The Impact of Visual Elements in Pedagogical Texts – An Investigation of Economics and Engineering Students

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Abstract

The aim of the study is to identify the degree of impact of visual elements of educational materials, such as infographics, highlights in the text, images, as well as 'emotional background' of graphic and textual components. It focuses on the impact on cognitive processes (information analysis) and on learning outcomes (quality of case solutions) for students of economics and engineering. The experimental study involved 82 first-year economics and engineering majors. These were divided by random sampling into teams of 5-7 persons. The study consisted of two main phases: active and reflexive. In the active phase, students were asked to complete a case study on environmental topics, and in the reflexive phase they answered questions concerning their case study work. Specially designed case assignments included both emotionally neutral and emotionally intense descriptions of the same environmental situations, accompanied by various visual elements. The results showed that visual elements, such as highlighting key phrases in bold, dramatising images and manipulating the scale of graphs, significantly influenced students' conclusions and elicited an emotional response from them. Emotionally colored presentations pushed students towards prohibitions, whereas neutrally colored case solutions were characterised by constructive and differentiated suggestions for preventing the effects of an environmental disaster-color The use of emotionally charged visual elements had a greater impact on engineering students than on economics students. The obtained conclusions allowed us to formulate practical recommendations for teachers and methodologists. These were aimed at improving the efficiency of the educational process by becoming aware ot the heightened responsibility that comes with visual rhetoric. Figurative presentations should be accompanied by textual ones, and case-study learning should be grounded in reality to counteract virtualization through visualization. The conclusion emphasises the importance of a careful development and moderation of teaching materials, as well as the need to develop critical thinking in students throughout the learning process.

Keywords: Visualisation; Typography; Infographics; Emotional coloring of tasks; Case study; Manipulation; Perception of graphic information

Исследование влияния визуальных элементов в педагогических текстах на студентов экономических и инженерных специальностей

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Аннотация
Настоящее исследование посвящено изучению роли педагогического дизайна в кейсовых заданиях и его влиянию на восприятие учебных материалов студентами и результаты обучения. Цель исследования – выявление степени воздействия визуальных элементов учебных материалов, таких как инфографика, выделения в тексте, изображения, а также "эмоциональный фон" графических и текстовых компонентов в кейсовых заданиях на когнитивные процессы (анализ информации) и результаты обучения (качество решения кейсов) студентов. В экспериментальном исследовании приняли участие 82 бакалавра первого курса экономического и инженерного направлений подготовки. Для минимизации влияния неконтролируемых факторов студенты были разделены на команды по 5–7 человек методом случайной выборки без перемешивания студентов разных направлений подготовки. Исследование состояло из двух основных фаз: активной и рефлексивной. В активной фазе студентам предлагалось выполнить кейсовое задание на экологическую тематику, а в рефлексивной фазе они отвечали на вопросы анкеты, касающиеся их работы над кейсами. Специально разработанные кейсовые задания включали как эмоционально нейтральные, так и эмоционально напряженные описания одной и той же экологической ситуаций, сопровождаемые различными визуальными элементами. Результаты показали, что визуальные элементы, такие как выделение ключевых фраз полужирным шрифтом, драматические изображения и манипуляции с масштабом графиков, значимо влияют на выводы студентов и вызывают у них эмоциональный отклик. Решения нейтрально окрашенных кейсов отличались более конструктивными предложениями по предотвращению последствий экологической катастрофы, тогда как эмоционально окрашенные задания подтолкнули студентов к запретительным мерам. Как показали результаты опроса, дизайн кейса оказал большее влияние на студентов инженерного направления подготовки, чем на студентов экономического направления. Полученные выводы позволили сформулировать практические, направленные на повышение эффективности образовательного процесса, рекомендации для педагогов и методистов с целью повышения качества подготовки контрольно-измерительных материалов для формирующего и суммативного оценивания, а также презентаций и наглядных пособий. В заключении подчеркивается важность тщательной проработки и модерации учебных материалов, а также необходимость развития критического мышления у студентов на протяжении всего процесса обучения.

Ключевые слова: Визуализация; Типографика; Инфографика; Эмоциональный окрас заданий; Кейс; Манипуляция; Восприятие графической информации

INTRODUCTION

With the rapid digitalisation of education and the unprecedented development of artificial intelligence, the teaching community is facing questions about the effectiveness of traditional and innovative methods of learning and assessment. AI tools promise personalisation, automation, and new forms of interaction, transforming the entire educational landscape and exposing the failure of traditional approaches to assessing learning outcomes. However, despite technological breakthroughs, working with case-studies retains its unique position as one of the most effective tools for formative assessments that track student progress as well as summative assessments of students' competence levels. Its strength lies in its ability to simulate complex, multifaceted real-life situations that require students not just to reproduce knowledge, but to critically analyse it, synthesise information, make decisions under conditions of uncertainty, and develop professional judgement – skills that remain fundamental and difficult to automate even in the era of AI.

Recognising the enduring benefits of case studies as a key assessment tool in higher education was the premise of this study. While its potential for developing practice-oriented skills and integrated assessment is undeniable, the role of the pedagogical design of the case study materials themselves is often underestimated. Visual elements (infographics, images, textual accents), the structure of information presentation and, most importantly, the 'emotional background' of case study materials – all this is not a neutral shell, but actively influences learners' cognitive processes, including perception, analysis of information, drawing conclusions and, ultimately, the quality of proposed solutions. In an era of information overload and increased emphasis on emotional intelligence, understanding how case design guides students' thinking and emotions becomes critical to ensure objective assessment and the realization of educational goals.

