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Oksana ZHYKHORSKA, PhD (Pedagog.), Assist.
ORCID ID: 0000-0001-9722-3160
e-mail: oksanazhykhorska@knu.ua
Taras Shevchenko National University of Kyiv, Kyiv, Ukraine

THE USE OF CHATBOTS IN STUDENT EDUCATION

Background. ***The article considers aspects of the use of chatbots in education and their potential to optimize the work of teachers and improve the learning process.***

The article identifies the areas of activity of teachers in which the use of chatbots for various purposes will optimize work, automate repetitive and routine tasks: preparation for classes and development of methodological support, assessment of students' learning outcomes, providing students with access to educational materials, communication with students, and organization of their own working time.

The article provides a list of online courses that help teachers to effectively use chatbots in their professional activities and design them on their own.

Purpose and objectives. It is found out that the use of chatbots can improve the organization of the educational process; improve the support of learning using distance technologies; increase the level of interactivity and playfulness of the educational process; promote the creation of an inclusive educational environment and personalization of learning; simplify the adaptation process of applicants and foreign students; improve the quality of informing applicants and conducting career guidance; automate the provision of information, psychological, legal, social support to all students.

Results. ***In general, the use of chatbots in student education opens up many new opportunities to provide effective, accessible, and modern education that meets the requirements of modern society and the labor market. Chatbots are actively used by higher education institutions to increase the interactivity of learning, organize online learning, and support learning using distance technologies.***

Conclusions. ***Chatbots help to organize the educational process for both teachers and students, personalize learning, and adapt the educational environment to the needs and capabilities of a particular user.***

Keywords: ***educational process, chatbot, artificial intelligence, higher education.***

Background

The development of artificial intelligence tools has had a significant impact on various spheres of human life and activity, primarily due to the ability to analyze data, recognize patterns, make decisions, and automate tasks. Artificial intelligence is actively and successfully used in the financial sector, industry, energy, business, transportation, and robotics, contributing to the automation, optimization, and improvement of processes and services.

According to the Concept for the Development of Artificial Intelligence in Ukraine, approved by the Order of the Cabinet of Ministers of Ukraine № 1556-p of 02.12.2020, the priority areas for its implementation are the introduction of artificial intelligence technologies in education, economics, public administration, cybersecurity, defense and other areas to ensure Ukraine's long-term competitiveness in the international market (The concept of..., 2020). The implementation of the state policy in the field of artificial intelligence will affect the key interests of such stakeholders as citizens, educational institutions, business entities, executive authorities and local governments (The concept of..., 2020). As of today, it can be stated that artificial intelligence is at the initial stages of development in the field of education. The use of artificial intelligence tools in student education opens up many new opportunities to provide effective, accessible, and modern education that meets the requirements of modern society and the job market.

With the development of digitalization and information networks in the field of education, the ways of interaction between participants in the educational process have changed. Artificial intelligence tools, such as chatbots, are actively involved in this interaction. Chatbots, as intelligent agents, have a powerful potential to improve the quality of education, organize the educational process, personalize learning, increase student motivation, and become valuable assistants for both students and teachers.

Literature review. In recent years, there has been a growing interest in researching the use of chatbots in the educational process, optimizing the work of teachers with their help, using chatbots in the study of certain academic disciplines and for communication with the administration of educational institutions, students, colleagues, and intensifying the scientific discussion on academic integrity and ethical aspects of using chatbots in student education. This is evidenced by the large number of scientific studies and practical recommendations on the use of chatbots in higher education, as more than 17 thousand English-language papers and more than 80 articles by Ukrainian scientists were published in 2019–2023, while in 2013–2018 only about 3 thousand English-language and less than 10 Ukrainian-language papers were published.

Ukrainian and foreign researchers pay considerable attention to the classification and typologization of chatbots in education. For example, after reviewing 89 unique chatbots for Facebook Messenger, P. Smutny and P. Schreiberova proposed a classification of educational chatbots by messaging channels and identified types of chatbots for learning by field of education and end user (Smutny, & Schreiberova, 2020). Y. Chaplinska analyzes the benefits of using chatbots in the educational process and offers her own classification of educational chatbots by function (Chaplinska, 2020). To understand the essence of chatbots, their advantages and disadvantages according to certain criteria, O. Trofymenko, Y. Prokop, O. Zadereiko, and N. Loginova formed a detailed multifactorial classification by the criteria of purpose, location, type of interface, number of users, form of access, algorithm, and functionality (Trofymenko, Prokop, Zadereiko, & Lohinova, 2022).

