The effectiveness of GitHub cloud services for implementing a programming training project: students’ point of view

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Abstract. In today's IT industry, it is important to develop the ability of IT students to collaboratively develop software, professional and personal skills. An effective method for developing such skills in future IT specialists is to organize different types of educational projects related to different programming technologies during the execution of mini projects, group and individual project assignments, term papers, academic training within the academic disciplines. The paper summarizes the results of a pedagogical study involving 29 expert students who study Computer Science and Software Engineering and used cloud service for GitHub collaborative IT development projects. The research findings testify, the most effective characteristics of this service, according to experts, identified the possibility of collaborative development of software (i1), the convenience of bug tracking (i3) and the convenience of the code editor (i7). It offers examples and results of using GitHub cloud service in the process of executing educational projects by future IT specialists.

1. Introduction
The World Economic Forum in 2019 revealed that it is important to pay attention to the ways and forms of organizing the educational process, among which are the study of information technology with an emphasis on teamwork. With the development of information technology (IT), the approach to the organization of collaborative development of software products is changing. Hence, it is necessary to take into account the fact that future IT specialists should be able to adapt instantly to new situations, make appropriate decisions and quickly solve their tasks not only personally, but also while working as a team. In order for students of IT profession to continue to hold leading positions in IT industry in their professional activity, to meet the requirements of customers and employers, it is necessary to develop in them the ability to design and manage projects, to work in a team, to develop skills to use cloud services for project management and team development of software products in the process of their academic training at the university.

2. Theoretical background
Cloud software for team development of software products allows users to collaborate on code, manage their versions, and more. Cloud services such as GitHub, Bitbucket, GitLab, Phabricator, Beanstalk, which were researched and described in the paper [13] become part of the cloud-oriented scientific and educational environment of the university if used on a regular basis [5]. GitHub is the most popular code management platform for software development, as it enables future IT professionals to manage and collaborate on their software development training projects.
GitHub is an online Git service that hosts Git repositories and provides other features such as issue tracking. GitHub has become the prominent platform for hosting open source projects [15]. GitHub has been embraced by the software development community as an important social platform for managing software projects and to support collaborative development [4]. The most important benefit of using GitHub is not to support the short-term priorities of a semester-long course, but, rather, to encourage sustainable and well-documented digital development, both of student projects and the course itself [2].

When using GitHub in education, one has to think about the purpose, what the goal is and then how the features in GitHub can be used to reach this goal. GitHub can be used in many different ways, but it might not be applicable in all types of courses because a certain amount of knowledge about Git is required to be able to use the features [7]. Git and GitHub into data science workflows is considered best practice, and provides thoughtful advice on how to conceptualize the GitHub workflow [5]. Other work describes a GitHub Education study that shows that using GitHub in the classroom can lead to a much improved understanding of students’ project management [9].

The most important skills employers seek in engineering are creativity, teamwork and critical thinking. The paper [12] presents the results of a collaborative learning experiment using GitHub in lab work, where the focus was on students’ direct interaction with each other’s learning process. Depending on how GitHub is implemented in learning programming, students may rely on GitHub for activities such as, submitting assignments, collaborating on group projects, and receiving feedback [10]. An immediate advantage is for classes that have group projects. With GitHub Classroom, instructors can easily assign groups of students to teams and give each team their own GitHub repository within a GitHub Classroom. Students can then use Git and GitHub to collaborate on a project, just as they would in an academic or industry research project. Because teachers can see each student’s commit history, it is easy to see how each student contributed to the project [5]. A collaborative tutorial assignment on the GitHub platform was embedded in an undergraduate cybersecurity course. Students were asked to create a tutorial that would be combined with their peers’ tutorials to create a course eBook. The tutorial topics were required to be in the general domain of network security. With regards to tutorial difficulty, students were told to target an audience that had completed an introductory computer networking course [14].

Instead, this study was aimed at answering the following research questions: a) how to use the cloud service to collectively develop GitHub for programming training projects; b) which function-based assessment indicators affect the effectiveness of the cloud service for collective GitHub development. The motivation for this study was to demonstrate the effectiveness of using the GitHub cloud service for student programming projects.