Thus, the relevance of this study stems from the lack of research on the impact of visual design of case study instructional materials on student learning outcomes, especially in the early years of higher education, and the urgent need for a focused effort to improve this technology. It is possible to maximise the potential of this method only through the conscious design of case assignments, taking into account the influence of visual and emotional components on cognitive processes and performance. Improving the methodology of using cases is inextricably linked to the in-depth study of theirdesign.

The empirical basis of the following study includes data obtained as a result of an experiment with the participation of first-year students from economic and technical areas working on case assignments. This includes the results of a survey of students with reflections on the influence of visual elements on their answers. The study used various visual elements, including emotionally colored and neutral images, graphs, diagrams, text highlights, to assess their impact on students' perception and analysis of information.

This study contributes to the understanding of the role of visual elements in the educational process and suggests ways to optimally utilise them to achieve pedagogical goals. The findings highlights the challenge of objective and balanced design of learning materials for developing analytical skills and preventing the manipulation of learners' opinions. The practical significance of the study lies in the development of recommendations for creating learning materials that promote a balance between

engaging design and objectivity of presentation, as well as the development of critical thinking in students. The results of the study can be useful for teachers, educational program developers and methodologists seeking to avoid unintentional manipulation of students' opinions and improve the effectiveness of learning.

PROBLEM STATEMENT

Education has undergone a long process of transformation, adapting to changes in how people perceive information in the digital economy (Akour & Alenezi, 2022). In the 21st century, the role of visualisation as a means of delivering knowledge is growing, driven by the development of digital technologies and changes in the psychophysical characteristics of young people (Meguid & Allen, 2022). The use of visualisation as an important component of pedagogical design is becoming a generally accepted standard in modern teaching. Teachers are increasingly using various visual aids to improve the assimilation of educational material, develop students' imagination and promote a deeper understanding of the phenomena being studied.

A number of factors contribute to the widespread use of visualisation in education. First and foremost are psychological factors (Bhattacharya & Bhattacharya, 2015): the younger generation is accustomed to consuming information quickly via gadget and computer screens, so text-based information is losing its appeal and visual symbols are becoming more preferable. The growth of technical capabilities for visualisation has a significant impact (Ostanina, 2021): the increased availability of digital devices such as smartphones, laptops and tablet PCs opens up wide opportunities for the visualisation of educational material. Economic factors (Larionova, et al., 2021) cannot be ignored: the use of visual aids makes it possible to replace expensive laboratory experiments and tests with much cheaper models and simulators.

Despite the many positive aspects of using various methods and techniques for visualising content in the educational process, as outlined below, the use of visualisation is controversial due to its emotional impact on students and, in some cases, indoctrination, which requires a conceptual rethinking of the application of this technology in the educational process. Thus, one of the negative aspects of visualisation in education is the superficiality of students' perception of information, as visualisation simplifies complex concepts, which can lead to a lack of deep reflection. In addition, frequent use of visual aids contributes to an increase in screen dependency, a decline in reading and writing skills, and a weakening of critical analysis skills. At the same time, visualisation requires significant effort on the part of teachers, which increases the cost of educational content and reduces the return on investment of educational programmes.

Table 1 lists the main types of visualisation and their specific applications in the educational process.

Table 1. Types of visualisation and their specific applications in the educational process

Types of visualisation in the educational process	Forms of visualisation	Methods of application	Examples of use
Illustrative visualisation (Rautek et al., 2008)	Illustrations, photographs, drawings and diagrams.	Accompanying educational information, supplementing the textual part of the lesson and contributing to better perception.	− Textbooks with vivid illustrations; − PowerPoint presentations with images; − Display of photographs of historical monuments or natural landscapes.
Information and graphic visualisation (Kabanov et al., 2020)	Charts, maps, infographics and graphs.	Conveying quantitative and qualitative information, facilitating the perception of data.	− Diagrams and histograms to demonstrate statistical data; − Maps of the area for subjects where spatial knowledge, navigation skills and understanding of natural conditions are important; − Infographics explaining various processes.
Modelling and simulation (Stoffa, 2004)	Simulation models of experiments and laboratory tests.	Reproducing physical phenomena or processes, allowing students to experiment and explore the laws of nature. These techniques develop thinking and practical problem-solving skills.	− Chemical experiments demonstrating the reactions of substances; − Biological laboratory with cell modelling; − Simulation of physical laws in computer programs.
Interactive visualisation (Wang et al., 2018)	Interfaces for interactive whiteboards, tablets and computers.	Opening up wide opportunities for actively involving students in the learning process. Students can independently control the image, move objects, and change the parameters of the experiment.	− Interactive posters on humanities subjects; − Electronic tests with animation and feedback; − Internet resources with multimedia components.

The use of images, models, presentations, and interactive tools allows us to expand learning opportunities, increase student motivation, ensure deep knowledge retention, and develop students' intellectual abilities. Educational technologies are developing rapidly, and visualisation has become an integral part of modern learning processes.

Whether we are talking about traditional teaching or distance learning, the inclusion of visual elements increases the effectiveness of teaching and learning. Let's consider how visualisation fits into various pedagogical technologies (Table 2).