The prospects of using chatbots in education, the effectiveness of their use in the educational process, and the analysis of advantages and disadvantages are the subject of many publications by Ukrainian and foreign scholars (K. Klioz, O. Olefirenko, I. Ushakova, O. Pedan, O. Nalyvaiko, A. Malyutina, D. Donovska, R. Winkler, M. Zellner, D. Dimitradis). O. Nalyvaiko and A. Maliutina devoted their scientific publication to clarifying the importance of chatbots in the educational process for

students, determining the level of involvement and prospects for their implementation in the learning process, analyzing the results of a student survey on awareness of chatbots and their functionality (Nalyvaiko, & Maliutina, 2021).

D. Donovska examines trends, forecasts, and examples of chatbots in education, analyzes how chatbots influence and change higher education and online learning. The author identifies five ways of such influence: automation of checking and evaluating essays, tests, and quizzes; supervision and control of students during testing, exams, or other online activities to prevent fraud and violation of rules; anonymous and open feedback from students, the ability to leave feedback on the teacher and the discipline; adaptation of the educational process in accordance with the student's capabilities and individual pace of mastering academic disciplines; use of interval learning technology, in particular when learning foreign languages (Donovska, 2019).

R. Winkler and M. Söllner devoted their study to a systematic and structured review of the use of chatbots in education, in which they identified factors that affect the effectiveness of their use in the educational process (Winkler, & Söllner. 2018). D. Dimitradis explores the evolution of chatbots, analyzes the advantages and disadvantages of their use in student learning, and considers the possibility of using chatbots as virtual assistants that free teachers from routine, repetitive tasks and help them focus more on providing quality education (Dimitriadis, 2020). S. Wollny, J. Schneider, D. DiMitri, D. Weidlich, and H. Draxler conducted a study of the areas of education where chatbots are already used, identified three different pedagogical roles of chatbots in education: the role of learning support, the role of assistant, and the role of mentor, and examined in detail the potential of using chatbots to personalize education (Wollny, Schneider, Di Mitri, Weidlich, Rittberger, & Drachsler, 2021).

However, in the current scientific literature, insufficient attention is paid to the study and analysis of the potential of using chatbots to improve the learning process and increase the efficiency of teachers in higher education institutions.

Results

The development and improvement of artificial intelligence tools, such as chatbots, has a significant impact on the expansion of their use. This process has opened up new opportunities and transformed many industries. In education, the use of artificial intelligence tools opens up new opportunities and changes approaches to learning and teaching, and their application contributes to the creation of electronic platforms for learning and development, improvement of the means of assessing students' learning achievements, and optimization of teachers' activities. One of the tools of artificial intelligence is chatbots and virtual assistants that use NLP (Natural Language Processing) and other technologies to understand queries and provide answers.

A bot is a special program that performs any actions automatically or according to a given scenario through interfaces designed for humans. Bots are designed to perform monotonous and repetitive work at the highest possible speed, such as bidding at auctions. Bots used to imitate human actions in communication are called chatbots (Ushakova, 2019, p. 77). The term "chatbot" was coined in 1994 to describe conversational programs during the gaming process, when it was defined as a robot player whose main function was conversation (Chaplinska, 2020). Over time, the tasks of chatbots have transformed, and today a chatbot is defined as a virtual interlocutor that can perform a variety of functions, depending on the application, and allows you to simulate a relaxed natural conversation through messaging. Such bots use artificial intelligence technologies (Trofymenko, Prokop, Zadereiko, & Lohinova, 2022, p. 147). In general, a chatbot is software that can automatically interact (simulate communication, perform certain actions) with users through a chat interface on platforms such as messengers, social networks, websites, or applications.