The problem of the research stems from the need to find effective information and communication technologies for the organization and implementation of various types of collaborative projects by future IT specialists. Therefore, this study was conducted to determine the characteristics of the GitHub cloud service, which affect the effectiveness of the execution of educational projects on programming in the process of training IT students.

### 3. Methodology of research

#### 3.1. General background

In order to determine how effectively GitHub’s cloud service enables students to carry out programmatic learning projects, such as interacting with team members, collectively working on code, sharing ideas, and reviewing each other’s work during research, students’ thoughts and impressions about using this cloud service were gathered. A descriptive study utilizing survey methodology was used as appropriate to achieve the objectives of the study. This allowed the researchers to gain a more detailed view of the students regarding the use of the GitHub cloud service in the execution of educational programming projects using pedagogical observation and peer review methods. The study was conducted among the 3rd year students of the Faculty of Information Technologies of the National University of Life and Environmental Sciences of Ukraine (NUBiP of Ukraine) during the second academic term of 2019.
3.2. Sample selection
There were 6 academic groups of students specializing in Computer Science and Software Engineering of the third year of studies at the Department of Information Technologies of NBUiP of Ukraine, but only two of them carried out educational projects in programming using the GitHub cloud service. Thus, only one group of 29 students was elected, which was a participant in the pedagogical study, based on a representative sample, as it was one group, which developed the skills to work with the GitHub cloud service. The participants in the study were confident that the results of their participation in the programming training projects using the cloud service, and their peer review by GitHub, would not affect their final results in the academic disciplines for the current term.

3.3. Instrument and procedures
In the experimental study, students performed two mini-projects in academic disciplines and one group project during technological practical training. The first part of the study was to carry out the students’ programming project using the resources of the e-learning course (ELC) of the academic discipline combined with the cloud service for the collective development of GitHub. Twenty-nine students of IT specialities performed a collective mini-project in the process of studying one informative module in the discipline “Object Oriented programming”. The study of this academic discipline was preceded by the study of “Database Organization” discipline; “Development of a program system for working with IT company management computer systems databases” was selected as the project theme. After completion of the technological practical training, an expert evaluation of the GitHub cloud service was conducted by the students in the second phase. To understand the attitude of students to the service for collaborative development, the following indicators of their evaluation from the point of view of functionality were determined: (i1) possibility of collaborative development of software; (i2) ability to manage code versions; (i3) convenience of bug tracking; (i4) ability to organize and plan teamwork; (i5) communication capability; (i6) the ability to support platforms; (i7) the convenience of the code editor; (i8) security and privacy; (i9) availability of wiki pages. In order to evaluate the GitHub collaborative development cloud service by specific indicators, a survey was developed, which consisted of 9 questions, in which the experts evaluated the importance of the indicators by assigning a ranking number.

3.4. Data analysis
The experts evaluated the significance of the developed indicators by assigning them a ranking number. The highest rated factor was assigned a rank of 1. The level of agreement of experts’ opinions was determined by the coefficient of concordance. The concordance coefficient was applied to assess the degree of consistency among experts, which was calculated by the formula: 
\[ W = \frac{12S}{m^2(n^3-n)} \]
where 
\[ S = \left( \frac{\sum x_{ij} - \frac{\sum x_{ij}}{n}}{n} \right)^2, \]
\( n \) – number of criteria evaluated, \( m \) – number of experts who evaluated the service. To calculate it, the sum of the assigned ranks and deviation squares of the rank sums from the average sum for each indicator were determined. The statistical significance of the coefficient of concordance was checked against the Pearson correlation criterion 
\[ \chi^2 = m(n-1)W. \]
Based on the sums obtained, the sum of the converted ranks was determined and the weight of each indicator was calculated to the formula, where 
\[ s_{ij} = x_{max} - x_{ij}. \]

4. Findings
One of the important types of projects in the process of IT specialists training is the projects on the collaborative development of software products, and therefore it is important to prepare students for the implementation of such projects since college times, to develop in them the necessary professional and personal skills, in particular the skills of shared software developments. When choosing cloud services for collaborative development of software products, the following issues should be taken into account:
interoperability on the code, bug tracking, discussion of the code with other team members, management of versions of code and integration of additional services, availability of a repository, wiki and code editor, etc. There arises a need to integrate additional services so that the cloud services of software products collaborative development could enable us to manage projects. While implementing software development projects, the students cannot be restricted by cloud services only while organizing the teamwork; the future IT specialists also need the services, which will allow them to work together on the product code they plan to develop.

