot with AI technologies used.

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