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Introducing Virtual Reality for Firefighter Skills Training

Opinions from Sweden and Brazil

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Abstract: The emergence of immersive virtual reality (IVR) technologies has raised interest in the use of fire and rescue services (FRS) as a supplement to the established practice-based hot fire-live simulation (HF-LS) training. This is due to features such as time efficiency, portable technologies, and training in scenarios not possible in HF-LS. However, whether IVR provides realistic firefighter training situations has been called into question. Previous studies have revealed differences regarding perceived presence in, and attitudes toward IVR training between novice firefighters (who can only relate to HF-LS training) and experienced firefighters (who can relate to both HF-LS and real fires). In the present study, two groups of experienced full-time employed firefighters, 53 from Brazil and 18 from Sweden tested the same IVR technology. The hypothesis was that differences in national education and training programs and real fire experiences might influence experiences in IVR technology. This study examines the differences and similarities in experienced presence, opinions on whether the graphical representations and tasks performed convey realism, and attitudes toward the IVR-supported training format. Data were collected via systematic post-training presence questionnaires and observations. The results revealed a highly experienced presence and perceived realism of the representations by the participants from both countries. However, attitudes toward using IVR technologies differed. The motivation to utilize currently available IVR training tools was higher in Brazil than in Sweden. This may be partly explained by less frequent HF-LS training opportunities in Brazil. Nevertheless, further research is needed to investigate the training transfer of IVR technologies and how these can better support skills training.

Keywords: *virtual reality; firefighter; training; comparison; immersion*

1. Introduction

Practice-based training is crucial for fire and rescue service (FRS) emergency personnel, as it prepares them to respond efficiently and effectively to a wide variety of civil contingencies. Live mimulation (LS) training on a training ground is a powerful training format that requires the trainee to act in realistic situations in which they can transform knowledge into skills (Blyth, Bloom, & Krathwohl, 1966), collaborate with others and use different equipment. Using real fire and smoke, hot fire-live simulation (HF-LS) is considered the most realistic format for training in both incident management and the practical skills required for real fire situations.

During the past decade, virtual simulation (VS) has become mature enough to facilitate incident management training that supports decision-making competences (Lamb, Davies, Bowley & Williams, 2014; Reis & Neves, 2019; Wijkmark, Metallinou & Heldal, 2021). Several studies have highlighted the benefits of training supported by VS technologies compared with other training formats such as lower cost, the possibility of using a broader range of scenarios, reduced risks, support for higher cognitive processes, and easily accessible training situations (Engelbrecht, Lindeman & Hoermann, 2019; Hsu et al., 2013; Wijkmark & Heldal, 2020; Wijkmark, Heldal & Metallinou, 2022). In such realistic and dynamic scenarios, VS can simulate how the fire can develop and spread, supporting trainees in experiencing the possible consequences of actions and non-actions taken (Riedl et al., 2008, Heldal, 2016). By providing concrete experiences, reflections, and the possibility to train again in the same or similar scenario, VS applications can contribute to experiential learning (Kolb, 1984). Additionally, VS scenarios can be developed to meet specific learning objectives, and their use can be adjusted to the training requirements (Wijkmark & Heldal, 2020).

Various immersive virtual reality (IVR) tools for firefighter skills training have been developed in recent years, including caves (Backlund, Engström, Hammar, Johannesson & Lebram, 2007), head-mounted displays, or other physical elements such as heat vests, hoses, and nozzles with haptic feedback (Levin, 2019). Despite increasing interest in novel IVR technologies from the FRS organizations responsible for training firefighters, end-users are reluctant to regard IVR training as being equally beneficial as HF-LS. Such hesitation has been shown to be higher among students and novices than among experienced firefighters (Wijkmark, Heldal & Metallinou, 2021) and is often substantiated by questions as to whether the training experience is realistic enough in comparison with real fires or to the accepted HF-LS format. Therefore, further investigation is needed to determine how previous real fire and training experiences

influence the user experience in IVR, and how IVR and HF-LS supplement and contribute to learning objectives. This would increase our understanding of how IVR technology and training formats may be adjusted for different user groups, and thus benefit future training.

