STEMBOT

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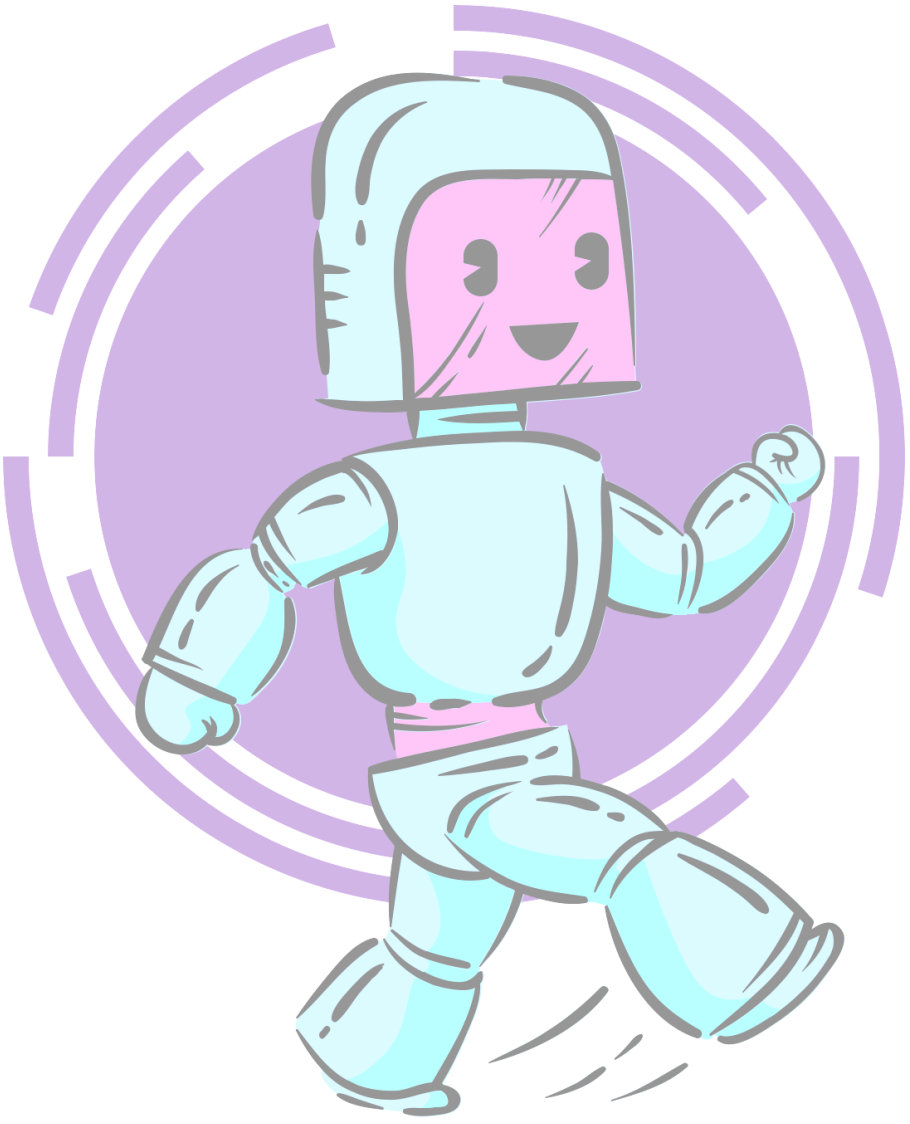
Pedagogical guide

Using STEM bot or similar in formal learning process



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INTRODUCTION

Most of us have gone through and are familiar with formal education – a structured form of education arranged in fairly rigid tiers from primary to university, based on formally adopted curricular, with a clear and often mandatory process of assessment of students' skills and learning competences. Graduates of formal education are issued certificates or some other types of recognition of completion of each level or degree. Vocational schools and centres, sharing all the characteristic features mentioned above, also belong to formal education. In recent years, however, non-formal and informal ways of teaching have come to the fore in the educational field.

This manual will look at the importance of STEM education in schools conducted through hands-on experience and analyse in detail why and how such applications as STEMbot can be useful in education at large and STEM-education in particular. The manual will also provide readers with practical examples of using STEMbot in the classroom, with specific focus on learners' individual aims and needs, as well as ways to promote inclusiveness using chatbots.

According to research (Donovska, 2020), 37 percent of educational organizations around the world already use artificial intelligence including chatbots for learning and organizing the educational process. At the same time, the survey shows that students and pupils are satisfied with the interaction with the program and believe that it helps better than a living person. The number of chatbots in education, as well as in many other areas, is growing rapidly from year to year. According to a study by Business Insider, the global chatbot market will grow from $2.6 billion in 2019 to $9.4 billion by 2024 in the near future.

1. INFORMAL AND NON-FORMAL EDUCATION - INNOVATIVE WAYS OF TEACHING

The following definitions are taken from the Benchmarks Manual of European council (European youth foundation).

- **Non-formal education** covers all planned structured programs and processes of individual and social education aimed at young people and aimed at improving a range of skills and competences, outside the formal education curriculum. It is an experienced-based learning which requires active participation, so «learning by doing».
  For example, it can be organised by educational activities that are intended to serve an identifiable learning clientele like students for example, with identifiable learning objectives used in places such as youth organizations, sport clubs, associations...

- **Informal education** is the process of learning throughout a person's life, by which he adopts behaviours and values and acquires skills and knowledge based on the educational influences and resources of his own environment and everyday life. You learn everywhere: in your family and neighbourhood, at the library, by visiting art exhibitions, through play, reading and sport, by watching documentaries...

1.1. The advantages of informal and non-formal education

First, it is important to see how these innovative learning approaches, non-formal education and informal education, can be beneficial for students and what are the advantages.

For a long time, these innovative approaches were in opposition to the formal education found at school, but thanks to several studies and research carried out, today they are seen as complementary and a tool made available both for students than for teachers. It is the inadequacies of the “classical school system” that have aroused this increasing interest in non-formal forms of learning as a complement to the school.

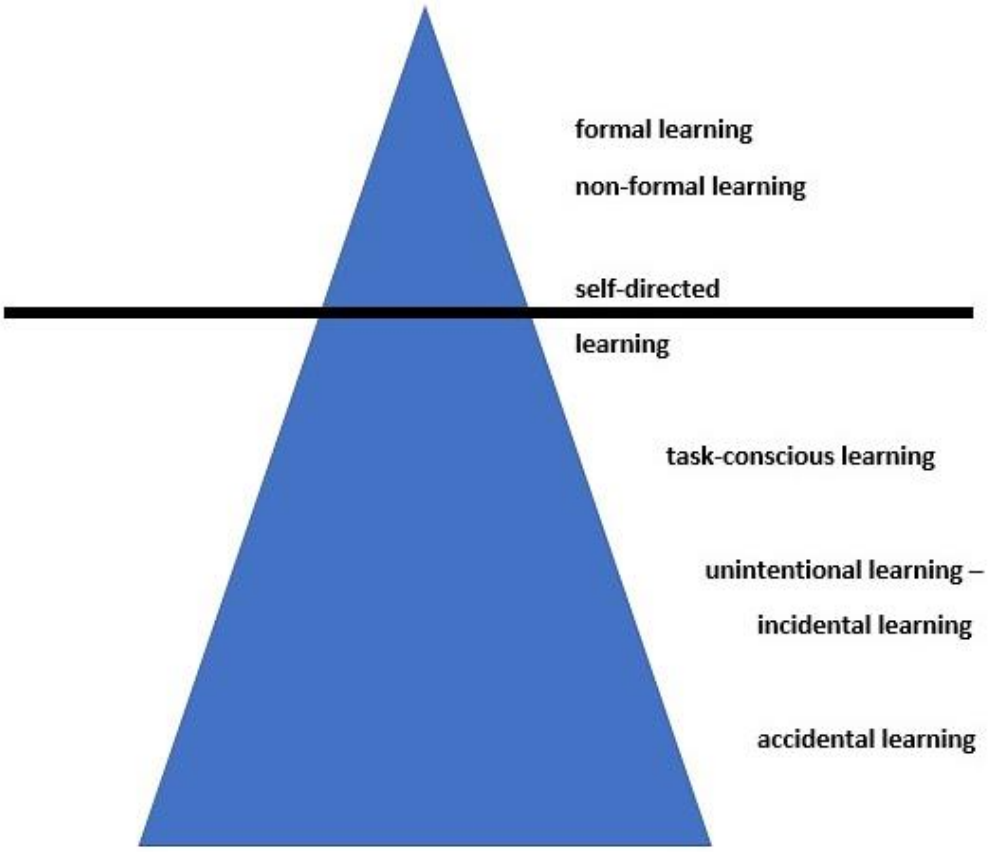

Image 1: The iceberg of learning. [Figure]. Fermat Science.

In fact,this interest is explained by advantages of innovative approaches for socio-economic and socio-cultural development, especially after the disappointing result of a school model whose educational content is ambitious but neither practical nor concrete, often away from students’ everyday lives.

These observations motivate, from many authors, the metaphor of the iceberg, whose visible part, only visible and only studied, designated school education, and whose submerged part, little apparent and little studied, comes from learning informal (CEDEFOP, 2003).

The limit on formal education is that we follow neither the interests, nor the rhythm, nor the needs of the child, who remains quite passive in the development process. Fortunately, innovating ways of teaching come as a compliment by covering needs or certain aspects that are missing in the regulated institution.

As seen previously, non-formal learning is embedded in planned activities that are not explicitly designed as learning activities (in term of objectives, time or resources) but which have a strong learning element. Non-formal learning is intentional on the part of the learner. It is a more open type of education: the principle is to enrich the environment with various activities, to let each child go towards what interests him, and not to impose any activity or timing. Thereby, a child can play with Legos, while the other paints, and a third reads a book.

The activities are individual, or in groups, autonomous and the adult is there to accompany the children at their own pace. The Montessori pedagogy, for example, is part of the non-formal pedagogies: each child goes about his or her business in a prepared environment. With non-formal learning, the priority goes to the autonomy of the students so that they succeed more.

“With non-formal learning, the priority is to empower students to be more successful, unlike traditional education where they are in the position of learners.”

(Louis Debono, Teacher at De La Salle High School in Malta)

With regard to informal learning, it arises from activities of daily living related to work, family or leisure. It is neither organized nor structured (in terms of objectives, time or resources). Informal learning is mostly unintentional on the part of the learner.

It is the fact of finding learning in daily life, in an open and lively way: baking allows, for example, to learn fractions, the properties of elements, emulsion, transformation, language, autonomy... Informal education is traditionally practiced at home, with grandparents, in the playground... but it can very well take place in a school: this is the principle of democratic schools. Most non-formal pedagogies can also have large informal aspects. Here too, the enrichment of the environment is essential.

The contribution of these innovative learning approaches is multiple. Non-formal education and informal education are deeply connected to the needs and interests of children. By allowing them to make choices and respecting these choices, we help them to grow serenely. Similarly, by not prioritizing learning, we allow the necessary decompartmentalization for children to integrate skills, and this, in a more fluid way. Children learn just as well, or even better!

"**Informal education is one in which the learning process is a process of osmosis between the learner and his environment. Whatever the type of education to which social group subscribe, informal education appears as an essential extension in the tools of individuals**."

(David R. Evans, Professor and Researcher, 1981)

Clearly, learning cannot be separated from a strong desire to learn on the part of students. In this sense, the proposed innovative approaches stimulate interest and autonomy, which encourage learners to research and communicate on the results of their work. These approaches, therefore, lead to the development of communication between people, which is one of the main components of skills-based learning and, of course, the collaborative dynamic. This learning process improves self-confidence and creativity. Make proposals, check hypotheses, try solutions, analyses results, make modifications...

Today, informal learning has become essential in the design of training paths from early childhood to school age and throughout life.

1.2. The benefits of practical experiences in STEM education

We have seen previously that there are several approaches to learning methods. For a long time, there was a division between formal and informal or non-formal education. Thanks to studies and research, it is clear that these different forms of learning are complementary. It is therefore important that learners have access to them, in order to maximize their learning.