In the scientific literature, there are concepts of "chatbot in education/student learning" and "educational chatbot" that should be distinguished. The term "chatbot in education/student learning" can be defined as a software tool based on artificial intelligence that provides automated and interactive interaction between users and educational resources through text or voice communication tools. Its main purpose is to provide students, teachers and other participants of the educational process with the opportunity to receive information, solve problems, receive support and communicate in a convenient and effective way, help in preparing for classes, remind about the time of classes, and provide an individual approach to learning by adapting the educational process to the needs of each student. Such tasks can be performed by chatbots specially created for the educational sector, as well as by multifunctional chatbots and monofunctional chatbots for non-educational purposes. An example of a chatbot specially created for use in education is the virtual assistant of Deakin University "Genie". The platform uses artificial intelligence, voice recognition, and predictive analytics, and is integrated with existing systems, including the university's learning management platform and digital library (Cunningham-Nelson, Boles, Trouton, & Margerison, 2019, p. 301).

Y. Chaplinska interprets the concept of "educational chatbot" as an automated intelligent learning system that operates on the basis of artificial intelligence, which provides learning content and forms a special environment for learning and testing knowledge on a particular subject in a dialogic form (Chaplinska, 2020). An example of an educational chatbot is the game-based accent learning bot "Baba Katrya" (@KatryaBot). Accordingly, an educational chatbot is a narrower concept and is included in the concept of "chatbot in education/student learning".

In higher education, chatbots can be used to:

- *improving the organization of the educational process* – chatbots can be involved in creating class schedules, sending notifications about changes in the schedule, reminding about the dates and times of important events and deadlines;
- *support for learning using distance technologies*, for example, students can ask a chatbot questions about educational materials, tasks or concepts that caused difficulties and receive an immediate answer and explanation; chatbots can provide feedback on errors in answers and solutions to tasks;
- *increasing the interactivity of learning, gaming of the learning process* – the use of chatbots can facilitate group dialogues and discussions during assignments, allowing students to exchange opinions in text or voice format, coordinate cooperation on joint projects; chatbots can be used to create educational games, tests, quizzes, tasks for testing knowledge, using elements of competition and virtual rewards, providing feedback, instructions and guidance; chatbots can help to create interactive stories in which students, by choosing a certain scenario, will influence the events and development of the plot;

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• *creating an inclusive educational environment and personalizing learning* – chatbots can provide individual support for students with different needs, distribute adapted resources, tasks, and learning materials, help transform learning materials into an accessible format; chatbots can provide students with special needs with alternative ways of communicating, taking into account physical or communication limitations;

• *adaptation of incoming and international students* – chatbots can provide assistance in various aspects of student life; information on the location of classrooms, libraries, canteens and other important campus facilities, internal regulations, requirements for academic activities; answer questions about tuition, tuition fees, visas, temporary certificates; provide language support, translate and adapt the necessary information, help with understanding the educational program, class schedules; provide information about local traditions, events and cultural activities;

• *informing applicants and conducting career guidance* – chatbots can answer applicants' questions about admission, educational programs, requirements and other aspects of study, career opportunities; create and distribute tests to identify interests and aptitudes, recommend appropriate specialties/educational programs based on the results of such testing; inform applicants about open days, career days, excursions to educational institutions, open lectures, information seminars, master classes and other events;

• *providing informational, psychological, legal, social support to all participants of the educational process* – chatbots can provide advice and recommendations on overcoming stress, anxiety and depression, healthy lifestyle and personal development, answers to questions about psychological well-being, well-being and emotional state; become a reliable virtual interlocutor, ensure the expression of their thoughts and feelings without time limits or shame; inform about the rights and obligations of students, teachers, other participants of the educational process; inform about student organizations, volunteer activities, social initiatives; scholarship programs, grants; assistance with organizational issues related to the educational process (changing groups, applications for a break in studies, academic certificates, etc.), additional and optional classes;

• *optimize the activities of teachers* – chatbots can help automate repetitive and routine tasks (answering students' questions about the schedule, educational materials, requirements for completing assignments, etc.); send reminders about meetings, classes, important events, inform about changes in the schedule, deadlines for submitting assignments; help generate reports on teachers' requests for student performance, statistics on attendance at classes; help check and evaluate certain types of assignments and tests; provide and regulate student access to educational materials;

• *improve communication between the administration, teachers and students, to provide continuous feedback* – chatbots can ensure accessibility and convenience of communication between all participants in the educational process, help avoid misunderstandings, ensure continuous and efficient exchange of information; help students and teachers agree on the time and place of meetings for additional consultations, interviews, and other events; collect students' feedback on classes, the content of academic disciplines, provide an opportunity to evaluate and leave feedback on teachers; provide round-the-clock consultations on various issues to teachers and students; enable students and teachers to submit proposals, ideas and feedback on improving the organization of the educational process.