In the current field study, 53 experienced full-time employed firefighters from Firefighter Corps training in Paraná, Brazil (in 2022) performed training in IVR. Data were collected and compared with data collected in a previous field study (Wijkmark et al., 2022) which involved 18 experienced firefighters from an association of three FRSs in west Sweden: Fire and Rescue Service Östra Skaraborg, Samhällsskydd Mellersta Skaraborg, and Räddningstjänsten Västra Skaraborg) (Sweden) (in 2020), who performed training using the same IVR tool. The aim was to investigate the user experiences of two diverse groups of firefighters and their requirements for scenarios and representations, thereby providing increased knowledge of context-specific needs. The main research question investigated was: *What are the similarities and differences between Brazilian and Swedish firefighters in experiencing presence, and their attitudes toward utilizing IVR in firefighter skills training?*

The focus of this study was on firefighters' sense of presence in the virtual environment, the perceived realism of the applied representations in the different scenarios they performed, and the attitudes of the management responsible for utilizing IVR training as a replacement or a supplement to HF-LS training.

The results may contribute to a better understanding of which general and essential contextual requirements must be considered when designing and adjusting IVR training for different user groups, contexts, or countries.

First, there are several limitations of this study that need to be addressed. Because the two countries have different climates, infrastructures, and building requirements this will influence firefighters' real fire experiences and education planning and curriculum, issues that are investigated in depth in this paper. The illustrative calculations in this paper are based on the available statistics on fires in buildings (defined by the respective statistics sources); therefore, the investigation excludes other types of fires, such as fires in vehicles, to allow discussions in relation to the HF-LS concepts to be included. A major difference that may impact this study is firefighters' earlier experiences in HF-LS training due to their access to training facilities and plans for their training sessions. Both countries use training facilities according to a common base, the internationally and widely used concept of Compartment Fire Behavior Training (CFBT) (Mackay, Barber & Yeoh, 2010). However, they use this to different extents. CFBT

includes three main steps: demonstration container (DC) for demonstration purposes, attack container (AC) for basic training, and multi-container (MC) for more complex team training in fire scenarios. In Brazil, only the first two steps are utilized, whilst in Sweden all three are followed. Using training scenarios supported by IVR technologies cannot be considered a direct digital corollary of CBT training. Because there is more than one year between the two field studies, there has been one update in the software that may affect their experience in IVR. This has not been investigated in this study.

2. Background

The hypothesis in this study was that participating firefighters from two diverse countries, Brazil and Sweden, may experience IVR training differently due to variations in previous experiences of real fires and training. The arctic circle runs through Sweden, while the equator runs through Brazil, implying large differences in geography and climate. The temperature in Sweden may vary between -30ºC in the winter in the north to +30ºC in the summer. This makes building requirements regarding insulation and construction for a large amount of snow different from the situation in the humid tropical and subtropical climate of the larger parts of Brazil. Family houses in Sweden are often built of wood, with wooden structures for roofs, whereas windows and doors are built to insulate against the cold. The interior of the typical Swedish home has wooden floors or plastic carpets, wallpaper, or paint on the walls, producing combustible gases when heated. In Brazil, the typical home has brick walls and tile floors, while the ceiling is often made of wood or PVC. These differences influence fire development and behavior, resulting in notably different fire scenarios when comparing an ordinary apartment or house fire in the two countries.

In Brazil, the FRS is organized within the military and all firefighters are employed full-time. In Sweden, every municipality is responsible for their FRS, and only one-third of the total number of firefighters are employed full-time, with the remaining two-thirds employed part-time. The difference in organizational preconditions and the continuous training and development provided for firefighters may induce differences in IVR training experience and corresponding attitudes. To ensure the results are comparable, only full-time personnel from Sweden were included in the study. In the following sections, the FRS organization, education, and continuous training are presented in more detail, together with the relevant theoretical background.

2.1. Educating firefighters in Sweden: The municipal FRS

All 290 municipalities in Sweden are responsible for having an FRS ("Government Office of Sweden", 2022) ("Sveriges Riksdag", 2022). Approximately 33% of Swedish firefighters are employed full-time by an FRS and 67% are employed part-time ("MSB:s statistik och analysverktyg IDA") meaning that they have an ordinary job that allows them to be scheduled on call. The governmental agency Myndigheten för Samhällsskydd och Beredskap (MSB) provides two study programs: the two-year study program Skydd mot Olyckor (SMO) which prepares students (after graduation) to apply for a full-time firefighter position at a FRS, and a six-week basic course, *Grib*, for part-time firefighters who are already employed. For SMO, students are admitted based on their high-school grades, provided they perform satisfactorily in the mandatory physical fitness tests. The SMO and *Grib* diplomas are not mandatory and the FRS may choose to hire persons without these and provide its own training program. Most firefighters in Sweden, full-time and part-time, have attended the education at MSB.