Innovative approaches to learning emphasize the value of hands-on experiences for knowledge assimilation and cognitive development. This is even more important for STEM, which is the combination of the four specific academic disciplines of science, technology, engineering, and mathematics into one coherent learning experience. Instead of teaching subjects separately and exclusively in a formal way, combining STEM programs with innovative approaches to learning more meaningfully develops the areas of creativity, critical thinking, confidence, resilience and more.

One thing that stands out in STEM learning is that, very often, these subjects seem too theoretical and complicated for students and, according to an American study (Kennedy et al., 2015), 52% of students report that it is too difficult because it appears too abstract. Through innovative learning pedagogical approaches and experiments, it is possible to prove them wrong and make them want to acquire or deepen their learning in this field. This will help restore imagination to alienated or undermotivated students and improve the atmosphere in the classroom.

It has been found that supporting STEM education with hands-on experiences can help facilitate students' love for science and math. Engaging and meaningful activities successfully implement this approach. For example, computer coding is known to be a language of the future. It allows students to use their creative, scientific technical and mathematical minds.

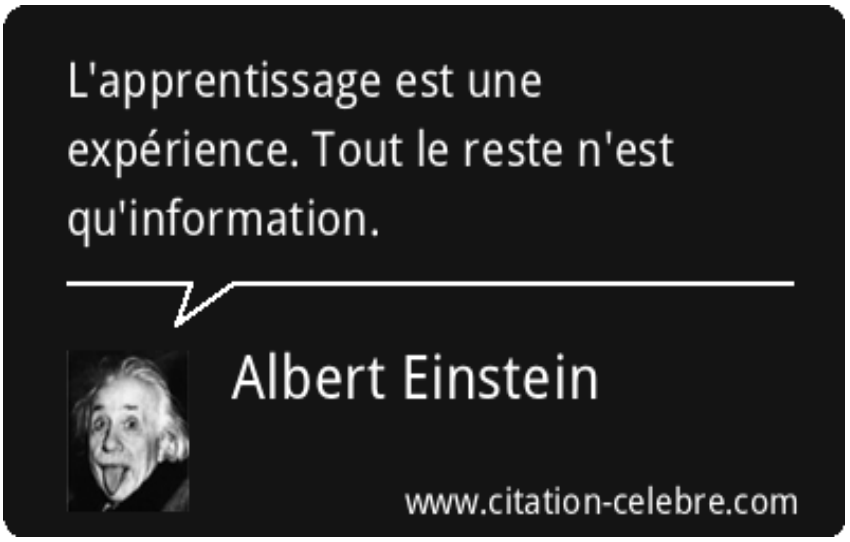

Image 2: Learning is an experience. Everything else is information. [Image]. retrieved from www.citation-celebre.com .

"Learning is an experience. Everything else is information."

In our time, it is critical to engage students to learn these STEM subjects. As studies show, most careers will be STEM-centric or have STEM components. Thus, by introducing hands-on experiences in STEM learning early in a child's life, you are introducing them to a world of possibilities and imparting the skills they need to succeed in the 21st century.

In addition, a curriculum based on hands-on learning experiences and focused on learning how to use technology increases collaboration, connectivity, and interactivity.

By participating in hands-on projects using a variety of tools, students can use the STEM experiences, to become more proficient and improve their mastery in

different areas such as the digital realm through computer programs like Google Drive, cloud computing, etc....

In addition, group activities during the learning process foster social skills such as active listening and open-mindedness. It opens them up to giving and receiving constructive feedback. Thus, students will be encouraged to answer questions or solve problems not based on memorization but based on actively engaging with the material to understand the issue at hand and solve it using logic.

Image 3: Incorporating "fun" into learning. [Photo]. Retrieved from https://www.evelynlearning.com .

Communication skills are essential as well. The ability to discuss and convey complex concepts to others while learning from each other will be the key to a child success as they grow up. Experiencing situations like this early in their education will better prepare them for their future. Hands-on experiences boost curiosity, improve cognitive skills and develop children's critical thinking engagement in this field.

By incorporating "fun" into learning, you can create an atmosphere of engaged learners and avoid the dreaded stale and stressful STEM classroom that reduces engagement and hinders learning.

1.3. How to use a more hands-on approach in teaching STEM

1.3.1. Hands-on approach – pros and cons

Hands-on approach is an essential technique for learning STEM, as it helps children to understand the essential concepts behind the theoretical knowledge of STEM subjects easier and more fun.

Traditional lessons have been an established model of learning for centuries, but the future requires new knowledge and new skills from children, to which their education must also adapt. At this point, STEM activities and the STEM way of learning using a hands-on learning approach can help a lot.

Image 4 and 5: Engaging students with hands-on learning activities. [Photos]. Retrieved from Canva Stock.

Practical learning has many advantages and benefits for students combined with conventional theoretical learning, but we can also highlight some of the problems that teachers face implementing hands-on learning process in the classroom.

Pros

Many children respond better to hands-on activities than to written exercises, which makes perfect sense given the amount of energy children radiate! Inquiry and play are in children's' nature, so activities that require their involvement and cooperation with a small amount of ingenuity can be very appealing to them. This means that students will be more involved in their learning and not just see it as a boring chore.
Active participation attracts students and creates interest in the topic and at the same time the specific subject they are studying. If children actively experience something, they remember it more, because all their senses are involved in the activity, and not just visual perception and touch (Dhanapal et al., 2014).

Students understand the matter at a higher level than is possible only by learning the theory from a book, because they can more easily put it in a different context, improve the idea and see problems and mistakes. It enables students to directly observe and understand what is happening and it leads to deeper understanding and better long-term memorization (Ekwueme et al., 2015).

Through effective teaching, students can learn the skills that are important to successfully perform most jobs in the 21st century, whether they are careers in STEM or any other field. Students acquire important life skills - independence, persistence, and adaptability when working in a group, as well as the elements of cooperation and teamwork. These experiences are often neglected in a situation where students are simply told facts and forced to memorize them.

Another advantage of STEM activity is that the activities can be adapted to different age groups, abilities, group sizes and interests and therefore are great for use in all teaching and learning environments. Students will also have some freedom in their lessons, so they will work more engaged and take more risks freely.

Image 6: Hands-on learning promotes improvement of 21st century skills. [Photo]. Retrieved from Canva Stock.

Cons

Many people doubt the effectiveness of this approach, and teachers are often completely without experience and practical knowledge. Although they want to bring experiential learning to their students, they do not know where to start and how to manage the situation during classroom activities. The teacher should know where and how to direct the students in order to get the most out of the learning activity. Without guidance and support, the tasks are ineffective.

Experiential learning also requires a different form of assessment, as the teacher must assess acquired skills rather than detailed theoretical facts. It takes time to plan and implement the activity and also some costs if we want to use some special material, equipment or transport.

However, it is necessary to start looking at learning in a more practical way as soon as possible, where the experiences and reflections presented to the students play a key role. Only in this way will we be able to properly equip students for the future, with knowledge and skills.

Image 7: Interaction among students and teacher is a key to successfull STEM class. [Photo]. Retrieved from Canva Stock.

1.3.2. Important features of a hands-on approach in STEM

There is no doubt that actively involving students in the educational process will improve their education. Both traditional learning and hands-on activities can be part of the learning experience that children will truly remember, just like the theory behind it. Hands-on learning is effective in providing a foundation for knowledge and understanding, but in some cases fails to develop ideas to a higher level. It is up to the teachers to make the effort and invest some time to prepare and use the dedicated resources and try to incorporate STEM activities into their lessons and thereby provide students with hands-on learning experiences.

Features, offered through STEM hands-on learning, are:

- **Interdisciplinary approach:**

A hands-on STEM teaching approach facilitates multidisciplinary teaching. It contains a scientific way of thinking that can help teach STEM subjects, as well as others such as art and history, in a practical way. This analytical approach helps to make the lessons more innovative and not only theory but also practice. Teachers and students will find ideas and guidance in this guide on how to incorporate hands-on experiences into your course and offer connections to other courses as well. The sky is the limit when we look at subjects from a STEM perspective.

- **Acquire knowledge through their own experiences in the examples from the real life.**

This means that it allows students to manipulate objects such as plants, rocks, water, magnetic field, scientific instruments, calculators and shapes while studying. In fact, it is a process of conducting scientific inquiry where students become active participants in the classroom. The students' shared learning experience will also increase their ability to think critically. Since the average retention rate for lecture-based learning is 5%, while the retention rate for on-the-job (activity-based) learning is around 75% (Letrud, 2012) it can be seen that retention rates increase progressively with the use of more interactive and activity-based learning directed learning methods.

- **Using inexpensive resources to produce teaching materials for teaching science and mathematics.**

Everything can be used as a learning material, which encourages students' creativity, and we also bring them closer to the idea of recycling and caring for our planet.

Image 8 and 9: Everything can be used as a learning material. [Photos]. Retrieved from Canva Stock.

- **Using innovative technologies for education.**

New technologies offer many different approaches for experiential learning – using virtual reality, 3D printing, using educational apps or chatbots on smartphones and tablets, and much more. Some of them require special equipment (for example 3D printers or a virtual reality device), but some things can also be done at minimal cost, through the use of tablets or smartphones that are accessible to students, as using the STEMbot. It will be available to all users, accessible via phone, tablet or computer with an internet connection.

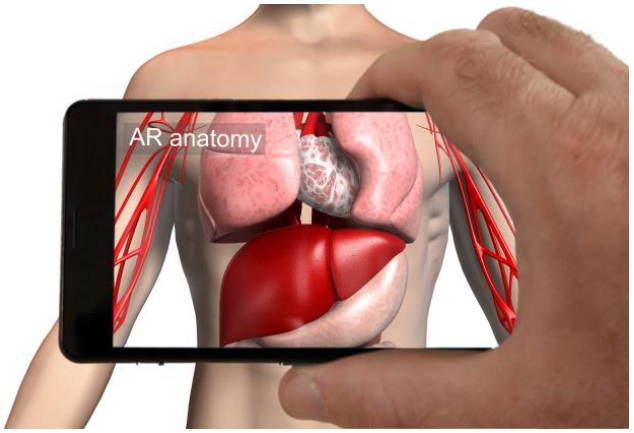

Image 10: Use of innovative teaching tools, as augmented reality, on smartphones. [Photo]. Retrieved from Canva Stock.

1.3.3. Presenting practical STEM examples how hands-on activities can be implemented in classroom.

STEM teaching is not only a more engaging learning experience for students, but it can also be more interesting for teachers. In general, in STEM activities, less attention is paid to learning the content itself for teaching and more to creating an environment that encourages creativity and interest.

In this paragraph you can find some tips to implement hands-on STEM activities in your classroom:

1. Determine the topic of the lesson - what you want the students to learn. For example, if you decide to teach your students about light, you can present them the theory behind the activities as Newton's disk or a rainbow, done with simple materials as paper, colour pencils, scissors, glue, CD, soap bubbles, water and flashlight.

Image 11-15: Rainbow can be used in different teaching aspects and connections in STEM activities (geometrical shapes, light wavelenghts, soap bubbles, weather, colour theory, Newtons disk, etc.)... [Photos]. Image 11-14 retrieved from Canva Stock, image 15 copyrighted by GoINNO.

2. Choose a STEM activity suitable for your classroom, according to the age, group and knowledge of the students; look for inspiration on the internet, in the resources of Erasmus+ projects, in books presenting STEM activities... The activity should be challenging enough to give students an opportunity to think, but easy enough to be able to carry it out on their own, with minimal help and

guidance from the teacher. The activity should imitate a problem from real life, something that students know and can identify with to increase interest in doing the activity.

3. Decide how the students will perform the activity, individually, in pairs or groups. However, it must be ensured that all students are actively involved.

4. Materials: Prepare enough materials for all participants, do not forget some additional prepared materials, just in case. Choose cheap and easily accessible materials, you can also ask the students to bring them from home, and thus include them already in the pre-preparation of the activity.

5. Before starting the activity, test it to see if it works and to familiarize yourself with possible problems and complications. Prepare the material in advance, because this can take more time and if you do it during the activity itself, the students can quickly get bored and lose interest. If you can, get someone to help you prepare and lead.