The above list covers only the main application segments and is certainly not exhaustive. It can be supplemented as new problems, needs, and challenges in higher education emerge, and it can be expanded as new chatbots emerge and existing ones improve their functionality.

The use of chatbots for various purposes in the professional activity of a teacher will allow to optimize work, automate repetitive and routine tasks in the following areas: preparation for training sessions and development of methodological support, assessment of the results of students' educational and cognitive activity, provision of asynchronous/synchronous access to educational materials for students, automation of communication with students, organization of working time.

1. Preparation for training sessions and development of methodological support:

• assistance in systematizing the material – processing pdf files, summarizing textual information (HUMATA AI), analysis of text (Consensus, ChatGPT, Supertools) and video content (ChatGPT);

• assistance in cataloging (by topic, section, type of material), sorting, ranking (by date, alphabetical order, popularity), creating packages and storing educational materials with convenient access from any device;

• assistance in finding and filtering the necessary information by keywords, topics, dates, file types, etc.;

• providing recommendations on information presentation, presentation design (Adobe Firefly, Midjourney, Leonardo AI, Gamma, tome, Slides AI, ChatBA);

• assistance in building diagrams, graphs, charts, tables, creating short videos, digital images from text/description (ChatGPT, descript, 2short.AI, Pictory, Dall-E-2, Midjourney);

• translation of support materials (ChatGPT, Deepl, @Multitran_bot);

• spell checker (@Grammarnazibot, @grammer_uk_bot);

• file converters (@toppdf_bot, @newfileconverterbot, @File_convertorbot);

• synthesize text into a voice message, text voice acting (Murf, Lovo, @uk_tts_bot, @voiceru_bot, @taras_voice_bot);

• collecting and analyzing students' opinions and suggestions on interesting/necessary topics or specific issues within the study of the discipline, methods of learning and teaching, assessment of learning outcomes, etc.

2. Assessment of the results of students' educational and cognitive activity:

• automation of assessment of certain types of tasks;

• collecting and analyzing information on the results of student assessment;

• notifying students of their grades, providing feedback and advice on their work, opportunities to improve their results, and recommending additional materials;

• help with test preparation (ChatGPT, ExamCram);

• recommendations on practical tasks;

• monitoring student progress and sending information about progress.

3. Providing asynchronous/synchronous access to learning materials for students:

• the possibility of placing educational materials (including multimedia), file documents (@Filetobot);

• management of access to educational materials (limited / unlimited access);

• the option to program a mailing at a specific time (@Skeddybot).

4. Automating communication with students:

• answers to frequently asked questions regarding the study of the discipline, the procedure for assessing and completing assignments, rules of conduct, exams and tests;

• safety instructions;

• prompt notification of changes in the schedule;

• providing recommendations and tips;

• additional literature, common mistakes in completing assignments;

• providing individual feedback on the results of assignments;

• sending reminders to students about upcoming deadlines for assignments and projects;

• registering students for consultations with the teacher;

• student surveys and voting (@pollbot).

5. Organization of the teacher's working time:

• providing information and notifications on class schedules, scheduled meetings and events (AlertBot, @task_reminders_bot, @Skeddybot);

• organization of meetings, consultations;

• reminders of deadlines for students to complete assignments.

All of the above steps can be performed with the help of existing chatbots and those created independently using online constructors (Corezoid, Goodpromo, SMMBOT, SendPulse, Gerabot).