Given the rate of change in the field of IT, the number of cloud services for teamwork is constantly increasing, but assessing the functionality of such services, they can be subdivided into two categories: cloud services for project management (1) and team development of the software product (2).

Recently, educators also started using GitHub as a teaching tool for programming courses by hosting code samples and managing student tasks, and organizing teamwork [1]. The ability to use version control is a valuable skill for computer science graduates to possess. Git is a well-established, well-received source version control system for the software development community and beyond ([3], [8], [11]).

4.1 Educational projects with programming

In order to complete the programming projects, students were asked to combine ETC resources in different academic disciplines with the GitHub service. Teachers of relevant disciplines and technological practical training placed tasks of collective projects in the ELC. The ETC, posted by the teacher, contained the theoretical material (Book, Lesson resources) and course terminology (Glossary resource), lab sessions assignments (Assignment resource), and the exchange of useful resources and files (Database resource). At GitHub, student teams create their own projects, in which they can further collaborate on code writing, use the repository, perform branches, issue releases, and communicate with each other while completing study project tasks. The scheme of combining Moodle resources with the GitHub cloud service is presented in figure 1.

![Figure 1. The scheme of combining Moodle resources with the GitHub cloud service.](image)

For project or lab assignments, student groups can work on a public repository sharing code and ideas. It also allows cross-team communication with multiple teams working on a larger project as it happens in industry settings or teams exchanging ideas and reviewing each other’s works. GitHub’s cloud service provides users with a user-friendly web interface to the repository, user profile tools, change tracking, messaging, comments and online access, allowing the instructor and students to track the contributions of each team member so that students can be held accountable for their work. Thus, we can single out the following features of the GitHub cloud service (figure 2), which are important in the course of the implementation of educational projects on programming:

- programming: code editor; code versions management; bug tracking; platform support; availability of wiki pages;
• collaborative development: joint software development; teamwork planning and organization; establishing communication; security and privacy.

Figure 2. Classification of GitHub cloud service features.

Precisely these features, inherent in GitHub tools, make it possible to apply different types of educational projects related to different programming technologies. This cloud service was offered to students for completing mini projects, for group and individual project assignments, term papers within academic disciplines.

While studying “Object Oriented Programming” and “Database Organization” academic disciplines students were asked to complete a mini projects using a cloud service to collaboratively develop GitHub software. The purpose of such projects was to develop professional competencies and personal effectiveness skills in future IT specialists. Students worked in teams of 4-5 people. In each team a leader was identified, he distributed the tasks among the participants of the collective project. The task of “Database Organization” organization mini projects was to design a relational model of databases for the future automated system (according to the topic chosen by students); constructing class diagrams and developing a system using a class composition.

Within the framework of mastering the “Object Oriented Programming” academic discipline, the students were offered to implement an educational project entitled “Development of a program system for working with IT company management computer systems databases”, the objective of which was to review and analyze modern design technologies; to develop and use software standards for common computer-driven control systems; to develop software structures for the computerized management system and UML diagrams of design entities; to develop a graphical interface for computer control system software; programming and debugging using object-oriented programming techniques; testing and analysis of the performance of the developed computer management software; reporting on the performance of computer-based management systems; development of a set of standard documents to support the developed computer management software.