6. If necessary, **divide the students into groups** and start the activity. First, present the result to them, distribute the material and let them make and learn alongside it.

7. During the activity, the teacher should be available to the students to solve any complications, especially by encouraging their questions and his/her own solutions. Let the student sometimes make a mistake, because it will effectively learn the correct procedure for solving a problem. The teacher should encourage the student to divide the work in the group, but make sure that all of them are still actively involved.

8. Children are always excited if they can take home something they made themselves. If we offer easily accessible and cheap or even recycled materials to make the product, we can allow children to take their product away with them.

9. Hands-on activities are excellent for carrying out as part of different based learning - project-based, problem-based and inquiry-based learning. If you decide to do it this way, it is more time-consuming, but the students acquire additional skills, and it requires more creativity and perseverance.

10. Use maths and science in hands-on activities - make it relevant to the activity and serve a purpose, e.g., an equation from mathematics can ensure that the product works correctly or knowledge of physics allows the product to work properly.

2. CHATBOT IN EDUCATION

2.1. Introduce the concept of chatbot in education

2.1.1. Chatbots in general – history and nowadays applications

A Chatbot is an intelligent agent capable of interacting with a user to answer a series of questions and provide the appropriate response (Clarizia et al., 2018, pp. 291–302). In other words, it is a computer program that mimics and processes human communication, enabling people to interact with digital devices as if they were talking with a real person (Ciechanowski et al., 2019). The first chatbot was developed in 1950 with the Turing Test. Computer pioneer Alan Turing suggested that if a text-based bot could fool 50% of people, it could be considered "intelligent." So, in order to pass Turings' test, a computer must be able to carry on a conversation that is indistinguishable from a conversation with a human being. It took a while until the technology was adopted and developed further. As technology advances, creation of modern chatbots follows, for example SmarterChild, Apple Siri, Amazon Alexia, IBM Watson, Microsoft Cortana, and Google Assistant. Since 2016, there is a rapid growth on chatbot development which results to the creation of various types of chatbot systems for industrial uses.

How does talking with a chatbot in an education environment work? AI chatbots can be used to personalize the learning experience, guide learners through the learning process and answering to their questions. Chatbots can create a learning experience similar to one-on-one teaching, making social and

interactive learning dialogue with an end-device possible. It can provide point-of-need training support by delivering media content, such as links, images, videos, etc.

Chatbots typically:

- Target a specific use-case.
- Provide a service.
- Use natural language to perform a task or provide service.
- Focus on answering certain types of questions.
- Chatbots that work in context know who you are and know what you want to do, and can provide intelligent answers.
- Are easier and more intuitive to use than applications that you have never used before and they navigate between screens, tabs or menus.

Nowadays, dynamic generative chatbots (like ChatGPT) represent the latest evolution in chatbot technology, quickly becoming the new standard. These AI-driven platforms use advanced natural language processing to generate real-time, human-like responses, offering an unprecedented level of interaction. They learn from each conversation, constantly improving and adapting to meet users' needs. This ability to handle a wide range of topics and create responses really fast has significantly enhanced user experience, setting a new expectation for intelligent, conversational AI across various sectors. They can be widely used also in the education area.

2.1.2. Applications of chatbot in education – now and in the future

We are constantly in pursuit of better, faster, and deeper ways to learn as education nowadays is more accessible than ever before with online learning tools. Modern chatbots can substitute the one-way conversations that offer learners with generic information (documents, videos, and "next" buttons), and start with tailor-made interactive training elements, which can lead to engaged learners with high knowledge retention and put them in control of their learning journeys.

According to a review made by Okonkwo in 2021, the number of studies on the use of chatbots in the educational domain is rapidly increasing. Chatbot technology has seen extensive integration in the education sector. The most common uses in education sector are as follows: 66% of the reviewed studies in this paper were applied to the teaching and learning aspect of education, 19% dealt with research and development areas, and 6% focused on student assessments. Administration and advisory research accounted for 5% and 4% of the total proportion, respectively.

1. Teaching and Learning: Chatbots can be used to deliver course content to students via an online platform as a conversational agent, capable of providing accurate information to users or providing an engaged experience. Students can use these chatbots to ask questions and get responses or individualized help, which leads to personalised online learning and makes learning materials accessible to students anywhere and anytime. Studies have revealed that chatbots can improve student learning interest, acquisition of cognitive skills, and achievement (Lin & Chang, 2020; Murad et al., 2019; Troussas et al., 2017)

2. Administration: It can deliver administrative tasks and function as a digital assistant, advising tertiary institutions on how to improve their current services, furthermore, giving administrative support to students on matters such as orientation, recruitment, and retention which enables students to have easy access to important information such as admission processes and scholarship. It can be used to support teachers and students with the execution of various administrative tasks in the education process, such as evaluating students' assignments, scoring, and providing feedback to students.

3. Assessment: Chatbots can be used to create an automated and intelligent teaching system that enables teachers to analyse and assess a student's learning ability. Chatbots provide students with learning materials, tests, and quizzes and record students' answers. When the tests are finished, the chatbots collect the results and send them to the teachers, allowing them to keep track of their students' progress.

4. Advisory: to provide advice to students on academic issues, thereby helping them to make some vital decisions on their various academic programmes or activities.

5. Research and Development: Some chatbots can provide research and development assistance to students by appropriately responding to conversations on academic research-related issues. For example, a chatbot system that can teach STEM-related research concepts to students (Ureta & Rivera, 2018) or assist students in retrieving information from various sources such as Wikipedia and supporting the training of students from various areas of knowledge in order for them to gain practical knowledge of their profession (Paschoal et al., 2018, pp. 839–848).

What are the potential future steps that could benefit from the use of Chatbots?

Future work should be applied to technological advancements, ethical principles development, and usability testing. This implies that the frameworks for the development and implementation of chatbots, as well as designed features and contents, must be improved.
With a higher number of chatbots users, it is necessary to have well-defined general rules for using chatbots that are compatible with user ethics. More research into the functionality of chatbot systems is also required, which will contribute to chatbots' positive impact on education.

2.1.3. Pros and cons

The use of chatbots in education has the potential to significantly improve learning outcomes and student happiness (Winkler & Soellner, 2018).
Chatbots have been perceived to benefit the educational system in a variety of ways, including:

Integration of Contents: Teachers are able to upload all necessary information about a specific subject to an online platform for easy access by authorized students, which includes the topics covered, as well as a timetable for assignments, tests, assistance, and examination.

Quick Access: Educational information can be quickly accessed which helps to save time and maximize student learning abilities and achievement.

Motivation and Engagement: Nowadays, learning through online platforms is commonly used among students. They would rather use their smartphones to browse and read information online than read textbooks. Students are kept motivated and engaged by interactive systems such as chatbots, allowing them to study in an exciting and comfortable environment; it also aids in increasing student engagement.

Allow Multiple Users to access the system at the same time. Many students from different locations can interact with a particular Chatbot without interruptions and obtain the required information.

Immediate Assistance: The usage of Chatbots in education enables students to obtain rapid replies to their queries and activities, instant support during individual learning, helps students to automate their activities such as submitting homework, responding to emails, adapting to learners' actions and emotions, as well as getting instant answers to their questions.

The adoption and use of chatbots in education also raise some challenges, including ethical, insufficient evaluation, user attitude, programming, and data integration issues (Chatterjee & Bhattacharjee, 2020; Rahman et al., 2017).

Ethical Issue: Users utilize natural language to communicate with Chatbots automatically. As a result, the use of chatbots, particularly in education, raises some ethical concerns, facing the use of a conversational agent, including plurality of approaches, trust and transparency, privacy, and agent person.

When creating a chatbot, it is important to consider the application domain and target user group and use contextual and plural approaches instead of abstract

principles. The functions of any chatbot should be explicitly detailed and users should decide on how to interact with the bot. Understanding a user's expectations of an agent is critical for avoiding abuse of the user's trust.

Evaluation Issue: Evaluating chatbot design solely based on its effectiveness, utility, and ability to fulfil and engage people do not seem sufficient. To test the usefulness of Chatbot systems, an appropriate process for evaluating the effectiveness of a software engineering product should be used, along with a larger and more significant sampling population.

User Attitude Issue: Another challenge facing the use of Chatbot systems in education revealed by the review of the selected articles is the user's attitude. If students have negative perceptions of Chatbot technology applications in education, they will be hesitant to adopt and use the technology. Positive perception of an innovation accelerates adoption.

Programming Issue: The creation of a chatbot involves the use of Natural Language Processing (NLP). NLP is a technology that enables machines to comprehend, analyse and interpret natural human languages. The issue is "How can a chatbot be programmed to give an accurate response?" Users' questions can come in different forms requesting for the same response. Chatbot systems should be able to learn how to provide appropriate answers to users, which can be accomplished through effective programming.

Supervision and Maintenance Issue: The development and implementation of effective and useful chatbots for educational purposes requires proper supervision and maintenance. Supervision ensures that the chatbot's input and output data are correct, and that the system's operation meets the design

objectives. Maintenance ensures that the chatbot is working properly and that the system's data bank is up to date. The user expects the chatbot system to provide accurate answers to each question, which is possible only when the input data are correct.

Furthermore, the information stored in the bot should be updated on a regular basis so that the chatbot can provide current and accurate information on any subject. The more data the bot has to deal with, the longer the search takes. This implies that building a chatbot system is a continuous process that necessitates consistent supervision and maintenance, which can be time-consuming and not an easy task.

2.2. Examples of how and why using a chatbot in STEM education

Chatbots are good technological innovations that improve student learning interest, acquisition of cognitive skills, and achievement. Chatbot systems are primarily used in the educational context for teaching and learning. Studies have shown that chatbots can be used to deliver course content to students via an online platform as a conversational agent capable of providing accurate information to users. The introduction of chatbot systems in education enables personalised online learning and makes learning materials accessible to students anywhere and anytime.

Education is evolving in lockstep with changes in the professional sector, demanding the use of Artificial Intelligence (AI) in teaching and learning. Chatbots may be used to model a student's learning style using natural language discourse in order to forecast and personalise their learning session.

Technology in the classroom seems like an obvious addition at first glance. Children are growing up with tablets in their hands, so teaching them about new technology and programs will only serve to prepare them for the wider world. Not to mention, technology can make a teacher's job much easier. However, there is also the complaint of devices causing a distraction and becoming more of a problem than a help.

Technology is getting better at education, though. The more we advance, the more tech is able to learn from us. Artificial intelligence, or AI, is becoming more common in the average person's life. Bringing AI and chatbots into education can be a game changer if they are used correctly.
Examples where technology in education can help:

- **Combine Student and Tech**

Not having some sort of technology in the classroom might actually hinder the current generation for the lack of having something familiar to learn from. Adding tech to the classroom has to be carefully thought out in advance, just like any other planned lesson.

- **Give Instant Help**

One of the hardest parts of teaching is reaching out to every student individually. Some schools may have one teacher for 30 or 50 students in total, from several classes where they teach, who need additional individual approaches as help from the teacher, each one needing the teacher's input. A chatbot can become a sort of teacher's aide rather than a teacher's replacement or a simple lesson tool. If a bot can provide the teacher with a little help through things like instant assistance, test scores and feedback, the students will need the teacher's attention a little less.

- **Bolster Student Engagement**

With students being used to technology in their everyday lives, learning from and with technology will be easier than the old-fashioned way with books and paper.

As a result, students will naturally be more engaged if technology is implemented correctly in the lesson. If a chatbot is always available, children will not be distracted while waiting for the teacher to get to them. They will also be less likely to give up quickly on a difficult assignment. Chatbots can keep the student engaged with the subject and provide fewer distractions as a whole.

- Educational Progress

The way we teach the next generation has always changed with the addition of technology. AI and technological devices are continually getting better and more advanced, and new generations are using them like never before.

There has been an increase in demand for women in the tech industry because of technology's rate of growth. Perhaps if we continue using chatbots in education, we may see further growth in the economy as well as student engagement.

- **Choosing the Right Operational and Educational Chatbots**

Chatbots are easily available and come in a wide variety of forms, but choosing a specific one should be well thought out, to be pleasant and useful for both students and teachers.