In general, firefighters in Sweden work in teams of five, comprising one team leader and four firefighters, two of whom are prepared for breathing apparatus (BA) entry or smoke diving inside a burning building, one is the BA leader responsible for safety and communication with the BA team and one operates the engine and pump. The Swedish Work Environment Authority's Statute Book regarding BA entry requires a minimum of four firefighters to perform BA entry ("The Swedish Work Environment Authority’s Statute Book", 2022). The same statute book defines the education needed for BA entry and the mandatory yearly training.

In Sweden, there are approximately 16000 FRS operational personnel with at least 50% operational duties. According to the national statistics tool IDA ("MSB:s statistik och analysverktyg IDA") provided by MSB, around 6500 fires in buildings per year result in an FRS response (2021) which corresponds to an average of 0.62 fires per 1000 inhabitants.

2.2. Educating firefighters in Brazil: The Military Firefighters Corps

The Brazilian Constitution states that the National Military Firefighters Corps is a military reserve and auxiliary force of the Brazilian Army. Most districts only employ firefighters full-time, the number of which in 2022 totaled 55072. In addition to this, 12633 firefighters are in the reserve or are retired firefighters who have attributions in public security and civil defense (Pública, 2022). There are also volunteer fire departments in the southern states (Santa Catarina and Rio Grande do Sul), with a total of 6295 firefighters in addition to civilian firefighters who

work in the area of health and safety. Regarding fire incidents, there are no national statistics available.

The fire departments provide the education and training for their personnel, for which a high-school diploma and a pass in a national exam is a necessary qualification for admission. Within the military fire department, there are two education programs: one for soldiers (firefighters) which is a 10-month program, and one for officers which is a three-year program that includes a university degree.

In Brazil, no statute defines the number of yearly HF-LS training sessions required for firefighters to perform BA entry. In general, firefighters work in teams of four, consisting of one team leader and three firefighters. The focus of this article is on the district of Paraná which employed 3020 firefighters in 2020. There were 4603 fires in 2019, a ratio of 0.4 fires per 1000 inhabitants.

2.3. Practice-based training: HF-LS

Practice-based training in situations which are as realistic as possible is important in firefighter training. To create these situations, cold smoke produced by smoke generators can be used, while for some training situations, real fire and smoke are used to provide the realistic heat and visuals, here referred to as hot fire-live simulation (HF-LS). HF-LS training is often based on the concept of compartment fire behavior training (CFBT) which originated from Sweden in 1984 and has since been internationally adopted (Mackay et al., 2010). The training is conducted in facilities consisting of steel ship containers, sometimes referred to as: demonstration container (DC), attack container (AC), and multi container (MC) training, several of which are connected to each other to represent a building. In the DC, a fire is set to allow trainees to observe fire development with no interactions (see Fig. 1). Specific types of DCs are used to trigger dangerous phenomena and illustrate signs and symptoms, as well as to explain the differences between backdraft, flashover, and smoke gas explosions (Bengtsson, 1999). (Backdraft is the burning of heated gaseous products of combustion when oxygen is introduced into an environment that has a depleted supply of oxygen due to fire such as when the BA team opens a door. This burning often occurs with explosive force). ACs are used to practice skills in handling the nozzle, cool gases and advance in thick smoke to find the fire. In MC facilities with a more complex layout, the fire compartment must be localized in the thick smoke, providing more complex BA entry training.

HF-LS training is traditionally appreciated, especially by instructors, as the only practice-based method that can resemble actual incidents. However, HF-LS is associated with limitations regarding the resemblance to real buildings, and the amount and type of fuel permitted for training purposes (Narciso, Melo, Raposo, Cunha & Bessa, 2019; Wijkmark et al., 2022). Safety measures and environmental regulations limit the amount and type of fuel that can be used. Depending on the training facility, wood, soft board, hardboard, particle boards, or LPG gas, are used to simulate fires. The pyrolysis and burning of standard modern building material and furniture, including plastic materials, is excluded. Additionally, the safe setting of these fires ensures that they cannot spread, which limits the illustration of fire and smoke behavior. After practicing individual skills, more complex HF-LS scenario training is conducted in MC, simulating the whole process from the initial call, when students are at the training ground fire station, to the end of the incident, involving a team of firefighters. The MC used, or concrete buildings represent apartment blocks, ships, and industries, even though they do not actually resemble any of these (see Fig. 2). These buildings will never burn down, even if the firefighters do not intervene. However, the simulation is performed in a physical space involving real equipment and interaction between people who are firefighters and role-playing bystanders, allowing for realistic collaboration and use of tools.