Table 2. Application of visualisation in educational technologies

Teaching technologies	Forms of visualisation	Ways to use visualisation	Positive aspects of using visualization
Traditional teaching technologies involve lectures, seminars and laboratory classes.	Illustrations and diagrams Demonstration stands Presentations Laboratory classes	Explain complex concepts by demonstrating clear examples. Allow students to study the subject independently. Provide direct observation of physical phenomena and chemical reactions.	Images are perceived faster and easier than text, which facilitates easier assimilation of educational material. The inclusion of visual aids attracts the attention of students, increases motivation and interest among the audience, and contributes to better perception of the material.
Modern active teaching methods	Case studies Business games Project method	Use presentations with graphs and tables to analyse real-life cases. Create game situations using graphic images. Visualise ideas and results through drawings, models, and videos.	It helps students visualise abstract ideas and theories by translating them into an understandable and clear form, encourages them to delve deeper into the learning material, increases their interest in learning, and stimulates cognitive activity. It allows students to model behaviour in real life. It allows them to acquire practical skills and learn to apply theory in practice.
Distance learning technology	Video lectures Infographics Virtual tours	Visualise lecture material using animation and graphic inserts. Compact and clear presentation of complex data and concepts	Visualisation helps students grasp abstract concepts by translating them into a visual form, stimulates imagination and creativity, and promotes the development of creative thinking and original solutions. It increases student interest and helps overcome distance barriers, making the learning process lively and engaging.
Blended learning combines face-to-face classes with distance learning.	Interactive presentations Simulators and trainers Forums and chats	Use of online platforms for collaborative editing and discussion. Virtual reproduction of laboratory experiments and real production processes; Active communication with teachers and classmates with the ability to add visual elements.	When viewing images and models, students think in images, which develops their imagination and creative abilities. Students begin to make associations and compare objects, finding similarities and differences. Active student participation in learning through visual stimuli stimulates mental activity, develops analytical skills and critical thinking

In traditional educational environments, visualisation is achieved through the use of illustrations, diagrams, posters, drawings and models. New technologies open up a wide range of possibilities for interactive and active teaching methods. Visualisation has gained a new lease of life, becoming an integral part of methods such as case studies, business games and project-based learning. Visualisation allows students to immerse themselves more deeply in the learning material.

In online learning, content visualisation is actively used in the creation of online courses. Teachers use presentation materials containing infographics, record video lectures, and incorporate virtual technologies into their courses. Visualisation increases student interest and helps overcome the lack of face-to-face communication with the teacher, making the learning process more lively and engaging.

In blended learning technologies, visualisation becomes a unifying element that flows smoothly from the traditional classroom to the online environment. This combination of traditional and distance learning is complemented by visualisation capabilities, which enriches the educational experience.

Thus, visualisation has taken a firm place in the modern educational process. Regardless of the chosen pedagogical technology, visual elements have become essential tools in pedagogical design. Competent use of visualisation increases the effectiveness of learning, improves the assimilation of material and attracts the attention of listeners, which contributes to their motivation and academic performance.

It should be noted that visualisation is closely linked to the phenomenon of indoctrination – the imposition of certain attitudes and ideas through the targeted use of educational technologies. Visual images have the ability to influence students' minds, shaping stereotypes and beliefs. This property makes visualisation a powerful tool for propaganda and manipulation if it is used dishonestly with a specific intent. At the same time, visualisation for the purpose of indoctrination can have both positive and negative effects on learning. On the one hand, it contributes to the formation of a positive worldview and universal competencies in students. On the other hand, it imposes certain views and beliefs, manipulating the opinions of learners. It is important for teachers and course developers to exercise caution when selecting visual aids to minimize negative impacts of visualisation on learning outcomes.

As mentioned earlier, the existing variety of educational tools, especially traditional ones, is currently being supplemented by new educational formats: distance learning, online learning, and blended learning (Walz & Kane, 2024). Traditional lectures, which represent the teacher's narration are transformed into interactive lectures 'press conferences', problem lectures, lectures-conversations, lectures-discussions, lectures-two-person, lectures-visualisations, lectures-provocations (Gorshkova, 2017).

According to Natalia Zyleva (2015) the task of a university lecturer in modern times is not just to give out ready-made material, but to encourage the student to search activity, to teach him to think and reason. One of the pedagogical techniques, which has a great developing and teaching potential, is the rarely used technique 'Planned Error.' The author concludes that evidentiary error detection requires from students attentive perception of information, actualisation and transfer of knowledge from other spheres outside the discipline, striving for accuracy and correctness of judgments and actions,

ability to build a logically correct and clear oral speech. However, according to Anna Andryunina (2024), interactivity at lectures is often limited to the interactivity of the teacher, leaving students as passive listeners. According to researchers, interactivity should be comprehensive, providing a holistic approach to the organisation of the educational process, changing not only the educational environment using digital tools, but also transforming the positions of the teacher and students (Korotaeva & Andryunina, 2021).

In order to improve the understanding of theoretical teaching materials and to develop students' analysis skills, teachers are increasingly using practice-oriented tasks in the form of case studies. Often, case studies include not only textual but also graphical components. Infographics, diagrams, photos, schemes and even text design (color accents, font highlights) are designed not just to illustrate information, but to perform important didactic functions: to structure complex data, visualise cause-and-effect relationships, emphasise key facts, create context and form a certain perception of the situation being described. They are powerful catalysts of cognitive processes and provide learning motivation.

