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Using infographics to teach object-oriented programming to future computer science teachers

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Abstract

This study presents the results of a pedagogical experiment in teaching object-oriented programming to students of a pedagogical university. The pedagogical experiment was conducted at the Faculty of Physics and Mathematics of the Abai Kazakh National Pedagogical University and at the Kazakh National Women's Teacher Training University. The aim of this study was to test the proposed hypothesis on the use of infographics when teaching object-oriented programming. In the process of conducting the pedagogical experiment, the students involved in the study were divided into 2 subgroups: a control group and an experimental group. The control group used traditional teaching methods and tools, while the experimental group used visualisation tools, in particular infographics. In order to assess the learning outcomes, tests were conducted in both the control and experimental groups. The authors of the study used statistical methods to confirm or refute the proposed hypothesis of the study, i.e., at the end of the pedagogical experiment, a valid conclusion about the difference and coincidence between the data obtained was drawn. The main purpose of the experiment was to test the scientific hypothesis of the study in practice and to evaluate the methodology applied.

KEYWORDS: Object-oriented Programming, Infographics, Computer Science Teacher, Higher Education.

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1. Introduction

In the modern phase, one of the strategies for learning is the visualisation of learning information. Visualisation of learning information is of great importance in education, and the use of infographics enabling the presentation of information in a clear and understandable form is seen as an important instrument in the teaching of object-oriented programming. The use of infographics to teach basic concepts of object-oriented programming when training computer science teachers has therefore become an important research issue. The purpose of this study is to use infographics in teaching object-oriented programming to future computer science teachers.

Various types of visualisations have always been and are used in the learning process, and their role in this process is significant (Pakhomova et al., 2023; Msosa et al., 2022). This is particularly the case when the use of visual aids is not limited to mere illustration in order to make the training course more accessible and easier to learn, but becomes an organic part of the students' cognitive activity, a means of forming and developing not only visual imagery, but also abstract-logical thinking. The modern educational process uses such tools for visualising learning information as timelines, mind maps, scribing; infographics are particularly popular nowadays. Infographics are defined as visualisations of data or ideas that can be used to convey complex information to an audience in a way that can be quickly used and easily understood (Smiciklas, 2012). Brain research related to the physiology of vision and the ways in which the information is processed through the eyes provides a compelling rationale for considering the issue of using infographics in the learning process (Smiciklas, 2012).

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Analysis of works in the field of teaching object-oriented programming has demonstrated that learning the object-oriented approach should be started by mastering fundamental concepts such as object, class, succession, etc. (Windish, 2021)

The main purpose of the research is to define the features of educational infographics and their position in the training system for future teachers of computer science in the framework of object-oriented programming.

2. Literature review

Visual learning proves to be a great aid in helping students gain a clearer understanding of the principles of programming. According to the authors of the study, the use of infographics in teaching object-oriented programming allows to see the essence of the studied material, simplifies the perception of such concepts as encapsulation, polymorphism, succession, classes, etc., making them more visual and interesting for students. Infographics have a rich history and ancient origins. M. Friendly (2008) sets the starting point for the history of infographics almost in antiquity. He calls tables, anatomical and geographical maps, the simplest diagrams and charts of the movement of celestial bodies the forerunners of infodesign (Alrwele, 2017). As it has developed, infographics have become extremely popular in print and online mass media, advertising, marketing and public relations (PR), industrial design, as well as in education.

Infographics can be used effectively:

- improve students' performance in learning course content, to enhance intellectual, life skills and emotional development of students (Ozdamli & Ozdal, 2018);
- to use time effectively, to specify course content in order to make the class interesting and to activate students (Ibrahem & Alamro, 2021);
- to improve students' skills and motivation, to easily and efficiently process and present significant amounts of information (Heimbürger et al., 2020);
- to develop skills such as graphic design, filtering information, synthesizing, identifying basic concepts and the connections between them.