Fig. 1: Fire development observation in DC (Sweden)

Fig. 2: A concrete construction representing an apartment building in HF-LS scenario training (Sweden)

2.4. Practice-based training: (I)VR

VR supporting skills training is utilized in several domains, such as education in medicine (Ruthenbeck & Reynolds, 2013), biomedicine (Frøland et al., 2022), architecture, managing emergency cases (Ren, Chen & Luo, 2008), or in the construction industry (Xiao, Wen, Hung-Lin, Xiangyu & Albert, 2018). Several European countries have introduced virtual reality in the training and/or assessment of incident commanders (IC), including in the United Kingdom (Butler, Honey & Cohen-Hatton, 2019; Lamb et al., 2014), Estonia (*Training Incident Commander's Situational Awareness---A Discussion of How Simulation Software Facilitate Learning*, 2019), Portugal (Reis & Neves, 2019), and Sweden (Heldal, 2016) in the fire academies or rescue services. In the IC role, the focus is on the whole incident scenario or one sector. It involves situational awareness, an overview that is required for risk assessments, anticipation, and decision-making (Wijkmark & Heldal, 2020). The IC does not enter a burning building or approach flames and smoke. This training is usually performed using non-immersive VR, with the virtual environment projected on screens so that the IC can move as they wish using a game control or keyboard (Wijkmark, Metallinou, et al., 2021). The firefighters' perspective on the incident scene differs. When holding the nozzle, approaching

flames and smoke, extinguishing, or entering the building on fire (BA entry) to search for victims, and so on, the focus is much narrower; for example, on the fire and smoke and its behavior, the compartment or the building layout, and associated risks. The physical parts, the heat, the heavy equipment, and the limited field of view in the BA mask are all aspects related to the firefighters' experience of the real fire situation and HF-LS and may also be required in IVR-supported training to provide valuable training experiences.

In a study by Grabowski (2022), a comparison of IVR and CAVE-based simulator training was conducted involving 67 cadets and seven instructors who were also active firefighters. The results revealed differences in the perceived spatial presence, with lower levels reported by the experienced participants and higher levels among the cadets. These results were explained by the fact that VR technology is usually perceived better among younger people, the tool was designed for cadets, and experienced participants may perceive lower levels of realism in the representations.

Although there has been an interest in VR for skills training in Sweden, demonstrated by MSB when initiating the first study on user experience and acceptance of IVR training in 2019 (Wijkmark, Heldal & Metallinou, 2019), there has been a reluctance to implement this in the firefighter training program. Such hesitation was shown by instructors participating in the study and explained by referring to the HF-LS as the most realistic training format, arguing against replacing any HF-LS training, and questioning the realistic experience in IVR settings compared with real fire situations. MSB purchased (in 2019) an IVR set identical to the one used in this study (FLAIM trainer) as the first public FRS in Europe, but did not implement any IVR training in firefighter education until 2022. It has previously only been used for demonstration and testing/research purposes. To the best of our knowledge, no FRS in Sweden has implemented IVR training for firefighter skill training. In Brazil, the Military Firefighters Corps purchased the IVR technology in 2021 and was the first organization in South America to do so.

2.5. Presence and immersion influencing practice-based training

Immersion is an objective feature of the technology (Slater & Wilbur, 1997) and denotes the extent to which the technology immerses (surrounds the senses of) the user. Presence, on the other hand, is defined as the subjective experience of "being there" in the virtual environment. Salas, Wildman, and Piccolo (2009) and Slater and Sanchez-Vives (2016) argue that two components: place illusion (the illusion of "being there" in the virtual environment) and

plausibility (the scenario is really occurring) are important in shaping the user's experience of presence in VR. The consequence of place illusion and plausibility is that the user behaves in the VR as s/he would do so in the corresponding real situation. Additionally, the experience of presence in a virtual environment is affected by two types of realism; social realism (reflects events as they would occur in real life) and perceptual realism (objects and people look and sound like they do in real life).