Thus, in an effort to engage students in the thinking process, to increase their learning motivation, to provoke them to critically evaluate the obtained materials, teachers use various techniques (Hao et al., 2024). Thus, IgorSharshov . and Ilya Bubnov consider the peculiarities of visualisation as a way of visual presentation of information that affects the efficiency of students' learning new knowledge and the formation of skills to critically reflect on the studied material, analysing the possibilities of using visualisation in connection with the specifics of students' perception of visual information (Sharshov & Bubnov, 2022). The authors conclude that, despite the need to use visualisation, there are certain difficulties in implementing its tools in the educational process of higher education, but if we take into account all the features, nuances and risks, the result of utilizing visualizations will be an increase in the quality of the educational process. According to Yulia Katkhanova, Elena Korzinova, and Sergey Ignatiev, this visualisation of educational information is the most striking trend in the development of educational information space (Katkhanova, et al., 2018). The implementation of this trend results in fundamentally new communicative, cultural, and educational phenomena that significantly transforms the environment and affects all its components: educational, social, informational and cognitive processes. The authors note the significant role of visualisation in the modern educational space and conclude that the translation of verbal images into graphic images – or vice versa – always results in the structuring and systematisation of educational information. Accordingly, there is never a single predetermined solution for a case-study task. Instead it emerges from the process of comparing statements and conditions of the set tasks, transforming information from one sign system to another by means of generalisation, system analysis and comparison of the obtained data.

Studying aspects of motivation in students' learning activities, Aleksandr Moshkin, Anatoly Kolesnikov, and Natalia Kokh note that the uniformity of exercises used to consolidate knowledge and the monotony of homework are strongly demotivating factors. In contrast, a creative and individualizing approach to learning activities and an emotional

coloring of educational material contributes to increasing interest in learning (Moshkin et al., 2017). However, there is a question of the ethicality of manipulation through visuals – does visual manipulation limit viewers' freedom of choice, is it addictive, does it disadvantage them? To the extent that they involce indocrtination, are visual and other persuasive technologies ethical (Cheng, 2024)?

According to David Lewin (2022) the negative connotation of the term indoctrination may not be appropriate since, after all, indoctrination is the way by which educators support and defend a normative view of education: Education should be directed towards something intrinsically valuable. Comparing education and indoctrination Lewin concludes that education and indoctrination always mutually influence each other. Whether there is a difference between education and indoctrination depends on how justified the influence is. Lewin believes that if the educator sincerely intends to improve the student's attitude towards something, indoctrination can be interpreted as a variant of education.

However, visual perception is influenced not only by the content of the materials offered to students, but also by their appearance and emotional coloring. Thus, according to Mustafa Günay (2024), typography serves as a tool to reinforce the meaning of the text, as different fonts, colors and layouts emphasise emotions and messages, the right choice of typography allows for a more effective connection with the target audience. The author notes that readability is influenced by factors such as font size, line size. spacing between headings and letters to ensure that the text is clearly understood.

According to Galina Nikulova (2006), the color design of educational materials affects the nature of their perception by students. She gives examples of coding information with color that increases the efficiency of its assimilation and the sustainability of students' attention. Elina Adieva, Marat Yunusov, and Aleksandr But, studied the role of images in information perception by conducting experiments on the influence of images on presentation slides on their perception by student viewers (Adieva et al., 2020). Based on a survey of students the authors concluded that through understanding how people perceive visual information and identifying patterns it is possible to improve the educational process. Thus, according to the respondents, the most preferable background for images is light, and text of two colors is perceived better by highlighting key words or main sentences in a brighter color. Edward Tufte and Peter Graves-Morris in their study of the visual display of quantitative information examine the various ways in which information graphics can distort data and even mislead users (Tufte & Graves-Morris, 1983). The authors note the importance of proportionality and removal of unnecessary data to improve visualisation.

However, there is a dearth of experimental studies in the literature evaluating the extent to which visual provocation affects student learning outcomes.

METHODOLOGY

The research methodology for oour empirical investigation is based on the use of an experimental approach aimed at studying the influence of visual elements on the perception and analysis of educational material by first-year undergraduate students.

The experiment involved 82 first-year undergraduate students, of which 45 students were studying in economic areas of training and 37 students were studying in technical areas of Ural Federal University. The students were divided into teams of 5 to 7 people by random sampling method. The study consisted of two main phases: active and reflexive.

In the active phase of the experiment different groups of students were randomly offered case studies. The students had to study and analyse the situation described in the assignment either independently or by using Internet sources (there was no restriction on the use of external sources of information). Specially developed by the authors case studies were devoted to the environmental problems of the Kerch Strait, in which the same situations were described in emotionally neutral and emotionally tense ways.

The descriptions of situations were accompanied by various visual provocations – bold text, graphs, diagrams and images with different emotional backgrounds. Students had to familiarise themselves with an environmental problem, analyse the options for solving the problem proposed in the case study task and propose their own options, as well as prepare an information poster about the environmental problem. The teams were given 60 minutes to complete the task, after which they defended their case solutions based on the information posters they had prepared.

One week after the active phase of the experiment, the students were offered a reflection phase. To conduct the reflexive phase of the experiment, the authors of the study developed a survey including questions about the perception of the visual elements, about the use of additional information sources, and emotional reactions to the images in the case study tasks.

The aim of the case study was to develop measures for the conservation of representatives of the Kerch Strait fauna. These represented were, firstly, the second representative was the Black Sea porpoise or dolphin-azovka as a rare, declining subspecies of the Black Sea. The second representative was these a pigeon, or slender-billed gull – a rare bird species from the gull family.