Similarly, infographics can serve as a useful tool for "authenticity"; in authentic assessment, teaching approaches usually reflect real life, i.e., the needs of students after graduation (Tarkhova et al., 2020). According to some scholars, the systematic use of infographics contributes to the development of personal media competence, which allows a specialist in any subject area to effectively address the challenges he or she faces. The use of complex structured infographics improves comprehension and learning of complex teaching material by an average of 20-25% (Kelidou & Siountri, 2020).

The use of infographics when studying a specific discipline can be used as an effective means of visual communication to enhance the quality of learning (Fadzil, 2018). Infographics improve the understanding of conceptual knowledge by providing an interesting way of explaining scientific concepts (Alqudah et al., 2020), helping to support students' perception of the information provided (Golubnycha, 2022). One of the characteristics of infographics is the presentation of complex and haphazard information by creating a story out of its components (Elaldı & Çifçi, 2021). Infographics can be used as training material when teaching complex topics. Instead of conventional presentations created with MS PowerPoint program, it is possible to use infographics, which are much more effective than presentations (Ozdamlı et al., 2016). Infographics can be used to present basic information about a subject, introduce new information or confirm information already known. Infographics are more instructive than textual material (Afify, 2018).

In the modern educational process, the following types of infographics are used: presentation infographics, mnemonic chart infographics, specialised infographics, directive infographics, cartographic infographics, static infographics, animated infographics, interactive infographics (Kelidou & Siountri, 2020). Static infographics enable students to focus on the subject matter being studied (Isamaeel & Al Mulhim, 2021), making it easy for students to grasp new concepts (Jaleniauskiene & Kasperiuniene, 2022). Meanwhile, a comparison of animated and static infographics revealed no significant differences (Alford, 2019).

While noting the great didactic potential of using infographics in the learning process, one also should not forget the possible difficulties accompanying this process, namely: poor elaboration of the key idea of the infographic object; the desire to focus attention in the infographic object on insignificant information not reflecting the main essence of the object or process being modelled; violation of the established requirements for designing an infographic object (Yildirim & Ozdener, 2021), lack of knowledge about this method of visualisation; the need for time to study and design infographics (Alford, 2019).

Using infographics in the learning process has revealed that students prefer to learn through visual material instead of books or other traditional materials (Alford, 2019). Teachers should be able to present information using infographics. In other words, teachers need to be able not only to decode infographics, but also to encode information by means of infographics. For instance, it is possible to provide students with individual concepts and then ask them to create an organised body of information depicted with the help of infographics. As a result of such work, students will have to synthesise their prior knowledge with the content, make adjustments to their mental schemata and create new associations between given concepts (Yildirim & Ozdener, 2021). All this points to the necessity of training teachers to use visualization tools in the learning process, and in the given case – to create and use infographics in the teaching of object-oriented programming.

3. The observations on object-oriented programming teaching

Object-oriented programming (OOP) is a discipline included in the curriculum for students specialised in teacher education. The object-oriented programming course is one of the core subject courses for training a future computer science teacher. Therefore, its content, forms and teaching methods should be in line with the state-of-the-art in programming languages, methods and technologies.

OOP teaching is a challenging task, both for the teacher, who has to find the best way to illustrate the concepts, and for the students, who have to understand them. Over the years, teachers are still experimenting with different styles and approaches to identify the best and most effective ways of introducing object-oriented concepts and methods. Here are some important issues of interest and decision-making (Boudia et al., 2019):

- which object-oriented language should be used?
- what should be the order of teaching object-oriented concepts?
- what should the learning environment be like?
- when and how deeply should elements of modelling and object-oriented design be incorporated?

Choices relating to these and similar issues greatly influence the structure and success of mastering an object-oriented programming course (Boudia et al., 2019).

J. Bergin (2023) argues that the most important topics should be taught first, as delaying the learning of important concepts can lead to students developing a faulty understanding of them. Given this statement, when teaching the discipline of "Object-oriented programming" using infographics, this plan has been followed:

1. Based on the infographics, discuss the fundamental categories of OOP in accordance with everyday experience:
   • create infographics for explaining the nature of classes and objects and the relationships between them using real-world examples. Explain the concept of a class as a description of something that many similar objects have in common;
   • based on the infographics created, explain the idea of generating an object from an existing class. Create infographics for explaining the concepts of "Inheritance", "Encapsulation", "Polymorphism".
2. After explaining the basic concepts with the help of infographics, proceed to the study of a specific language.
3. To reinforce the skills of working with infographics, offer students the task of designing infographics independently.