No matter what chatbot is used in the classroom, it is obvious that integrating them in educational environments is a must. The future is coming fast, and the turning point for changing the way we learn is here.

Educational chatbots for Facebook Messenger that support learning, have proven to be very good, using the Facebook Messenger platform based on the analytic hierarchy process, the quality attributes of teaching, humanity, affect, and accessibility. We found that educational chatbots on the Facebook Messenger platform vary from the basic level of sending personalized messages to recommending learning content. Results show that chatbots, which are part of the instant messaging application, are still in their early stages to become artificial intelligence teaching assistants. The findings provide tips for teachers to integrate chatbots into classroom practice and recommendations on the types of chatbots they can try out.

How can we use STEMbot in education?

STEMbot is a conversational bot that can be used to help students study STEM subjects. It can be used both in the classroom and at home, for group teaching and individual teaching:

- In the classroom, when presenting the new teaching materials, highlighting the parts that are a problem for students to understand.
- As direct help in mastering the new teaching materials.
- Asking questions, looking for answers, solving applicable everyday tasks and checking their accuracy using STEMbot.
- As a guide for learning project-based lessons.
- To tailor lessons to the individual student and encourage their learning.

It is known that STEM subjects are a special scientific discipline among students. A special approach is needed to study them. Some students have particular difficulties in acquiring knowledge in STEM subjects. Because of this, they feel a certain amount of insecurity and fear of them. If, in the process of acquiring new

knowledge, students have the help of an artificial intelligence application such as STEMbot, they will master the teaching units more easily. At any moment they will have the opportunity to ask a question from the material they are not sure about. In STEMbot, a number of different options for exploration, discovery, experimentation or guidance can be linked through a series of instructions that leads to the answer to the questions. In this way, not only will the self-confidence of students with lower priorities in STEM subjects increase, but it will also become a challenge for students to master as much of the teaching materials as possible.

A big advantage is that STEMbot can be used from a laptop and from a mobile phone, anywhere and anytime. STEMbot can be used as an aid in doing experiments in chemistry or biology. As a guide through the process and at the same time to clarify it. It can be used when solving tasks in mathematics, physics. Explaining the theoretical part and simultaneously providing help in solving specific results.

The use of chatbots in STEM education is a very important approach to enhance and promote a more personalized learning experience.

The most important benefit of using chatbots in STEM education is the personalization of the education process. Each student follows an individual path, depending on their personal potential, qualities, interests, desires and creativity.

Each student does not acquire knowledge in the same way and at the same time. Each student learns and understands at a different rate, which has always been a challenge for educational institutions. This especially applies to STEM subjects, such as Mathematics, Physics, Chemistry and Science. Students cannot simultaneously master the teaching materials of these subjects. That is why the

introduction of chatbots in the teaching of STEM areas is of particular importance for students: to facilitate their learning process, to master new teaching materials, to perform practical experiments, to increase their interest... Chatbots are becoming one of the most widespread applications in the education sector, as this trend is constantly evolving.

Chatbot for education enhances learning experiences and increases students' interest in them by making them more engaged and participatory.
That is why the integration of chatbots in educational applications or on websites is especially important.

The benefits of chatbots in the education sector:

1. Increases Student Interactions

Students' primary source of knowledge these days is available online, and using applications that answer all of their questions is common and desirable.
These educational applications attract quite a number of users because they are intuitive with a fun user interface that is way better than looking at traditional textbooks.

Just like in classroom interaction, a chatbot emulates similar experiences for students where a question is asked and an answer is given in an instance.
In addition, material about any topic of study is always available at all times.

2. Act as a Teaching Assistant

When we find a subject difficult to understand, we usually seek the assistance of a teacher. However, with a chatbot, all of the knowledge can be obtained without the presence of a teacher, owing to the usage of relevant study material available online.

Other than this, a chatbot can:

- ease everyday tasks such as task allocation, rank tests, and tracking project assignments;
- provide answers to questions about the course modules, each task, and their due dates;
- help teachers offer individually tailored messages for a better learning experience;
- make availability of online learning suggestions based on their learning patterns.

3. An Instant help tool

Image 16: Chatbot as virtual assistant. [Image]. Retrieved from Free Stock Images.

The virtual chat assistance is designed to do an excellent job of providing immediate answers to any student's query. With this, students can also automate tasks like assignment submission, email replies, text messages, and feedback. Students are given online study material suggestions using the chatbot option, which would help them finish their tasks faster.

4. Act like a Learning Medium

Using chatbots in educational applications to assist students has made learning fun and improved their experience.
All the difficult concepts can be easily understood by students and the virtual teaching system offers an easy record of student performances.
The ability to learn through regular messages on a chatbot at their own pace anytime is something that is appreciated by many students.

Chatbot enables teachers to record answers and interactions to evaluate student performances**.**
Another advantage of the virtual support in the learning medium is that it provides learning modules, exams, and quizzes in the same way that a classroom does, with the added benefit of collecting and submitting these tests to the teachers.

5. An Intelligent Feedback Mechanism

The key to improvement in any learning process is feedback. It is not just for students; the virtual chat tool can also be used for faculty evaluations.

The entire feedback process can be made interesting using conversational forms and automated replies.

A conversational form can be used for surveys and getting information on lecture quality and hence improve the experience of the course for students. Teachers also get to share feedback for their students' assignments at one place and highlight needed points through a mobile app using the chatbot option.

6. Better Support to Students

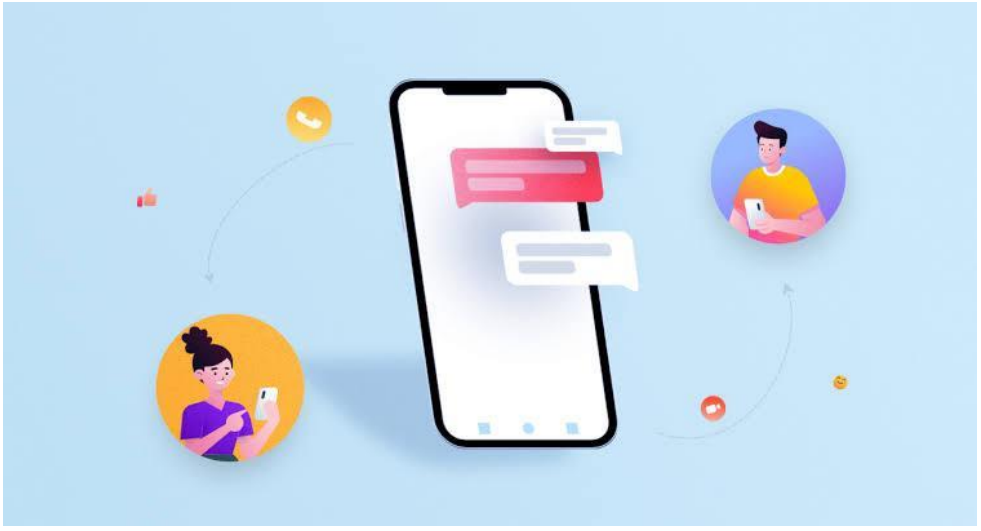

Image 17: Chatbot as students' support. [Image]. Retrieved from Free Stock Images.

Every student at some point looks out for additional courses online in order to understand the textbook or lecture concepts better. Here, an educational chatbot assists a student with information for his assignment or offers study material according to the subject chosen. This enhances the knowledge of the student and lessens the workload for teachers who can engage learners with slow learning rates who require extra instruction.

7. Quality Education in the Future

AI Chatbots for education make learning more dynamic and lessen a student's uncertainty about various study areas by providing the answers they need. On the other hand, it also reduces a teacher's burden and improves the teacher-student relationship.

The most essential advantage is that students are required to use these digital platforms for training on a daily basis in order to prepare them for the future. As we all know, the future is all about automation and technological breakthroughs, therefore chatbot is an appropriate addition to help people learn how to get their outcomes faster.

8. Assessment and Evaluation

All student responses can be automatically assessed and scored using artificial intelligence and machine learning. Teachers can totally utilize technology, filling students' scorecards based on AI chatbot findings.

9. Proactive Assistance

In the education industry, chatbots can be properly tailored to provide answers to students even before they inquire.

Assistance with payments, the inclusion of a new module to the curriculum, or the meeting of a deadline can all be proactive and beneficial to a better student experience.

10. Virtual Personal Tutoring

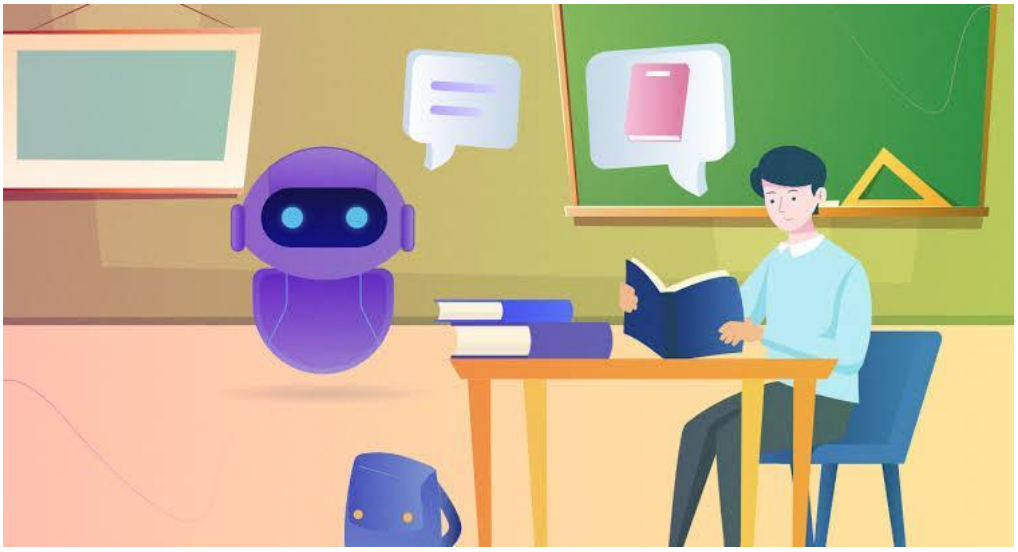

Image 18: Chatbot as virtual personal tutor. [Image]. Retrieved https://acquire.io/blog/use-cases-of-chatbots-for-education/ on 22. 2. 2023.

Students and their study patterns can be given individual attention by AI chatbots. They can closely monitor students' studying and information consumption patterns and, as a result, assist them in excelling in their fields.

Schools can deliver personalized learning experiences since not all students understand and learn in the same way. Chatbots can **personalize the learning plan** to meet the demands of each student by ensuring that students get maximum knowledge- both in and out of the classroom.

11. Administrative Companion

Chatbots for the education sector can act as their administrative assistants. Rather than going to the office and waiting in long lines for responses, obtaining information via chatbots is a preferable choice.

Information regarding fee structure, course details, scholarships, campus guides, school events, and much more can be made available through the AI chatbot.

Why chatbots should be used in STEM education?

Based on the research findings, implementing a cognitive style-based chatbot in learning science courses, as STEM subjects are, can lead to the development of the science concepts as well as critical thinking skills of students because the chatbot provided an opportunity for the pupils to be engaged and immersed in their own learning process and provided more practice to retain knowledge. In conclusion, the use of chatbots in learning science has improved students' achievement and performance.

The researchers confirmed the effectiveness of using a cognitive style-based chatbot in developing science concepts and critical thinking skills as follows:

- chatbots can be used to increase curiosity by asking pupils challenging questions, which is one way to develop critical thinking skills;
- chatbots can help pupils organize their own learning process by working at their own pace;
- chatbots can be a knowledge resource that supports learning in the classroom by changing the educational environment to one that is student-centred and this has been confirmed by constructivist theory;
- chatbots provide an effective means of collaboration and communication with pupils through conversations and chatting. They provide them with accurate scientific information and answers to questions that hinder their understanding according to communication theory;
- chatbots provide immediate feedback and individually lead pupils in their own learning process, in line with learning style theory;

- chatbots increase the students' motivation to learn and enhance their self-awareness in line with a motivation theory;
- chatbots make students more engaged and immersed in their learning process inside and outside the classroom;
- chatbots address individual differences of students by providing personalized learning.