The environmental problem to be solved consisted in oil pollution of the Kerch Strait water area, disturbance of the environment in the Strait area by various anthropogenic impacts (construction of the Crimean Bridge, organisation of oil products transportation by tankers, accidents during cargo transportation) and the influence of these impacts on the life activity of these fauna representatives. The description of the situation was accompanied by photos, graphs, diagrams showing some related numerical indicators. In the text of each case study, options for improvement of the described situation were proposed. Each description was designed as an A4 sheet printed on a color printer.

Both quantitative and qualitative methods were used to analyse the results. Quantitative analysis of the obtained survey data included their statistical processing, while qualitative analysis was aimed at interpretation and evaluation by expert teachers of case solutions proposed by students and identification of key points in their group work.

All ethical standards were observed in the study, including voluntary participation of students and confidentiality of data. Students were informed about the aims and procedures of the study and had the opportunity to withdraw at any time.

FINDINGS

To identify the degree of influence of visual provocation on the students' conclusions, they were asked to study the main causes affecting the number of the marine representatives, analyse the proposed measures for their conservation, and develop effective measures aimed at preserving the population. Table 3 presents for the experimental and control groups the key phrases highlighted by the students from the text of the case study task and in the following lines their descriptions of visual elements in their information poster as well as their proposed solutions to the environmental problem.

Table 3. Results of students' work in the active phase of the experiment

Results of student work	Case study about the Black Sea porpoise - azovka	Case study on the Black-billed Gull, the Black Sea dove
Neutral text, visual elements, graphics		
Key phrases	Anthropogenic impact, environmental conditions, piling, discomfort, don't like noise, crashing, etc.	Transport artery, changing ecological situation, feeds on small fish, etc.
Visualisation on an information poster	Smiling sun, palm trees, blue water and happy dolphins swimming. (Figure 1 in Table 4)	Cheerful birds, sewage treatment plants, artificial reservoirs, bright colors blue, green, pink predominate.
Proposed solution to an environmental problem	Azovka is crying only on one poster, but she is drawn in a fishing net, over a spot of fuel oil and near the propeller of the ship. In the drawing the colors are bright – the vessel is pink, the fuel oil stain is multicolored (pink, green, lilac). (Figure 2 in Table 4)	Enlightenment, environmental education, protected areas. (Figure 3 in Table 4)
Emotional text, visual elements, graphics		
Key phrases	In the text of the assignment, the students emphasised the text in bold: ecological disaster, polluted sea, fishing nets, anthropogenic impact, above the maximum permissible norms, etc.	In the text of the assignment, students placed emphasis on the text in bold: ecological disaster, oil products, 500 tonnes annually.
Visualisation on an information poster	Calls for banning shipping, banning noise, banning fishing nets (note that for hamsa, the main food of azovka). (Figure 4 in Table 4)	In addition to the text in bold, the following was noted: Red Book of the Russian Federation, pollution from industrial effluents. (Figure 6 in Table 4)

| Proposed solution to an environmental problem | Elimination of noise, fish protection zones, islands with food, creation of artificial reefs to restore the marine ecosystem. (Figure 5 in Table 4) | Crying birds. |

Examples of posters prepared by students when solving case studies with neutral and emotionally charged visualisations are presented in Table 4.

Table 4. Examples of posters prepared by students when solving case studies with neutral and emotionally charged visualisations

Neutral text, visual elements, graphics	Emotional text, visual elements, graphics

Figure 1

Figure 4

Figure 2

Figure 5

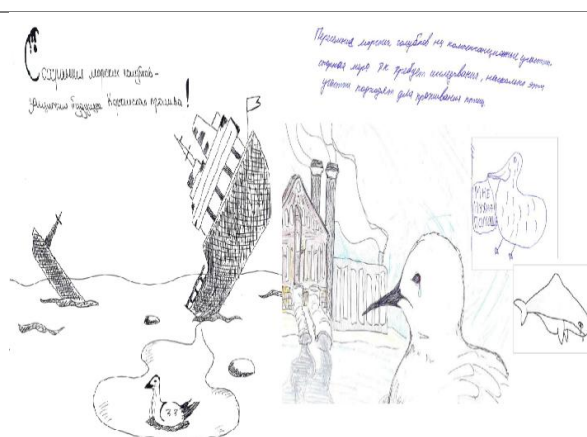**Figure 3**   **Figure 6**

As the results of the analysis of the active phase of the experiment have shown, students in most cases perceive the teaching material offered by the teacher as dogma and do not check the adequacy of information.