Within the framework of the project and technological practical training, students performed a collaborative project using the GitHub cloud service aimed at the development of their professional and personal competencies, namely: improvement of practical skills in software development and design using modern approaches and tools for flexible software development, development of teamwork skills in students, which are in demand on the modern IT labor market. The task of the team project was to develop software with web interface and relational database using HTML, CSS, JavaScript, MySQL, PHP technologies. Work on the educational project was carried out in line with the principles of Agile flexible development and Scrum methodology, which provides an incremental and iterative approach and specific roles of the participants in the development of the collaborative project. In the course of collaborative IT development using GitHub, future IT specialists kept the educational project code and necessary documentation in the public domain. In addition, a version control system was used to provide integrity and multi-user access.
4.2 Experimental results

In order to determine the effectiveness of the cloud service for GitHub collaborative development, 29 students were surveyed on the above-mentioned evaluation indicators after the implementation of the programming educational projects. A questionnaire was developed to ask students to assess the importance of each of the indicators:
   - i1. Possibility of collaborative development of software;
   - i2. Ability to manage code versions;
   - i3. Convenience of bug tracking;
   - i4. Ability to organize and plan teamwork;
   - i5. Communication capability;
   - i6. Ability to support platforms;
   - i7. Convenience of the code editor;
   - i8. Security and privacy;
   - i9. Availability of wiki pages.

Table 1 provides an assessment of the results of determining the effectiveness of cloud service for GitHub team development in the course of executing educational projects on programming by future IT specialists. The highest-rated indicator was assigned a rank of 1.

| Indicator | Rank sum | S       | Concordance coefficient | Pearson criterion | Sum of converted ranks | Indicator weight |
|-----------|----------|---------|-------------------------|-------------------|------------------------|------------------|
| i1        | 35       | 12100   | 0.85                    | 197.2             | 15.5                   | 0.22             |
| i2        | 121      | 576     |                         |                   |                        | 0.13             |
| i3        | 62       | 6889    |                         |                   |                        | 0.19             |
| i4        | 147      | 4       |                         |                   |                        | 0.11             |
| i5        | 173      | 784     |                         |                   |                        | 0.08             |
| i6        | 248      | 10609   |                         |                   |                        | 0.01             |
| i7        | 96       | 2401    |                         |                   |                        | 0.16             |
| i8        | 227      | 6724    |                         |                   |                        | 0.03             |
| i9        | 196      | 2601    |                         |                   |                        | 0.06             |
| Σ         | 1305     | 42688   |                         |                   |                        | 1                |

The concordance coefficient \( W = \frac{12 \times 42688}{29^2(9^3-9)} = 0.85 \), indicates a high degree of convergence among experts. Pearson correlation criterion was calculated to assess the significance of the concordance coefficient \( \chi^2 = m(n - 1)W \). As the calculated one \( \chi^2 (197.2) \) is higher than the table value \( 15.5 \) for the number of degrees of freedom \( K=n-1=9-1=8 \) and at a given level of importance \( \alpha=0.05 \), we may conclude, that the obtained coefficient of concordance of 0.85 is not accidental, and therefore the results obtained are statistically significant.

Based on the obtained rank sum the weights of the indicators considered were calculated. The survey matrix was transformed into a matrix of transformed ranks according to the formula, where \( s_{ij} = x_{\text{max}} - x_{ij} \), in which \( x_{\text{max}} = 9 \) and the weight of each indicator was calculated.

The analysis of the significance of the factors studied revealed that the following indicators were noted by the students as being the most significant ones: the possibility of collaborative development of software, the convenience of bug tracking, the convenience of the code editor, and the ability to manage code versions when completing educational projects on programming.
5. Conclusions
The educational projects on programming are an effective method for shaping the professional and personal competencies of future IT specialists. To work on educational projects, you should use modern cloud services for collaborative IT development, such as GitHub. The most effective features of this service are the possibility of collaborative development of software (i1), the convenience of bug tracking (i3), and the convenience of the code editor (i7), which are determined by the statistical processing of student peer review. Other features of this service that have also been explored include the ability to manage code versions (i2), the ability to organize and plan teamwork (i4), the ability to communicate (i5), the ability to support platforms (i6), security and privacy (i8), availability of wiki pages (i9).

The GitHub cloud service can be applied to complete mini projects, group or individual work, term papers, or during the academic training of the students. The examples of using GitHub discussed in the paper show that the specific features of this service completely satisfy the needs of students of IT profession in the implementation of the tasks of educational projects on programming. Further research may be related to the specificities of group projects using GitHub cloud service and their impact on the future professional and personal skills of future IT specialists.

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