That is why science teachers are advised to consider the use of chatbots to support their teaching process and enhance the learning of their students. Incorporating different technological tools into their teaching methodology, and selecting effective methods for interacting with students and their science content.

3. PROMOTING STEM WITH CHATBOTS

3.1. How to empower students to feel confident in STEM subjects applying chatbots in education

3.1.1. What drives a student's interest in STEM and how can we empower it?

Students' interest in STEM goes beyond simply choosing school subjects. Some studies have been made to investigate the reasons behind students' interest in STEM.

One of these studies was performed by Kaleva et. al (2019) who analysed Finnish students' reasons behind choosing mathematics in upper secondary school. Its results have shown that the majority of students who have chosen mathematics have done so because of its usefulness and the fact that it opened more options for their professional and/or academic future. Another reason stated was enjoyment and interest. For example, some students wanted to challenge themselves, others enjoyed solving mathematical problems, and others had previously achieved good grades, and wanted to continue to study the subject. Advice from parents or peers was also an important factor, as well as teaching style, meaning enjoying the way the subject was taught.

Another study by Sellami et. al (2017) explored the factors that help predict students' interest in STEM in Qatar and found that four main factors tend to influence students' interest, namely the teacher, perceptions of homework assignments, self-confidence and intention to pursue further study in a STEM

degree or profession. The first factor, the teacher, has to do not only with the way the teacher exposes students to STEM subjects but also with the way they can build interest in the way they explore the subjects and also in how they help develop the students' self-confidence. Homework assignments were also viewed as vehicles for fostering students' interest in STEM, motivating them to read materials prior to class, enabling discussion in the classroom and offering opportunities for working on challenging material and potential solutions to problems. Self-confidence was also mentioned, in the sense that the more confidence a student has in themselves and their ability to be successful in STEM subjects, the more likely they are to pursue them, not only in school but also in further studies.

To empower students to pursue their studies of STEM subjects, the first step would be to build their self-confidence and interest from an early age (Stewart, n.d.). This can be done through hands-on practical activities, where students can have a sense of ownership concerning their work and can become confident in decision-making. Gamification of STEM subjects has also been successful in raising students' interest. The positive impact of virtual lab simulations has also been documented, such as increasing students' intrinsic motivation to learn (How schools can increase student interest in STEM careers, 2021). In general, the best way to motivate students to be interested in STEM moves away from the traditional classroom model, where students listen to lectures and cram for tests and exams, to a program that fosters the students' curiosity, with new approaches and learning environments that can raise students' intrinsic interest for STEM, such as blended learning, inverted classroom, active learning approaches where students are actively involved in the learning process (LIYSF, 2020). Additionally, chatbots are also a way to help students be more engaged and interested.

3.1.2. How can a chatbot help students to be more engaged and gain interest in STEM subjects?

Chatbots are "computer software systems that use natural language processing to assist humans in activities of various kinds" (Mendoza, Sánchez-Adame, Urquiza-Yllescas, González-Beltrán, & Decouchant, 2022, p. 1). In education, chatbots can be used for varying purposes. For example, they can be used for increasing online learning engagement, as a tool to carry out academic and administrative tasks and facilitate communication and even as tutors. Artificial Intelligence (AI) chatbots have the potential to help students be more engaged, for example, through Virtual Personal Tutoring, by delivering customised learning experiences, after studying the student's pattern of studying and content consumption (10 Powerful Use Cases of Educational Chatbots in 2022, 2022). AI chatbots can develop learning plans that cater to the student's needs and also, for example, cater to learning disabilities, by adapting content to maximise learning.

AI chatbots can also engage with students at times when student-teacher and even student-student engagement is not possible or not available. Chatbots can clarify student doubts instantly and students can also create groups to exchange information with other students through chatbots.

Chatbots are also great ways to deliver student support and answer students' queries, administrative or subject-related. AI chatbots can also be used for feedback and assessment and as a data repository tool.

Educational chatbots can foster student engagement and interest in STEM subjects in several ways. They promote anytime-anywhere learning strategies (Kumar, 2021), encourage student participation and provide a safe environment where students can make mistakes and learn. The students can also, through the engagement with technologies, solve real-life problems, develop verbal and technological skills, being actively engaged in a lesson, which in turn leads them to "master cognitive science techniques, formulate theories, and test them and remember the theory better" ((Basogain, Gurba, Hug, Morze, Noskova, & Smyrnova-Trybulska, 2020, cit. In Burbaite, Zailskaite-Jakste, Blazauskas, Narbutaite & Ostreika, 2021). Chatbots can contribute to better assimilation of theoretical information through the implementation of real projects.

Additionally, the building of chatbots can be a task in itself, fostering interest in STEM subjects. By creating chatbots as a part of students' educational activities they can develop algorithmic and computational thinking.

Overall, chatbots have been proven to have the potential to increase student engagement, as well as interest in STEM subjects.

3.1.3. Importance of chatbot as an interactive teaching tool, which contributes to student independence

As mentioned in the previous section, chatbots have great applications as interactive teaching tools. Chatbots have been used to provide students with a personalised learning experience (Kuhail, Alturki, Alramlawi, & Alhejori, 2022), providing student support in situations where individual support by a teacher is not possible or difficult to obtain.

Chatbots have not only the possibility to answer student queries but also to provide educational content, such as resources to study, illustrate examples and provide assignments and rehearsal questions. Students can study independently with the aid of a chatbot, with content and resources customised to their needs and interests. Chatbots can provide scaffolding, defined as “teaching approaches used to gradually bring students toward better comprehension” (Kuhail, Alturki, Alramlawi, & Alhejori, 2022), which entails improving students’ learning by offering aid when needed (voice or text-based), gradually helping the student comprehend the topics better and reach more independence.

In addition to independent study, chatbots also provide the opportunity for collaborative learning activities, and students can form groups with other students, to study or to do assignments. Educational chatbots enhance students’ learning by providing content that is customised to their learning goals, which promotes active learning, defined as “any learning activity in which the student participates or interacts with the learning process, as opposed to passively taking in the information “(Keep Learners At The Center Of The Design Process, n.d.). The student is no longer a passive recipient of knowledge but is actively involved in their own learning, being more independent, and having the opportunity to choose how, what and when to learn.

3.2. Show the role chatbots can have in supporting teachers in technology-enhanced learning and transforming the interaction between students and teachers

Educational chatbots are not all created equally. There are several ways in which they can support students and teachers. Let’s take a look at some of their applications in the education industry.

1. Applications of supporting teacher and student interactions

Educational chatbots can work as intermediaries between students, teachers, and other educational staff. For example, Mendoza et al. (2022) proposed a model that bridges the gap between teachers and students, interacting with both. The teacher's and the student's role alternate between the role of producer and consumer of information. In the table below the roles of students and teachers in both positions are described.

Role	**Teacher**	**Student**
Producer	• Can create extra-class materials to reinforce topics covered in class, and assign them to one student or groups of students • Can create event announcements (exams, homework, assignments) • Can publish reminders for event announcements	• Can deliver homework, assignment, projects
Consumer	• Can accept pieces of homework from students • Can receive reports on student performance	• Can accept extra-class materials • Can receive announcements/reminders for academic, administrative or athletic events

2. Chatbots can give students support during the learning process if the teacher is not available

Educational chatbots "facilitate the achievement of the core tasks of teaching and knowledge transfer" (Khidir & Sa'ari, 2022, p. 183) and offer students personalised support in several ways. For example, they can instantly respond to typical student queries, concerning lesson plans, course modules, assignments, and deadlines.

Chatbots can also provide tutoring for students, adapting the style and content to their needs. This is particularly useful because not all students learn in the same way and chatbots can not only offer customised study materials but also support students with learning disabilities, such as dyslexia or dyscalculia, promoting inclusiveness in education.

Chatbots can also increase student exposure to e-learning (Khidir & Sa'ari, 2022) by making it more accessible than it would be otherwise. Chatbots can help students manage and prioritize their work in e-learning and also clear any doubts concerning the functioning of the systems themselves, which reduces teacher overload and enables educators to focus on more demanding tasks, rather than IT support for these systems (Capatina, 2020).

3. Using chatbots to deliver lessons, lectures, and course material to students before/during/after lessons.

Chatbots can certainly help teachers teach. Chatbots can centralise content and resources provided by the teachers and make it possible for students to access the content simply by asking the chatbot for whatever they are looking for.

Chatbots are also used for communicating key course information, essentially working as virtual teaching assistants. Chatbots can also help teachers with different learning models, such as the concept of flipped classroom. This concept is a student-centred type of b-learning model where students are introduced to content at home and then discuss and practice the content in the classroom (Tangkittipon, Sawatdirat, Lakkhanawannakun, & Noyunsan, 2020). This type of learning can sometimes face problems like a lack of student engagement.

Chatbots could increase student engagement in the following ways: providing automated help to students while they are preparing before class, boosting their motivation to meet the course competencies and increasing the behavioural engagement to all learning objects (Tangkittipon, Sawatdirat, Lakkhanawannakun, & Noyunsan, 2020). Similarly, this model could be applied to traditional education as well, only that instead of the focus being on pre-class support, the students would need more support after the lesson/lecture.

4. Chatbots as a way for teachers to obtain feedback from students

Chatbots are powerful tools for collecting feedback. Teachers can obtain feedback concerning student activities and progress and they can also work as survey tools for teachers to receive anonymous scores from students concerning lessons or lectures and also more descriptive or detailed feedback. This type of feedback can help teachers track their progress, increase their efficiency and improve their skills.

5. Other examples

Some other examples of uses can be found in previous chapter of this guidebook on page 28 (chapter 2.2. Examples of how and why using a chatbot in STEM education).

4. PRACTICAL EXAMPLE OF USING CHATBOTS IN STEM CLASSROOM

4.1. Using chatbots in STEM education – practical examples

Image 19: Talking to chatbot by using a smartphone. [Image]. Retrieved https://lessondelivery.com/chatbot/zachem-nuzhny-chat-boty-v-obrazovanii-i-marketinge.html on 22. 2. 2023.

According to the research, 37 percent of educational organizations around the world already use Artificial Intelligence, including chatbots for learning and

organizing the educational process. At the same time, the survey shows that students and pupils are satisfied with the interaction with the program and believe that it helps better than a living person.

All students have a different pace of learning and understanding and this has always been a challenge for educational institutions. Juggling between meeting the expectations of students, parents and teachers, the education sector has been compromising on giving a thought to students' learning experiences. There is a one-stop solution to all the hassle which is using chatbots in education. Educational chatbots are brilliantly transforming the way institutions interact with their students. They are working towards making it easier for students to learn and reach out to all the activities that they can do during their course of study.

Practical teaching can give authentic learning experiences and teach valuable skills for undergraduate students in the STEM disciplines. One of the main ways of giving students such experiences and laboratory teaching are chatbots.
In practice, chatbots collect statistical information about students, this is a great way to get feedback from students, provide students with information about their progress, chatbots work as a pedagogical tool.

Chatbot in STEM subject can offer the student additional tasks, links to the necessary resources. If at some point in the conversation the user has problems expressing his thoughts, the bot will give him a choice of several possible phrases. If the student completes the tasks incorrectly, the bot gives a link to the theoretical material, suggests better preparation and allows you to complete the tasks again.

A chatbot allows you to instantly and at any time of the day get access to such data without spending a lot of time searching. It aggregates the information from different sources and displays it in one window. A chatbot can provide a unique pedagogical approach to each individual student. He easily remembers everything that the user has previously talked to him about. If a student constantly requests links to Wikipedia, then the bot can give them out first.

There are several practical examples of using chatbots in STEM education:

1. Nina- biology chatbot.

Image 20 and 21: Biology chatbot Nina. [Images]. Retrieved https://play.google.com/store/apps/details?id=com.education.nina&gl=US on 22. 2. 2023.

Nina - Biology Chatbot is a *Free Education app*, developed by Planetbeyond.
It is friendly A-level biology It takes time and dedication to become a doctor.

Keeping that in mind, Nina is a program that will help everyone to learn and reinforce the concepts.