There are several ways to learn how to effectively use chatbots and build them yourself: online courses, studying online resources (blogs, video content, articles) and training materials on chatbot platforms. There are a number of online courses, webinars, and trainings that will help teachers acquire the necessary competencies to use artificial intelligence technologies in the educational process and develop the existing ones, for example:

"Fundamentals of AI" ("Основи AI") is a course by Google Ukraine and the Ministry of Digital Transformation of Ukraine aimed at acquiring practical skills for the effective application of artificial intelligence without technical experience;

"Getting Started with ChatGPT" ("Початок роботи з ChatGPT") – the course by Oleksandr Krakovetskyi (on the Prometheus platform) that will teach how to create high-quality queries to ChatGPT and use artificial intelligence to solve various tasks;

"Make Teaching Easier with Artificial Intelligence (ChatGPT)" – the course by Anthony Bohrinis (on the Udemy platform) designed to teach teachers how to use artificial intelligence to automate administrative and routine work (planning classes, creating test tasks, providing feedback to students, grading assignments, etc.);

"AI for Everyone" – the general course from Coursera that will introduce the possibilities of artificial intelligence and help you understand the ethical and social debates around artificial intelligence;

"Automate Useful Professional Tasks using Open AI" – the course by Mick Jones (on Class Central and YouTube) aimed at understanding how to optimize working hours using artificial intelligence technologies;

"Time Management with ChatGPT" – the course from Sri Harsh Navundru (on the Udemy platform), which will teach you how to use time management techniques in everyday life, create a personal schedule, prioritize tasks, and increase productivity using ChatGPT, Google Keep and Google Calendar;

"ChatGPT Teach-Out" – the course from Coursera that will introduce the capabilities of artificial intelligence tools, the principles of chatbots, and consider the ethical aspects of using ChatGPT results;

"Learn Prompting" – the course that will teach you how to write queries and tasks for ChatGPT and other artificial intelligence tools.

Discussion and conclusions

Chatbots are a modern, innovative, multifunctional artificial intelligence tool that is actively used by higher education institutions to increase the interactivity of learning, organize online learning, and support learning using distance technologies. Chatbots help to organize the educational process for both teachers and students, personalize learning, and adapt the educational environment to the needs and capabilities of a particular user.

Chatbots make it possible to optimize the activities of teachers, automate repetitive and predictable tasks, support the mobility and accessibility of the learning process, and improve the interaction between teachers and students.

References

Cabinet Ministriv Ukrainy. (2020). *The concept of artificial intelligence development in Ukraine*. (Order dated December 2, № 1556-p) [in Ukrainian]. [Концепція розвитку штучного інтелекту в Україні, *Кабінет Міністрів України*. (Розпорядження № 1556-р 2020, 2 грудня)].

Chaplinska, Y. (2020). Possibilities of using chatbots in the educational sphere. In Dyatel N.L. (ed.) *Media Creativity in Modern Realities: Confronting Media Trauma: June 19, 2020. Materials of the All-Ukrainian Scientific Internet Conference (with international participation)* [in Ukrainian]. [Чаплінська, Ю. (2020). Можливості використання чат-ботів в освітній сфері. У Н. Л. Дятел (Ред.) *Медіакреативність у сучасних реаліях: Протистояння медіатравмі. Всеукраїнської наукової інтернет-конференції (з міжнародною участю), 19 червня 2020 р.*]. http://mediaosvita.org.ua/wp-content/uploads/2020/06/Chaplinska.pdf

Cunningham-Nelson, S., Boles, W., Trouton, L., & Margerison, E. (2019). A review of chatbots in education: practical steps forward. In *30th annual conference for the australasian association for engineering education (AAEE 2019): educators becoming agents of change: innovate, integrate, motivate*. 299–306. Engineers Australia. https://aaee.net.au/wp-content/uploads/2020/07/AAEE2019_Annual_Conference_paper_184.pdf

Dimitriadis, G. (2020). Evolution in education: chatbots. *Homo Virtualis*, 3(1), 47–54. https://ejournals.epublishing.ekt.gr/index.php/homvir/article/view/23456.

Donovska, D. (2019) Chatbots Are Changing Education [Trends And Predictions]. https://chatbots.studio/blog/chatbots-are-changing-education-trends-and-predictions/

Nalyvaiko, O., & Maliutina, A. (2021). Use of chatbots in the educational process of a higher education institution. *Scientific Notes of the Pedagogical Department*, 48, 117–122 [in Ukrainian]. [Наливайко, О., & Малютіна, А. (2021). Використання чат-ботів в освітньому процесі закладу вищої освіти. *Наукові записки педагогічного факультету*, 48, 117–122. https://periodicals.karazin.ua/pedagogy/article/view/17553].