Graphs and diagrams. Students were offered to study three graphs – an information-rich and reliable graph, a graph with an embedded error (deliberately changed scale on the vertical axis) and a pie chart with no reliable sources (Fig. 7):
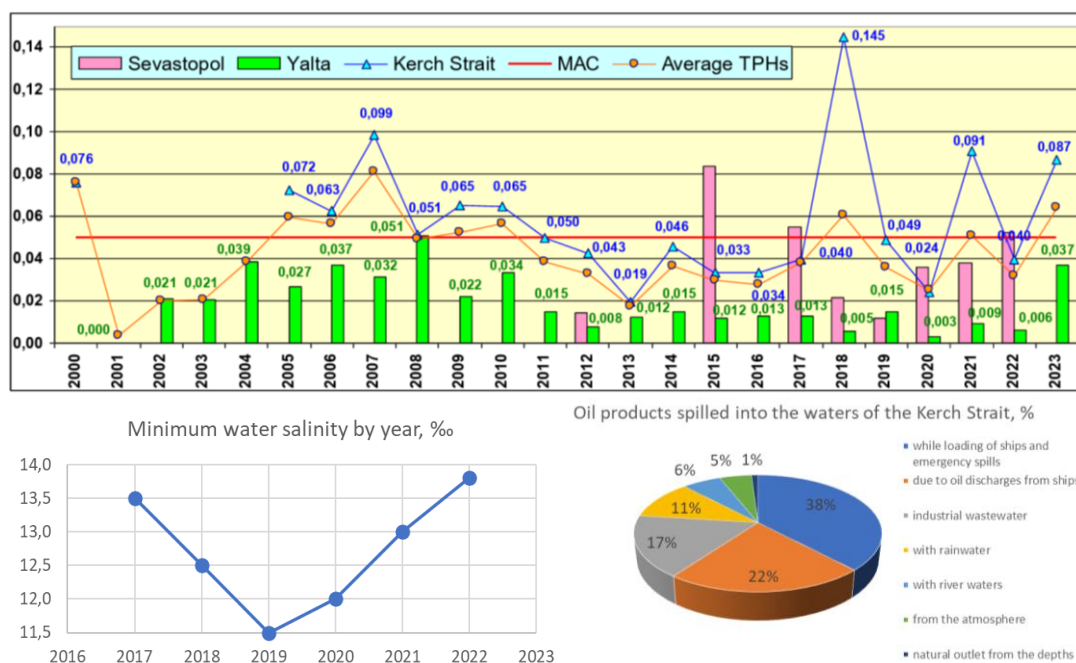

Figure 7. Graphs and diagrams inserted into the text of case assignments

It should be noted that the distorted graph and pie chart were considered by students and accepted as grounds for thinking about the situation in the case study with the same confidence as the reliable graph. Moreover, the most complex and information-rich graph

of multi-year dynamics of petroleum hydrocarbon concentrations in the coastal waters of Crimea was least used by students for decision-making. According to the authors, this was due to the fact that students did not want to study complex information in detail and understand it. If we refer to this fact in terms of Bloom's taxonomy, students 'know' and 'understand' relatively complex information, but have not yet developed the skill to 'apply' it.

Pictures of fauna. To give an emotional background to the information, different pictures of azoids and bluebirds were used (Fig.8). On the left are dramatic, emotionally negative pictures, and on the right are neutral pictures.

Figure 8. Pictures with images of Kerch Strait fauna representatives presented in case studies

Visualisation in the case study task had a greater impact on engineering students than on economics students. Neutral and negative images provoked different images on information posters and different proposals to eliminate the consequences of the environmental disaster. Thus, students who received neutral images used bright colors, positive images and smiles when preparing posters. Conversely, students who received tasks with negative pictures used dark colors, images of tears, and a large number of appeals reinforced with exclamation marks on their posters. As a result, the solutions of neutrally colored cases were characterised by more constructive proposals to prevent the environmental situation, whereas the negatively colored assignments pushed students towards more prohibitive measures, which provoked proposals to relocate fauna, ban fish catching, etc.

Task text. To provoke emotions in students, separate phrases in the text of emotionally colored tasks were highlighted in bold and capital letters. As expected, students emphasised their attention mainly on these phrases, fully trusting the instructor. In neutral tasks there were no text highlights, and students independently made more highlights of phrases important in their opinion, emphasising details. That is, in this case they perceived the initial information more broadly, and proposed programmes for monitoring and protection of fauna, environmental education of the population, as well as proposals for reproduction of the species in question.

It should be noted that students did not critically evaluate the information proposed in the tasks. For example, 500 tonnes of oil products were mentioned in the text, but the source of information was not indicated. Nevertheless, students took this figure on faith and did not try to find additional information.

Formulated solution. Under time constraints (1.5 hours), students prioritise the tasks in the most obvious order:

1. study the material on the case sheet,
2. analyse already proposed solutions,
3. formulate their own solution which included drawing on Internet sources.

Other parts of the survey showed that students of economics direction used Internet sources more actively than students of engineering. Nevertheless, when formulating solutions to improve the situation, in most of their answers students did not go beyond the options proposed in the text of the case study task, i.e. they remained in the information field of the text. The reason for this, in our opinion, may be that the teams did not have (or did not develop in the allotted time) 'idea generators' – people capable of self-organising themselves to formulate meanings different from the proposed ones within a limited time. All teams of engineering students gave specific proposals, but were not very confident about their originality. Students of economics were more confident about the originality of their proposals, but one team out of thirteen could not formulate a proposal.

In the reflexive phase of the experiment, students individually answered questions related to the work they had done on the case at the previous stage. The results of the survey were analysed in two directions:

1. in regard to different fields of study, a comparative analysis of engineering and economics students was carried out;

2. in regard to the different designs of assignments a comparative analysis of answers to neutrally colored and emotionally charged case assignments was carried out.

In the first case, the research question was posed whether there is a difference in the perception of graphic information by students of different fields of study or training. In the second case, the hypothesis was tested that the emotional coloring of case tasks has an impact on students' responses regardless of their area of training.

As a result of the survey, it was revealed that students paid mostattention to the text description when analysing the case: 89.2% of engineering students and 82.2% of economics students. Engineering students were more critical of the text than economics students (22.6% and 13.3% respectively), finding contradictions and false assumptions. Most students considered the text description 'quite sufficient' to solve the case (91% of

economics students and 81% of engineering students), but economists paid more attention to the marks in the text than engineers, taking them as 'key phrases' (53.3% and 46% respectively).