Nina works according to the plan: she sends 5 questions each day. All of the questions are related to one particular topic. They are all scenario-based and tell a story to keep a student engaged and thinking. The purpose is to help a student to retain knowledge and even if he does not get the question right, Nina will explain the concept again. Also, Nina is sending a student the questions that he got wrong. Nina was created to ensure that every student realizes his/her true potential. Crafted by leveraging the latest technology and cognitive techniques. Nina was created by experts who see a future where anyone can maximize their potential. Nina - Biology Chatbot has gained enormous popularity with its simple yet effective interface.

2. AMY chatbot

Image 22: Amy, math tutor. [Image]. Retrieved https://www.amy.app/ on 22. 2. 2023.

Amy is an AI-based private tutor for math that makes learning MATH easy for everyone. She does this by giving students feedback and automatically filling their knowledge gaps as they learn. Dynamic teaching, as we call this, is a paradigm shift on the current model of adaptive learning because it can pinpoint gaps in knowledge and seamlessly move between topics to address them.
Amy easily integrates into all online learning systems and can be set up to teach in different languages and curricula. We are shifting the world from the one size fits none model of education to the age of completely individualised learning. Amy was made so everyone can learn no matter where they are or when they

want to learn. It easily integrates into all systems and has over half a million unique questions.

Amy:

- Allows students, teachers and parents to monitor student progress and understanding.
- Motivates students with their progress
- Gives teachers the data they need to be more effective
- Understands students using the intuitive dashboard
- Provides insights for students, teachers and parents

Amy continuously adjusts assignments to optimise learning for each student. It provides one teaching assistant for every student in the class, gives learning-outcome driven assignments and creates unique assignments for each student. Amy customises assignments as students learn so everything they need is covered and automatic feedback at every step prevents students from getting stuck. Using Amy is like learning from a friend.

- It increases confidence by showing students their personal progress
- Amy is eternally patient and never makes students feel incapable
- Chat to Amy just like your other friends and learn math in the process
- Amy speaks 4 languages.

3. Botsify

Image 23: Botsify logo. [Image]. Retrieved https://botsify.com/chatbot-for-education on 22. 2. 2023.

Botsify is an educational chatbot that aims to help both teachers and students in STEM subjects as well as in all other subjects. Botsify is one of the leading chatbots in education that presents learning subjects to students in the form of images, text and videos via Messenger. Lessons are presented in a conversational-style format which creates an interesting form of education that has proven to be astounding.

Students receive customised learning through increased interaction as the bot learns more about the student's profile and constantly assesses their strengths and weaknesses on each topic through machine learning.
After the students have learnt about a particular topic, Botsify then sends quizzes to test their understanding. The results are then submitted to their teachers so that their performance and progress are charted.

4. Your Physics Trainer Bot. Physics for Foreign Students.

The recent use of chatbots in education opens up the need to investigate how to use them and their effects on learning processes. This research aims to measure the effects of integrating a Physics chatbot with an active learning sequence for first-year physics students or in-depth learning in high school. The chatbot's purpose was to help the student understand the concepts in the different resources it contained.

Image 24: Physics trainer bot. [Image]. Retrieved https://ceur-ws.org/Vol-3013/20210253.pdf on 22. 2. 2023.

The study was conducted in a private higher education system, where the sequence was implemented to a population of 145 freshmen engineering students in five different groups (classes) of introductory physics courses. The data analysis of this quantitative exploratory research was conducted using descriptive and parametric statistical methods. We implemented the Half Force Concept Inventory (HFCI) as pre- and post-tests to measure the learning gain of the conceptual understanding of Newton's laws. This research contributes to understanding the impact of the chatbot on the learning of first-year university engineering students. It outlines the best practices for providing empirical evidence on using chatbots as digital learning resources. The research results indicated a heterogeneous change in the students' conceptual understanding, attaining a positive gain among half of the freshmen. Also, the ANOVA statistical analysis showed equivalent behaviour between each group of students, where Hake's gain was significantly equivalent.

After the study students were faced with the task of comparing an educational process with and without the chatbot. The survey indicated that a significant fraction of participants considered the chatbot and its notifications before the class to be useful and motivating. Besides, students revealed that quick feedback from the tutor gives a helping hand in overcoming stress as they come to the lesson halfway familiar with the material.

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

5. SnatchBot

Image 25: Snatchbot logo. [Image]. Retrieved from https://snatchbot.me/ on 22. 2. 2023.

Not all educational chatbots are solely for the benefit of students. SnatchBot is a clever chatbot assistant which can be automated to free up time for teachers commonly spent on repetitive administrative tasks. This bot can be set up to answer many common student queries regarding course modules, lesson plans, assignments and deadlines which can take up a lot of a teacher’s time.

Additionally, SnatchBot can delve deeper and can also be programmed to monitor the learning progress of each student and provide personalised feedback to each student regarding their progress. Through machine learning, the bot can analyse each student's learning needs and recommend learning content to assist them in their progress.

4.2. Using chatbots to tailor lessons to individual student to foster their learning

Artificial Intelligence-based chatbots are well known nowadays in the eCommerce sector, but they are more and more popular in other fields like education. In this chapter, we will discuss how chatbots support individual learning and how to build up your chatbot as a teacher if we caught your interest.

Chatbots as educational assistants

It may sound weird at first, but chatbots are talented supporters of individual learning processes. Of course, they cannot replace the teachers, but they can be valuable assistants of them. Focusing on individual learning is essential in the educational system since each student is learning uniquely; however, in Europe, the average number of students in classes is 18-26. Due to this high number, it is challenging for teachers to pay attention to them individually. In short, they could use some support to fulfil their missions.

The question arises, how can a chatbot effectively support individual learning?

First of all, **the chatbot speaks the language of the learners**. As young people very often hang out on different social media platforms and are in constant contact with each other through chat apps, this kind of familiar communication makes learning not only more accessible but also fun, comfortable and interactive, thus making it more engaging for learners in the subject and in learning in general.

Also, for the convenience of the students, **it is always available.** There is no that late hour when it is inappropriate to disturb your chatbot. So, the students can always get individual support with their homework.

Another advantage that can be helpful for individual learning is **starting over with the same material at any time**, so if some of the students need more help or repetition, they can get it without feeling ashamed.

One of the most significant advantages of the chatbot in supporting individual learning is that it can **assess the level of students' knowledge** through assignments and quizzes. It can even be programmed to **give grades and personal feedback** to students, which frees up you as a teacher to focus more on teaching, and it helps you **to identify common mistakes** so you can create lesson plans for each class, **making the lessons more personalised**. On the other hand, the chatbot allows students to determine their difficulties and offers them **additional help to catch up.**

Of course, these are just the most valuable features of chatbots that can be used for personalised learning, so it is worth finding out what else they can do for you.

How to build up and personalize your chatbot?

The previous chapters have shown that a well-designed chatbot can significantly help your teaching career. So, let's see how to start building your chatbot?
At first glance, making a chatbot may seem daunting for those who are not computer literate. But do not worry; with some practice, anyone can become a chatbot host. Just follow the instructions below.

1. **Give a purpose for your chatbot.**

Think about why and for what you want to use your chatbot. It will help you to decide what features will be helpful for you to accomplish the main goal of your chatbot.

2. **Choose the platform you want it to appear on.**

Do you know which platform is the most popular among youngsters? Ask your students to be sure. You can implement your chatbot on social media platforms such as WhatsApp, Facebook Messenger, Instagram, or Telegram. It is up to you and your students which one you prefer.

3. **Choose a chatbot editor.**

If you know where you want your chatbot to appear, you can find the chatbot editor that fits your goals. First, it is worth watching some tutorial videos and becoming familiar with the interfaces of the editors. Then, choose the one that suits you the most!

4. **Design your chatbot.**

This is the most exciting and also the most time-consuming part. Think about what you want, practice, experiment, and ask for help from people who have already created a chatbot. Remember that sometimes less is more; it is enough to prepare a test lesson in advance.

5. **Test it!**

Test it with your students, and ask their opinion and ideas to develop the chatbot. Remember that the primary purpose is to support them and fulfil their needs.

6. **Develop your chatbot.**

After the testing phase, you can train your chatbot to know more and more to become a professional assistant for you and your students.

7. **Gather feedback.**

Ask for feedback constantly, and implement them from time to time to improve your chatbot. Everything can be perfected.

+1 Give a personality for your chatbot.

Creating a personality for your chatbot is essential. It will make it more human and more friendly. Think about what kind of personality could support your students the best, and when you write the chatbot's content, pay attention to

the style and tone you use. You can also implement multimedia content to make it more inclusive and funnier. For example, you can insert images, videos, memes, infographics, emojis, or Gifs. You can even give it a name.

Do not worry if your chatbot is not perfect beforehand. Instead, let yourself be inspired by your students' feedback and implement them to end up with a valuable tool. Remember that chatbot is only an assistant; your students need your support in their learning process.

4.3. Promoting inclusiveness in education using chatbots.

Inclusion is a keyword in education, but we are at the beginning of the journey to reach fully inclusive education worldwide. In this chapter, we will go through the European strategies to develop the education system to be more inclusive, what inclusive education means, and how a chatbot can support inclusion.

Inclusion in education - European overview

In the European Union, we pay a highlighted attention to inclusion and accessibility in education. In December 2017, the European Council, the European Parliament and the Commission approved the European Pillar of social rights, which promotes social, cultural and educational inclusion in the European Union. Regarding education, it is said: “Everyone has the right to quality and inclusive education, training and life-long learning to gather and develop skills that support them to participate fully in society and apply to the labour market successfully.”

As a part of the "Inclusion plan", the Commission supported the new framework of the Erasmus+ programme, which, according to the plan, will support millions of youngsters Europe-wide with various backgrounds to study in a more inclusive environment. It also aims to inspire national improvements in the Member States.

The Europe Strategy 2020 and ET2020, among others, targeted to decrease the number of early leavers between the ages of 18-26 and provide more opportunities and support for Europeans between the ages of 30-34 to attend higher education.

What demonstrated the importance of inclusion in education was the fact that this idea took place among the primary principals in the Agenda for Sustainable Development (Agenda 2030). Sustainable Development Goal (SDG) 4 aims to “ensure inclusive and equitable quality education” and “promote lifelong learning opportunities for all.”

Even though there are several good practices for inclusive education in the world, like in the UK, the USA, France, Germany and Finland, we still need to reach the goal of making the educational system globally inclusive. You may think you are too small to generate changes, but if each part of the system (never mind how small it is) does what it can, one day, we will fulfil our mission and create a fully accessible and inclusive educational system.

What does inclusion in education means?

Inclusive education is based on the needs and competencies of the individuals and on the assumption that each young person is part of the system, so they are

capable of learning. As a result, everyone gets the support they need to be an equal part of society and part of the labour market with the same conditions as anyone else.

The usual mistake is that people think inclusive education is only about supporting youngsters with special needs or Specific Learning Disabilities. In reality, it is the bigger vision of schools and educational services that support all students' academic, social, emotional and behavioural success.
Inclusion also refers to a general human right which says everyone has a right to access a high-quality education irrespective of race, gender, religion, disability, social background, medical or any other need.

The main pillars of inclusive education

- **Supportive policy**

As a first step, it is vital to be openly committed to acceptance and inclusion as a school or educational service provider to ensure that you will do as you can to protect your students from being a victim of discrimination.

- **Positive attitude and atmosphere**

Your students need a friendly and accessible space where they can feel safe physically and emotionally too. The first step on this path is to train the teachers and educators to be able to become role models for the students.

- **Partnership**

Treat your students as partners; make them feel they can share their needs and doubts with you. Trust them in knowing their needs and empower them to articulate them.

- **Communication**

Communicate openly, honestly and assertively, and ensure everyone is heard and accepted.

- **Flexibility**

A flexible curriculum and pedagogy are considerable advantages when discussing inclusive education. More flexibility would allow teachers and educators to use different tools and methods to engage their students more effectively.

- **Multi-sensory approaches**

We all learn uniquely, so various tools and approaches can support the different kinds of learners well. So be bold and use ICT tools, the methods of informal or non-formal education. You will experience a massive difference in the commitment of your students.