Using the Piktochart service, an infographic was created to explain the basic concepts of object-oriented programming. The following are examples of infographics (Figures 1 and 2).

4. Materials and Methods

When conducting the pedagogical experiment, the students were divided into two subgroups: a control group and an experimental group. Both groups were trained based on the same curriculum, but using different methodologies. The control group (CG) used traditional learning tools and the experimental group (EG) used infographics. To determine the effectiveness of the methodology used, the pre-test and post-test were conducted one time. The tests were graded on a 100-point system. In order to determine the students' initial level of knowledge in the discipline of "Object-oriented programming", a Pre-Test was conducted, as well as a Post-Test was held at the end of the course. The tests consisted of 20 questions, each with four possible answers. The students were given 30 minutes to complete the test. The questions for the tests were taken from the training materials. Moreover, a questionnaire survey was carried out in order to identify students' interest in the use of infographics in the learning process.

Rationale for the choice of Pearson's chi-square test of homogeneity (χ^2) in this study is used to assess whether the distribution of categorical variables differs between two or more independent groups or populations. It is also used when categorical data are available and there is a need to determine whether there are statistically significant differences in the distribution of categories between groups.

In this study, in order to make a comparison between the two groups, the first group was considered as the baseline group and was the control one, and the second group was considered as affected by the infographic tool and was the experimental one. The study was carried out at two educational institutions: the Abai Kazakh National Pedagogical University and the Kazakh National Women's Teacher Training University. The authors of the study compared a control group in which training was conducted by using conventional means and methods (textbook, data demonstration and whiteboard) and an experimental

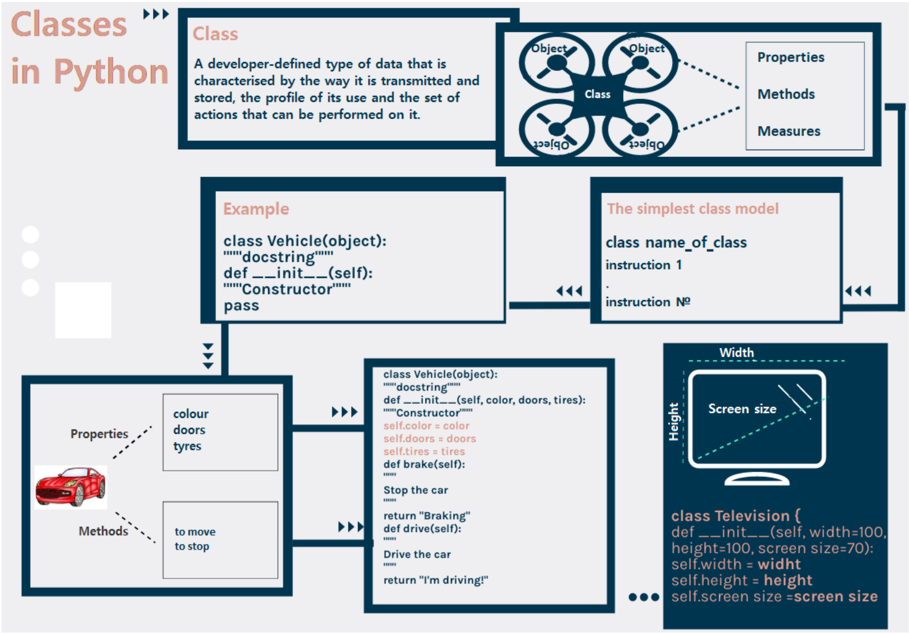

Figure 1 - Infographic on "Classes in Python".