Flach and Holden (1998) argue that "the reality of experience is defined relative to functionality, rather than to appearances" (p. 94), meaning that the experience of *being there* (a.k.a. presence) depends on the ability *to act there*. Slater argues that the real power of VR is "being there", the perceptual illusion that makes a person perceive and react to the situation as if it were real, even though they know it is not (Slater, 2018).

Earlier, a common assumption was made that experiencing high presence in VS would result in better performance in real life (transfer) (Youngblut & Huie, 2003). Although the literature is not conclusive as to whether there is a causal relationship between presence and positive training transfer (to real-life performance), it is believed that a sufficient level of fidelity, that is the extent to which the simulation recreates the real world system, is required for effective training (Jonathan & Kincaid, 2015; Salas, Bowers & Rhodenizer, 1998; Salas et al., 2009).

Software for firefighter skills training is less mature than tools developed for other domains, such as navigation and aviation, which poses challenges for proof of transfer. The visual and sensory fidelity associated with firefighter practice is described as immaturity of technology by Engelbrecht et al. (2019), as well as a lack of multi-user fidelity (Engelbrecht, Lindeman & Hoermann, 2019). Simulation developers need better understanding of the variables contributing to higher experiences and how these can be refined to influence learning and performance. Thus, further research is necessary to achieve and assess the adequate level of fidelity in firefighter training.

3. Methodology

The aim of this study was to compare results from two field studies, one from Sweden and one from Brazil. The technology, study design, and data collection procedure used in the Swedish study (Wijkmark et al., 2022) were also applied in Brazil. The motivation for designing the Brazilian study and comparing the results was to generate more generalizable knowledge about the way in which contextual factors influence firefighters' experiences using IVR training.

3.1. The study set-up and data collection

Two field studies were conducted during IVR training at 1) the FRS Östra Skaraborg training ground facilities Hasslum, in Skøvde, Sweden in October 2020, and at 2) the Firefighter Corps training center in Paraná, Brazil in April 2022. Data were collected systematically by designing similar situations, using similar technologies and applications, and collecting data in similar ways. Two questionnaires were used, a background questionnaire covering users' individual and professional background in the FRS, such as their experience of HF-LS and real fires, which was completed before the IVR training, and another questionnaire covering the IVR experience with items asking participants to relate the IVR experience to their previous experience of HF-LS training and fighting real fires. The development of the questionnaires for the firefighters was based on the battery defined by Slater, Usoh, and Steed (1994) and complemented with questions for firefighter skills training inspired by Schroeder and his colleagues (Schroeder, Heldal & Tromp, 2006; Schroeder et al., 2001). The additional questions concerned necessary actions for learning and practicing firefighter training. Responses were made on a five-point Likert scale (1= very low, 2 = low, 3 = medium/acceptable, 4 = high, 5 = very high) or by "yes" or "no", with the option to explain this in text.

Each participant followed three steps: 1) answer the background questionnaire; 2) dress in personal protective clothing (suit and gloves) and conduct the training; and 3) answer the post-exposure questionnaire. The management of the training section selected the IVR scenarios to reflect two common fire scenarios and one uncommon scenario (Slater et al., 1994). The Swedish study scenarios were: 1) fire in a kitchen, 2) fire in a bedroom on the second floor of a family home, and 3) fire in a car involved in a traffic accident in a tunnel. For the Brazilian study, the scenarios were: 1) fire in a bedroom, 2) car accident on a highway, and 3) an airplane engine on fire. The IVR training was performed for 15-20 minutes and observed by one researcher. In addition, the head of training at both organizations answered 25 questions, in writing, describing the real fire context, fire and FRS statistics, the education and training background, and the HF-LS training utilized in their organizations, as well as their main objectives for using IVR training and plans for implementation.

3.2. Participants and their experiences

The Swedish group included 18 experienced firefighters, 17 men and one woman. Information on age was not collected in this questionnaire. All participants were employed full-time with an average of 14 years in the occupation, spanning from two to 30 years.

In the Brazilian group, 53 firefighters participated, of whom 4% (n= 2) were women. The average age was 43, with the span ranging from 30 to 55 years of age. All Brazilian participants were employed full-time with an average of 19 years (6-32 years) of employment.