- **Personalization**

As we said before, paying attention to individual learning processes is inevitable. In inclusive education, everyone is supposed to get personal support to have equal opportunities to grow

- **Meaningful reflection**

Personal and solution-oriented feedback is also vital. The students must know where they are, where they could be and how to get there to keep their motivation high.

How can chatbots support inclusion?

Those who are living with Specific Learning Disorders have to face different kinds of difficulties (one or more at the same time) regarding using language (spoken or written) that may cause an insufficient ability to listen, think, speak, read, write, spell or perform mathematical calculations—considering that students with SLDs have various problems and because of that different kind of learning strategies how they are dealing with their challenges. So, they need a flexible and individual learning plan to address the curriculum.
As we have already discussed before, chatbots can provide individual support for students. They are also able to recognize a student's difficulties and give personalized feedback, which, if we check again the pillars of inclusive learning in the previous chapter, is one of the essential aspects of inclusion.
Furthermore, chatbots are flexible and entertaining learning assistants that can provide interactive content. You, as a teacher, can implement various learning methods into a chatbot, like quizzes, images, videos or infographics. You can even use multiple strategies for the same curriculum and let your students find

the best way for themselves. Summaries support your students to be able to see the bigger picture and the connection between different parts of the curriculum, and the short texts help them to understand and concentrate. Last but not least, a more friendly tone entertains and engages them in learning.
If you can engage the students, you can provide them with various support and help them find the way they can learn the best, you are giving them the most important thing you can. They will feel they can do things and succeed despite their difficulties. In addition, they will likely be more motivated to learn, which is the key to success.

4.4. Using STEMbot in practice

Incorporating STEMbot into classroom settings has demonstrated significant potential to improve STEM education by providing interactive, engaging, and personalized learning experiences. This section introduces practical examples and feedback from the STEMbot testing period, implemented in the project lifetime, to outline strategies for effectively utilising STEMbot to enhance teaching and learning processes.
STEMbot has been instrumental in increasing student engagement through its interactive platform, offering hands-on experiments with video tutorials, reinforced by lesson plans and quizzes, all accessible through the chatbot experience. Teachers have successfully integrated STEMbot into their curriculum by aligning chatbot activities with lesson objectives, thus enabling students to explore complex STEM concepts at their own pace and level of interest. For instance, video experiments followed by quizzes have made abstract concepts tangible, fostering a deeper understanding and retention of knowledge.
STEMbot's innovative approach has been effective in tailoring lessons to individual student needs, addressing various learning styles and abilities, by

allowing students to choose topics and control the complexity of their learning activities.

Feedback from educators and students alike underscores the value of fostering a collaborative environment with STEMbot. Group activities facilitated by the chatbot have encouraged peer learning and discussion, enhancing critical thinking and problem-solving skills. Additionally, the autonomy and responsibility promoted by interacting with STEMbot have motivated students for future learning, emphasising the importance of active participation in their educational path.

Despite encountering technical challenges and equipment availability issues, the overall positive reception of STEMbot highlights its potential as a valuable tool in the modern classroom.

Examples of STEMbot Implementation in project partners' countries

Portugal: STEMbot was primarily utilized on mobile phones, with class sizes varying and sessions lasting between 30 to 50 minutes. Teachers played a facilitative role, aiding students as they navigated through resources like videos, lessons, and quizzes. The tests revealed the importance of stable internet connections and the potential for technical challenges, especially in larger or younger classes where engagement levels varied.

Figure 26 - Students testing STEMBot. Portugal.

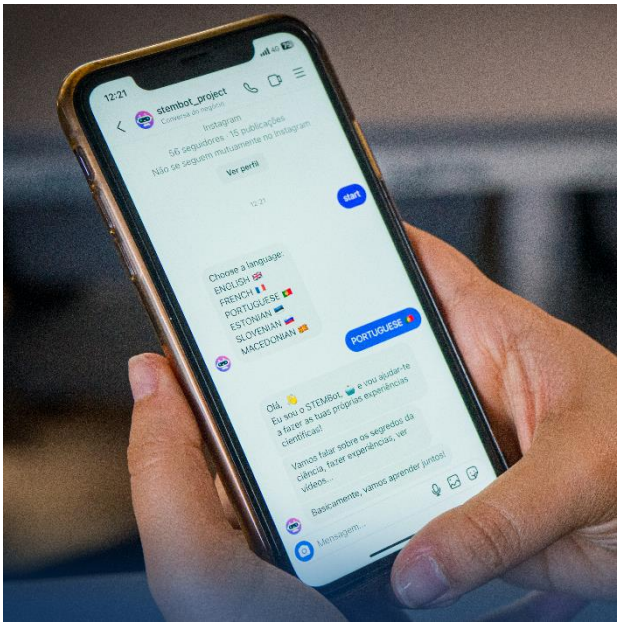

Figure 27 – Chatting with STEMBot in multiplier event, Portugal.

France: STEMbot usage extended beyond the classroom, including at-home assignments and participation in national events like the Fête de la Science. This approach highlighted the flexibility of STEMbot in different settings, though

challenges such as limited device availability and engagement with the complete range of resources were noted.

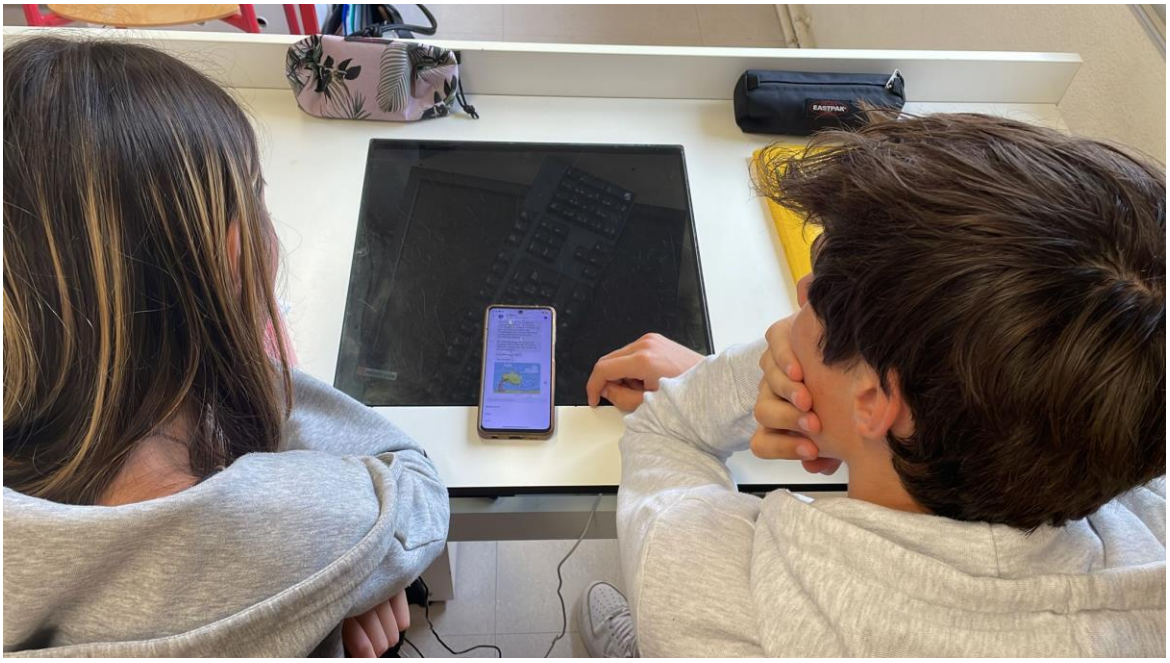

Figure 28 - Students testing STEMBot. Beaumont-de-Lomagne, France, june 2023.

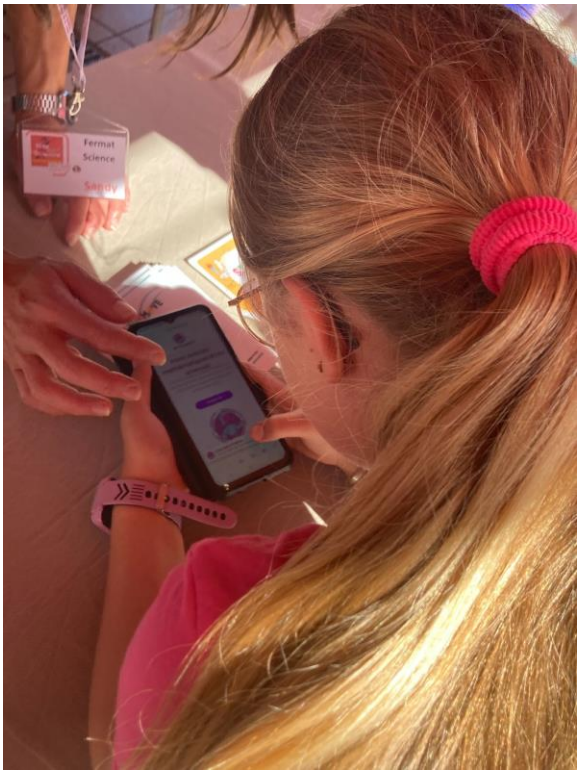

Figure 29 - Girl testing STEMBot during the event Fête de la Science, Beaumont-de-Lomagne, France, october 2023.

Slovenia: Implementations were characterized by small, mixed-age groups participating in the 2 hours workshop and included direct interactions with STEMbot via projected displays and independent exploration with individual devices. These sessions showcased the adaptability of STEMbot to workshop settings and the benefits of hands-on engagement. Classroom testing was introduced in the similar way.

Figure 30 -31 – Testing sugar density rainbow with STEMbot in Primary school Selnica ob Dravi, Slovenia, in December, 2023

Figure 32: Students doing the experiment Hydrophylicity. Primary school Ljutomer, Slovenia, December 2023

Belgium: Classroom tests lasting two hours involved conducting experiments followed by discussions with STEMbot. The choice among Facebook Messenger, Instagram, and the project website versions of STEMbot offered insights into platform preferences, with most students opting for Instagram. Technical issues were occasionally encountered but were promptly addressed.

Figure 33 - Students testing the "Apparition" experiment. St Ghislain, Belgium, December 2023.

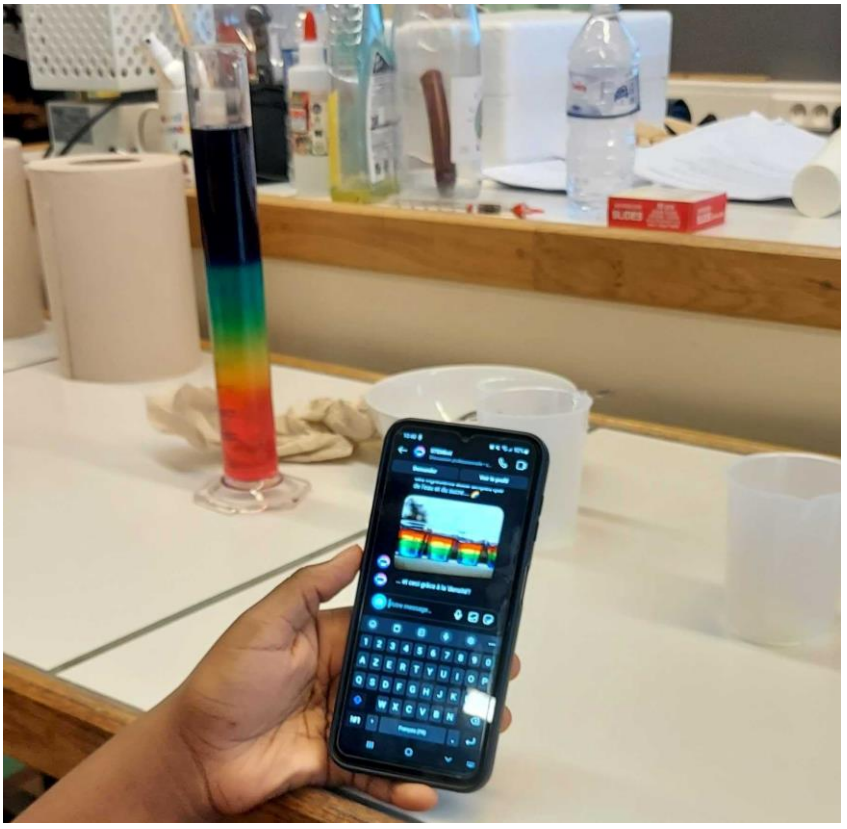

Figure 34 - A student discussing with STEMbot about the "Sugar Rainbow Density" experiment. St Ghislain, Belgium, December 2023

Estonia: The chatbot was introduced to students in science lessons, as well as in Estonian and English lessons, due to STEMbots' great advantage, being able to communicate in different languages. Duration of each lesson was 45 minutes. The students who tested the STEMbot ranged from 9 to 15 years old. Feedback from the students emphasized the high interest in STEMbot's interactive and experimental learning methods, especially providing and implementing hands-on experiments. The students were very interested in dialogues with the STEMbot; they wanted to ask him a lot of questions. This element of informal learning undoubtedly had a positive impact on students' motivation to learn.