Smutny, P., & Schreiberova, P. (2020). Chatbots for learning: A review of educational chatbots for the Facebook Messenger. *Computers & Education,* 151. https://www.sciencedirect.com/science/article/pii/S0360131520300622

Trofymenko, O., Prokop, Y., Zadereiko, O., & Lohinova, N. (2022). Classification of chatbots. *Systemni tekhnologii,* 2 (139), 147–159 [in Ukrainian]. [Трофименко, О., Прокоп, Ю., Задерейко, О., & Логінова, Н. (2022). Класифікація чат-ботів. *Системні технології*, 2(139), 147–159].

Ushakova, I. (2019). Approaches to creating intelligent chatbots. Systemy obrobky iformatsii. *Mediatvorchist v suchasnykh realiiakh: protystoiannia mediatravmi*, 2(157), 76–83 [in Ukrainian]. [Ушакова, І. (2019). Підходи до створення інтелектуальних чат-ботів. Системи обробки інформації. *Медіатворчість у сучасних реаліях: протистояння медіастратегіям*, 2(157), 76–83]. https://journal-hnups.com.ua/index.php/soi/article/view/soi.2019.157.10

Winkler, R., & Söllner, M. (2018) Unleashing the Potential of Chatbots in Education: A State-Of-The-Art Analysis. *Academy of Management Proceedings*, 1. https://www.researchgate.net/publication/326281264_Unleashing_the_Potential_of_Chatbots_in_Education_A_State-Of-The-Art_Analysis

Wollny, S., Schneider, J., Di Mitri, D., Weidlich, J., Rittberger, M., & Drachsler, H. (2021). Are we there yet?-a systematic literature review on chatbots in education. *Frontiers in artificial intelligence*, 4, 654–924. https://www.frontiersin.org/articles/10.3389/frai.2021.654924/full.

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Оксана ЖИХОРСЬКА, канд. пед. наук, асист.
ORCID ID: 0000-0001-9722-3160
e-mail: oksanazhykhorska@knu.ua
Київський національний університет імені Тараса Шевченка, Київ, Україна

ВИКОРИСТАННЯ ЧАТ-БОТІВ У НАВЧАННІ СТУДЕНТІВ

Вступ. *Розглядаються аспекти використання чат-ботів в освіті та їхній потенціал для оптимізації роботи викладачів і поліпшення процесу навчання.*

Визначено сфери діяльності викладачів, у яких використання чат-ботів для різних цілей дозволить оптимізувати роботу, автоматизувати повторювані та рутинні завдання: підготовка до занять і розробка методичного забезпечення, оцінювання результатів навчання студентів, забезпечення доступу студентів до освітніх програм. матеріали, спілкування зі студентами, організація власного робочого часу.

Подано перелік онлайн-курсів, які допомагають викладачам ефективно використовувати чат-боти у професійній діяльності та самостійно їх розробляти.

Мета і завдання. З'ясовано, що використання чат-ботів може вдосконалити організацію навчального процесу; поліпшити підтримку навчання з використанням дистанційних технологій; підвищення рівня інтерактивності й ігровості навчального процесу; сприяти створенню інклюзивного освітнього середовища та персоналізації навчання; спростити процес адаптації абітурієнтів та іноземних студентів; підвищити якість інформування вступників і проведення профорієнтаційної роботи; автоматизувати надання інформаційної, психологічної, правової, соціальної підтримки всім студентам.

Результати. *Загалом використання чат-ботів у навчанні студентів відкриває багато нових можливостей для забезпечення ефективної, доступної та сучасної освіти, яка відповідає вимогам сучасного суспільства й ринку праці. Чат-боти активно використовуються закладами вищої освіти для підвищення інтерактивності навчання, організації онлайн-навчання, підтримки навчання з використанням дистанційних технологій.*

Висновки. *Чат-боти допомагають організувати навчальний процес як викладачам, так і студентам, персоналізувати навчання, адаптувати освітнє середовище до потреб і можливостей конкретного користувача.*

Ключові слова: *навчальний процес, чат-бот, штучний інтелект, вища освіта.*

Автор заявляє про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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