Secondly, pictorial elements like photos, graphs, or charts were analysed by 56.8% of engineering students and 44.4% of economics students. At the same time, 75.6% of economics students tried to apply them to extract information, while the share of engineering students was unexpectedly lower in this question – 67.6%. The majority of students (89.2% of engineering students and 84.4% of management students) tended to believe that graphical information helped them find a solution.

The students from different fields answered in almost the same way the questions related to the content of the charts: 82-84% of students responded correctly to questions about the information-filled chart, 31-32% about the 'distorted' chart, and 16–20% about the pie chart.

Special attention in the study was paid to the analysis of students' emotional response to the presented case tasks. Figure 3 shows the results ofstudents' answers to the question 'What emotions were evoked by the pictures with animals inserted in the text?'
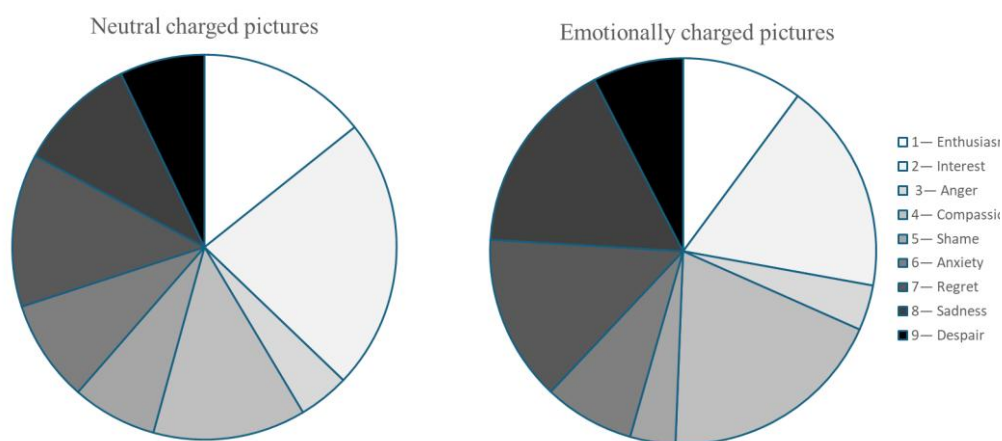

Figure 9. Emotional response of students to pictures presented in the case study task

The following emotions on the scale from more active to more passive are marked by shades of colors from white to black, where white – enthusiasm; black – despair; shades of gray from light to dark – interest, anger, compassion, shame, anxiety, regret, sadness, accordingly. A comparative analysis of the answers of students solving cases of different designs has shown that compassion and sadness are expressed 1.3–1.4 times more often by students solving cases with emotionally negative pictures, while interest and enthusiasm in solving the problem are experienced 1.5–1.7 times more often by students solving cases with neutral pictures. Significantly more students of the first group experience shame (2.2 times more often), anger and anxiety (1.3 times more often). This supports the view that emotionally negative pictures cause passive emotions that do not stimulate action: theydo not contribute to the generation of their own ideas when solving cases.

The negative emotional background of case study tasks had a greater impact on engineering students than on economics students. They empathised with the injured animals to a greater extent. However, students felt shame least of all (15.6% of economists and 10.8% of engineers). Nevertheless, the main emotion of the majority of students was interest, which, in the authors' opinion, was caused by working on the case study and (or) the active form of class organisation as more active, communicative and team-based and less 'academic' (44.4% of economists and 48.6% of engineers).

Thus, it cannot be denied that pictures have an impact on students' emotions, and this should be taken into account when developing teaching materials, based on the pedagogical goals set by the teacher. In this regard, it is important to notice that students working with case assignments with neutral design were more optimistic in evaluating their solutions: 72% of students responded that their solution was characterised by originality, whereas only 66.7% of students who received negatively colored case studies considered their solution to be original.

CONCLUSIONS

The results obtained in the course of the study indicate that case study design plays an important role in pedagogical design and that the use of visual elements that are unjustified from the point of view of learning objectives can have a significant impact on learners' cognitive processes and even impose certain ideas and beliefs on them. In the literature, such a technique is called indoctrination. It is often deliberate on the part of the educator and deprives learners of the opportunity to critically reflect on what they have heard or to question their ideas. As a rule, teachers give students only the information that corresponds to their pedagogical goals, and the student, with full trust in the teacher, has no desire to learn other points of view and draw conclusions independently. Biased information is based on selective data and subjective evaluations to convince the listener of a certain point of view.

Let us consider the results of the experimental study from this perspective. To evaluate the role of visual elements in the educational process, a dramatic illustration of a bird in fuel oil was added to the text of one of the case studies, a phrase in bold capital letters, which should cause a feeling of guilt before nature, about 'ECOLOGICAL CATASTROPHE!' was highlighted in order to convince students of the need for radical measures to reduce emissions without providing a complete picture of the amount of pollution and its sources. The experiment showed that students trusted the information in the case study without questioning the information presented in them. For example, in the case study assignment the amount of pollution of seawater by oil products was given as 500 tonnes. Students did not even think about whether it was a lot or a little, and did not search for confirmation of this information, although open sources have data on 9,000 tons of oil and oil product discharges only from loading, discharges and accidents (Nemirovskaya et al., 2018).