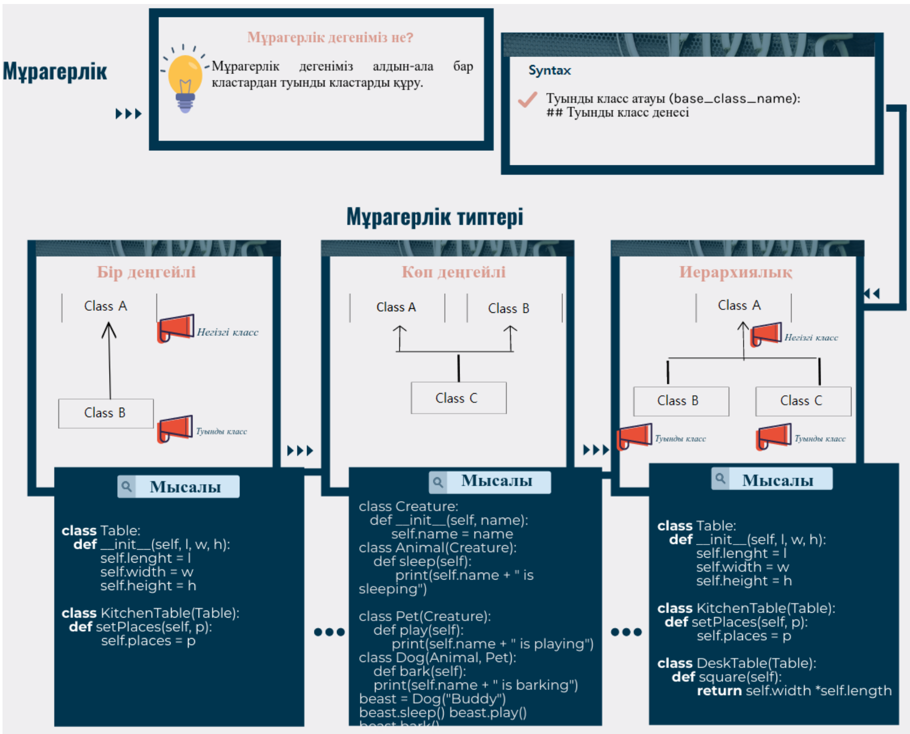

Figure 2 - Infographic on "Inheritance".

group in which training was carried out using a developed training course with the use of infographics. The pedagogical experiment was conducted in the course of classes of students studying physics and mathematics at the Abai Kazakh National Pedagogical University and Kazakh National Women's Teacher Training University (2019-2020 academic years). Fourth year students in the 5B011100-Informatics specialisation took part in the experiment. A total of 70 students from the Faculty of Physics and Mathematics at the Abai Kazakh National Pedagogical University and the Kazakh Women's National Teacher Training University took part in the "Object-oriented programming" course. Overall, 78.5% were women and 21.4% were men.

5. Results

In this situation, the authors of the study chose Pearson's test for homogeneity x2, since the number of gradations in the ordinal scale (different points) was greater than three (L=4) and the sample size included 70 students. The results of the "pre-test" and "post-test" tasks were systematised on an ordinal scale (Table 1). The students' scores obtained were divided according to proficiency levels in percentages: L=4. Table 1 presents the results of the Pre-test.

Table 1 - Results of knowledge measurement in the control and experimental groups before the experiment.

Point (%)	CG pre-test (students)	EG pre-test (students)
100-90	2	1
89-70	11	10
69-50	12	14
49-0	10	10
Total	35	35

Table 2 presents the results of the descriptive statistics of the pedagogical experiment conducted. Based on the data in Table 2, one can see that the results of the experimental group are significantly higher than those of the control group, namely the arithmetic mean value of the experimental group is higher by 5.76 points and the median is higher by 10 points.

Table 2 - Descriptive statistics of the number of correctly solved tasks in the control group and the experimental group after the pedagogical experiment.

	Sample volume	Minimum	Maximum	Average	Median	Trend	Variance
Control group	35	30	95	68.78	70	75	324.9
Experimental group	35	40	98	74.54	80	75	260.72

The significant difference between the experimental and control groups was the amount of variance of the data around the arithmetic mean. The sample variance of the experimental group decreased compared to the control group, which was calculated from the post-test (Table 3).

Table 3 - Results of knowledge measurement in the control and experimental groups after the experiment.