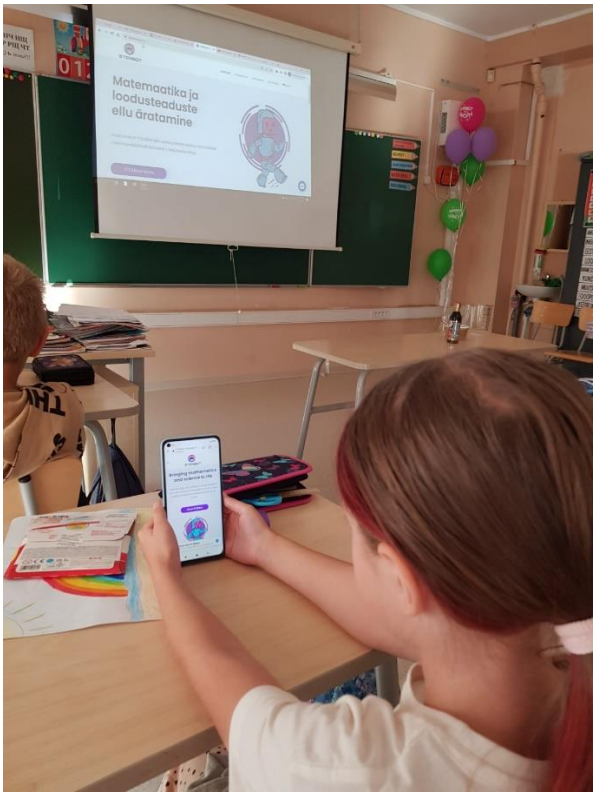

Figure 35. Students test the STEMbot on a phone Basic School Narva Pähklimäe School – Narva November, 2023

Figure 36. Students test the STEMbot on a phone and make the experiment Hidden sugar Basic School Narva Pähklimäe School – Narva November, 2023

North Macedonia: STEMbot's integration into high school education showcased its versatility across different educational levels. Teachers were instrumental in introducing STEMbot, guiding students through its features and facilitating interaction through the 45 minutes long lessons. Feedback from students highlighted the value of STEMbot in offering personalized learning experiences. Despite facing technical challenges and constraints around session durations, the approach was adjusted by allocating STEMbot exploration as homework, thereby enriching the subsequent classroom discussions and feedback processes.

Figure 37: Students test the STEMbot on a computer Secondary School Jane Sandanski - Strumica June, 2023

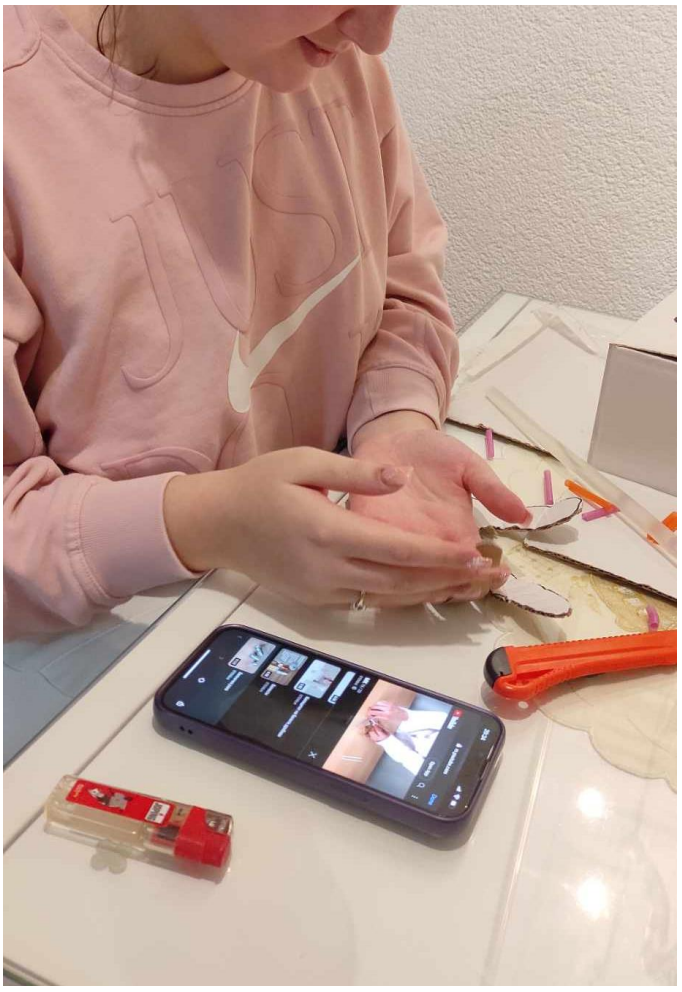

Figure 38: Student makes the Bionic hand experiment by watching the corresponding video SOU Jane Sandanski –Strumica October 2023

4.5. Tips for the educators

Project partners gathered some useful and practical tips for teachers and educators, which will help you to be better prepared to use the STEMbot in your classroom for the first time and enjoy its variety of implementation uses in your teaching practice.

1. To engage students the most, show them an experiment first, before starting to chat with the STEMbot, and involve them in it, so they can all actively participate. They will be more motivated if they have practical experience of what are they going to do.

2. Hands-on experiments accompanying STEMbot use required more time than you may expect. Try to offer enough time for the activity or divide it into several parts.

3. If you plan to have a STEMbot activity in your classroom, make sure in advance that most students have a Facebook or Instagram account to interact with the bot. This will allow you to better organise the activity and make them work in small groups if necessary.

4. Remember that STEMbot is a traditional sequential chatbot. It follows a scripted and controlled pattern, carefully created by the project partnership's members, and allows for simple user interactions. Before using the STEMbot chatbot with your group of young learners, give them a simple introduction to the concepts of artificial intelligence and types of chatbots. However, students shouldn’t expect to interact with STEMbot the way they would with ChatGPT, for example; it’s a different use case.

5. It also seems important to discuss the subject of social networks. As this chatbot can only be used with a META account, it seems important to talk about the dangers of the internet (specially with social media) - if this is part of the school curriculum in your country, it could be an interdisciplinary subject.

6. At the very first student's meeting with STEMbot, it is best to explain the concept of the project first. Clarify, what STEMbot contains: Videos with experiments, lessons to explain the scientific basis of the experiment's topic and a quiz to check the acquired knowledge. Point out what areas are covered and availability of learning materials at different levels: easy, medium and hard.

7. When the basics are covered, move to the next step - explain the communication with STEMBot, how we can access it, through a Facebook account or Instagram; what the conversational bot STEMbot allows us, how it can guide us through the entire learning process, depending on our interests, desires and possibilities. Highlight, how direct communication with the chatbot allows us to reach personalized learning and not uniform one (the same way of learning for everyone).

8. Utilize peer collaboration: Implementing group activities where students work together to interact with STEMbot can enhance engagement and learning outcomes. Encourage students to discuss their interactions with the STEMbot, share insights, and collaborate on experiments or problem-solving tasks facilitated by STEMbot. This not only promotes teamwork but also enriches the learning experience through collective exploration and discussion.

9. Assign STEMbot-based review sessions for homework: After conducting experiments in class, encourage students to revisit and reinforce their understanding by interacting with STEMbot at home. Provide specific prompts or questions related to the experiment or the scientific concepts covered, prompting students to engage with STEMbot's resources and quizzes. This not only reinforces learning outside the classroom but also encourages independent exploration and self-assessment, fostering a deeper understanding of the material.

10. If you think you need a different chatbot for your classroom – create your own! Some students and teachers express mixed feelings about the use of GIFs on the STEMBOT or lacking content about specific subjects. Try to develop your STEMBOT with the help of your students and regarding your own needs and teaching goals. This way they can provide you with important cues on how they will better engage with it. Adapting the chatbot as much as possible to them, in an interactive way, will better capture their attention and interest. Even if the STEMBOT has not incorporated the subject or the content you would like to use in your class, you can always develop your own chatbot using the STEMBOT Creation Manual. You will find in there not only information about how to create your chatbot but also on how to design a step-by-step experiment and how to create your experiment videos.

CONCLUSION

A key conclusion of the pedagogical guide to come up is that chatbots in STEM education are sure to contribute to noticeable improvements in knowledge quality. The chatbot is reasonable to be used as an essential component of the educational process for self and distance studying. Virtual consultants are developed both by companies for profit or by teachers, in search of new solutions in teaching physics, chemistry, mathematics, biology, technology and engineering, or by the students themselves, as a part of scientific work.

Comprehensive development and education of a harmonious personality in accordance with public needs is the primary task facing modern pedagogy. Innovative methods in education are designed to improve learning outcomes. Corporations no longer need just engineers. They are looking for people with engineering, management and agility skills. STEM, an educational model at the intersection of different disciplines, helps to prepare such workers.

Unfortunately, some children such as girls and underprivileged students are often underrepresented in Science, Technology, Engineering and Mathematics (STEM) education programs. By including educational chatbots designed for pedagogical purposes, educational activities might become more attractive to a broader audience and students engage in flexible, active, and integrated learning. Working with AI helps the development of the student's soft skills, this happens naturally without the constant supervision of a teacher, parents, and is an impetus for the development of internal motivation.

Chatbots appear to increase students' motivation and interest, fostering the learning process. Furthermore, they might support teachers in an effort to make their lessons easier and more enjoyable. The variety of artificial intelligence chatbot learning activities seems to attract students and, in some cases, might have cognitive, social and metacognitive benefits at all levels of education. Similarly, students might develop several useful skills such as problem-solving, self-efficacy and collaboration. These skills are essential, as they will help students cope with the challenges of their adult life. Chatbots are successfully used in practice as an option for homework, which will not be boring, but interesting and interactive. Such tasks are selected individually according to the level of a particular student. Homework with a chatbot is motivating, as the tasks are usually practical, visual, with accompanying video and voice messages. The chatbot gives the teacher the opportunity to control the completion of homework, as the chatbot keeps statistics.

Chatbots are also an excellent substitute for a teacher in case of his absence from school with the necessary tasks or the ability to perform independent work.

Chatbots is a very useful aid to mitigate the lack of interest towards STEM subjects at schools. They also have the potential to change students' understanding and to facilitate students' learning of STEM subjects.

Taken as a whole, the underlying framework of this pedagogical guide suggests a fluid interaction among a chatbot, a student, and a teacher. It could be concluded that by integrating chatbots into STEM, one cannot only establish increased learning but also captivate a broader audience and tackle differences in age, gender and socio-cultural backgrounds.

However, one must be aware of the fact that such educational activities might ask of a higher commitment of teachers. Moreover, the acquisition of skills with fewer affordances (e.g., programming) require developed teaching tools, more time, and guidance.

As in every industry which has received integration of artificial intelligence disruption in recent years, the education industry is benefitting from AI's many advantages, with the results being more satisfied and educated students. AI's natural language processing, instant messaging, speech recognition, automation, and predictive capabilities are providing students across the world access to personalised education which is constantly evolving. Teachers are easily able to chart each student's progress with Artificial Intellect chatbots delivering personalised progress reports in real-time.

And this is just the beginning. As Artificial Intellect continues to advance and finesse its capabilities, chatbots in education will help usher in a new era of learning — the results of which will be a marvel to witness.

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