In the text of the case study, the authors also bolded some phrases to attract the attention of students: 'feeds mainly on small fish', 'likes silence.' This provoked the

students to propose artificial cultivation of small fish as a solution to the environmental problem, as well as the creation of noise shields on barges.

The mention of hamsa as a food source for azovka led students to conclude that it is necessary to increase the population of this particular fish without considering alternative food sources for this fauna species. Intentional visual distortion of the scale on the graph of salinity changes in the Kerch Strait waters and mention of dove nesting on the shores of saline waters led students to the idea of measures to keep water salinity at some average level. At the same time, students unfamiliar with the units of salinity (ppm) failed to realise that the scale of the graph indicates that there is no change in water salinity and that temporal fluctuations in the salinity index are not significant.

These examples show that visual elements, text, and the presentation of information in the text of the assignment can be used to manipulate students' opinions and even indoctrinate them, inclining them to a certain conclusion without considering the full picture. However, such case study assignments can be aimed at making students understand the importance of critical attitude to information. In this case, the instructor deliberately include false information in the case and asked students to find untrue facts and distortions. From the point of view of pedagogical design, the final stage of a case study should be a reflection with a full analysis of errors in case tasks and students' final decisions.

In general, educators should seek out infographics that strive to be objective, presenting data in context and without bias As opposed to biased infographics, instructive infographics avoid imposing a particular point of view .

Students, regardless of their field of study, generally showed the expected result for their level of preparedness (1st year) of working with the case study material, which can be formulated as follows: superficial consideration of the topic under time constraints with non-unique final results. In the course of the experiment, statistically significant differences were found in the attitudes towards information in students of two different areas of training. At the same time, there was a clear dependence of the quality of final solutions and their originality on the emotional background of the case being solved by the students. The results of the experiment indicate that manipulations using visual elements of the simplest type (emotional background of pictures, marks in the text, distortion of the scale of graphs) have an impact on first-year students and affect learning outcomes.

These findings are consistent with those of Janssen et al. (2024) who studied the effect of anecdotal information and data visualisation on the conclusions of 56 medical students and found that visualisation influenced prescription of medications.

In this regard, it is important to note several methodological recommendations that arise from the findings:

1. Educational materials for 1st year students should be moderated by the criterion of absence of various kinds of distortions and errors, which imposes additional responsibility on the developers of educational materials. When introducing new methods of teaching in higher education institutions, such as online learning, VR-trainers, interactive presentations, etc., appropriate methodological work with teachers is necessary. This applies especially to young teachers who are just starting to develop

teaching and learning materials. They should be taught the basics of pedagogical design and methods of questioning their materials, helping them become aware of unintentional 'manipulation' of the learner's cognitive processes. Yushen Liu, Stanislav Pozdniakov and Roberto Martinez-Maldonado, in their study of the impact of visualisation on teachers' cognitive skills, note the need for a simpler interface for inexperienced teachers (Liu et al., 2024). Also, different pedagogical purposes have different requirements for content and its design. For example, for the transfer of knowledge in full it is necessary to be guided by the criterion of 'no distortion,' while for formative and summative assessment it is acceptable, and in the game form it is even advisable to use the method of 'embedded error'.

2. Textual 'sign system', based on the given results of the study, was closer and more understandable to the students, caused more trust and less difficulties than the structured figurative 'sign system' (graphs). The unstructured figurative 'sign system' (drawings) had a secondary, additional character. This conclusion can be used in the preparation of presentation training materials, applying on the slides necessarily at least two 'sign systems': textual and figurative. However, in order not to make a slide 'boring', one should be guided by the well-known requirements of not overloading it with text, and with circumspection add emotional background. Also, following Katkhanova et al. (2018), it is necessary to create conditions for conscious transitions of students as their reflections move from one 'sign system' to another. This is achieved, for example, by discussing the slide materials, students' comparison of figurative and textual information on the slide.

3. Critical and analytical thinking of 1st year students should be developed by using a variety of cases. However, it is important that they are based on real-life examples. In this sense, it is important, from the authors' point of view, to focus the student's attention on details, their critical and emotional reflection. This is the advantage of real tasks over solving classical tasks that are methodologically and didactically established and isolated fromcontext. The latter help to structure thinking, develop skills in applying analytical methods, but being devoid of 'vitality' and emotional content, they are necessary but not sufficient for the development of students' thinking. Thus, transforming a 'life' situation into an analytical scheme or set of equations and correlation with known laws and theorems, gives students an understanding of the applicability of fundamental knowledge and motivates them to study it. This agrees with the findings of Oleksandr Chastnyk and collaborators who concluded that the use of interactive teaching methods and techniques significantly contributes to the creation of communicative relationships in the group and with the teacher. These contribute to the maintenance of a positive atmosphere, and in combination with a high level of professional motivation for learning, contribute to the professional growth of students, effective accumulation and use of knowledge and skills (Chastnyk et al., 2024).

It has been shown in numerous studies that interactive forms of cooperation with students play a significant role in the success of the latter, influencing the effectiveness of achieving educational goals (e.g., Chastnyk et al., 2024). The opinion of teachers also agrees with the need to use interactive teaching methods. For example, Walz, Kane

showed the importance of using puzzles, quizzes, case assignments, role-playing games and group work in teachers' work (Walz & Kane, 2024).

Within this context, the results of the present study emphasise the importance of careful development and moderation of teaching materials, including their content and design, and the need to develop critical thinking in students throughout the learning process.

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