Point (%)	CG post-test (students)	EG post-test (students)
100-90	4	7
89-70	10	17
69-50	10	6
49-0	11	5
Total	35	35

Since the value of χ^2=14.035 obtained empirically exceeds the critical value of the criterion χ^2=7.815 it can be concluded that the reliability of differences between the characteristics of the experimental and control groups after the experiment is 95%.

Based on statistical processing of the data from the pedagogical experiment, it has been proved that the use of infographics in teaching "Object-oriented programming" provides effective learning and increases students' motivation to learn. In order to determine the students' interest in using infographics in the learning process, the students in the experimental group (35 people) were asked to fill in a questionnaire after the lecture (Table 4).

Table 4 - Questionnaire to determine students' interest in using infographics in the learning process for students in the experimental group.

	Statement	Yes	No
1	The lecture material was clearly presented		
2	The lecture material was presented in an interesting way		
3	The lecture material was presented in a comprehensible way		
4	The lecture material stimulated creative thinking		
5	The lecture material was of great interest to you		
6	The lecture material did not take much time to understand and assimilate		

The questionnaire showed that 72% of the participants thought that the lecture material was clearly presented, 18% of the participants answered negatively to the statement, and 10% of the participants found it difficult to answer. 50% of the participants agreed with the statement that the lecture material was presented in an interesting way, 25% disagreed with this statement, 25% of the participants found it difficult to answer. The results of the questionnaire show that 72% of the survey participants think that infographics have enabled them to present lecture material in a comprehensible way, 18% disagreed with this statement, and 10% found it difficult to choose an answer. 67% of students think that the use of infographics in lecture material stimulates creative thinking, 3% – answered “difficult to answer”, 30% – said “no”. The lecture material using infographics was of great interest to 84% of the participants, 10% of the respondents disagreed with this statement, while 6% of the students found it difficult to answer. 86% of those surveyed felt that the lecture material did not take long to understand and assimilate, while 4% of respondents disagreed with this statement and 10% found it difficult to answer. The questionnaire survey confirmed the benefits of using infographics in the learning process.

6. Conclusions

The main purpose of the experiment was to test the scientific hypothesis of the study in practice and to evaluate the methodology applied. The authors of the study used statistical methods to confirm or refute the proposed hypothesis of the study, i.e., at the end of the pedagogical experiment, a valid conclusion about the difference and coincidence between the data obtained was drawn. The work of confirming or disproving the proposed research hypothesis consisted of the following steps:

1. Calculation of the empirical value of the criterion based on the results of the “pre-test” and “post-test” of the experimental and control groups.
2. Comparison of the empirical value of the criterion with the critical value of the criterion (significance level 0.05). The reliability of the differences in the characteristics of the experimental and control group members will be 95% if the resulting empirical value of the criterion is greater than the critical value.

According to the results of using infographics in object-oriented programming classes at a teacher training university, although there were no significant differences between the experimental and control groups based on the pre-test, there was a significant difference between the scores of the groups after the test in favour of the experimental group. The results obtained demonstrate that infographics increase students’ performance in object-oriented programming. Based on the results of statistical processing of the data from the pedagogical experiment, it has been proven that the use of infographics in teaching object-oriented programming provides good training for students. The proposed hypothesis was confirmed. Moreover, students were more motivated to use infographics in their teaching activities.

The results of the research analyzed in this article show that infographics are an effective means of enhancing students’ learning of course content and that infographics have significant potential in education to enhance students’ intellectual, life and emotional development. It can be argued that the use of infographics in teaching object-oriented programming helps in understanding the basic concepts and also improves student performance. This can also enhance visual and verbal levels of learning. The results of this study can form the basis of solutions for teachers who teach complex or abstract concepts to students.

Limitations of this study include the limited generalisability of the study due to its focus on a specific educational context, potential bias due to sample size and selection, lack of long-term impact assessment, lack of detailed control for external variables, reliance on self-reported motivation and the potential influence of the Hawthorne effect. In addition, the scope of the study is narrow as it predominantly explores the benefits of infographics without considering possible drawbacks and variations in their design.

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