3.3. The technology used

The participating organizations chose the IVR tool (see Fig. 3) based on its promised higher experiences, high-fidelity simulations, and rich sensory inputs. The participants wore a head-mounted display (HMD), a self-contained breathing apparatus (SCBA) with an air bottle and harness (includes a half-face mask that was not used in this study as a COVID-19 safety measure), a vest including responsive heat elements (responding to the distance and direction of the fire), and the protective clothing and gloves for the ordinary firefighter. The only exception in terms of the standard equipment was the helmet, as this did not fit under the HMD. This simulated the experience of weight, heat, and clumsiness in the movement and handling of the nozzle. A proper nozzle for applying water providing a sense of the recoil of water flowing through it was included. The instructor was able to watch the users' field of view on a screen (in Fig. 4). For more information on the IVR, see Wijkmark et al. (2022).

Fig. 3: The IVR used in this study

4. Results

4.1. The participants' earlier experiences of real fire situations

There is no exact data on how many real fire situations every firefighter has been involved in. Using the available fire statistics at national and regional levels, the number of firefighters and the size of ordinary teams, an estimate can be calculated as follows. In Sweden, 16000 operational FRS personnel make up 3200 teams. The 6500 fires in buildings in Sweden each year, divided by the number of teams, would result in two fires per team and year. In the region of the participating Swedish FRS's, there were 149 (30%) full-time employed firefighters (14 women) and 346 (70%) part-time firefighters (10 women) in 2021 which corresponds to the Swedish distribution. In this region, the FRS were called to 358 fire incidents in buildings (2021) corresponding to 0.92 fires per 1000 inhabitants, of which 110 fires were not causing any damage, while 248 fire were considered real fire experiences. We then calculated the number of fires per team and year corresponding to the national level: 495 firefighters, divided into teams of five which gives 99 teams, resulting in 2.5 (248/99) fires per team per year. This reveals that an average of 14 years in the occupation gives an experience of 35 fires (14*2.5) for the participating group. However, it is important to bear in mind that 70% of the FRS's firefighters are part-time employees, on call in specific weeks which means that there are fewer real fire experiences for the majority than the illustrative calculation suggests, and correspondingly more for the experienced firefighters in the participating group. Details of the number of fires per person was not available.

In total, 73% (n = 11) of the participants in the Swedish group stated that they have experienced more than 20 real fires during their career. Specifically, 22.2% (n = 4) have experienced over 50 fires, 33.3% (n = 6) 21-50 fires, 22.2% (n = 4) six to 20 fires, and 22.2% (n = 4) one to five fires. However, no national statistics on fires in Brazil are available which makes it difficult to compare the FRS responses on a national scale. The corresponding illustrative calculation was undertaken for the Paraná context: usually, the firefighters work in teams of four. Dividing the total number of 3020 firefighters by four firefighters per team, 755 teams are formed. Dividing the total of 4603 fires among the 755 teams would result in six fires per team and year. This calculation indicates that an average of 19 years in the occupation means an experience of 114 fires (19* 6) for the participating group. When asked to approximate their experience of real fires, 70% (n = 37) stated that they have experience of more than 20 fires, 52.8% (n = 28) over

50 fires, 17% (n = 9) 21-50 fires, 24.5% (n = 13) six to 20 fires, and 5.7% (n = 3) one to five fires.

Comparison between the two groups indicates that the Brazilian group in general have experienced more than double the number of real fire incidents experienced by the Swedish group.

4.2. Participants' earlier experiences of HF-LS training

All Swedish participants had attended the SMO education provided by MSB which includes approximately (there are some variations between the two MSB colleges and time periods) 12 HF-LS training sessions distributed among the three general types of HF-LS training environments;: DC, AC, and MC training, as described in Section 2.3 where the firefighter student performs BA entry. Every training session is planned for 3.5 hours and includes two BA entries of approximately 15 minutes for each firefighter. Following the SMO education, the employer (the FRS) is responsible for continuous training and development. According to the statute book, four yearly training sessions are mandatory, of which two must involve heat, that is HF-LS of some sort (not further specified). For the Swedish group, this is conducted in ACs in addition to a number of scenario-based training sessions involving HF-LS. The participants in the Swedish group have been firefighters for an average of 14 years. Given that they have all passed the SMO program and participated in all mandatory HF-LS training yearly, they have earlier experience amounting to an average 40 (12 + 14*2) HF-LS training sessions.

Within the Brazilian Firefighter Corps education program (Paraná), the students perform five to six HF-LS sessions for four hours, where each individual acts in BA for approximately 15 minutes twice. For development and continuous training, one HF-LS training session per year is performed, although no statute book or law regulates this. The participants in the Brazilian group have, on average, spent 19 years in their occupation as firefighters which encompasses experience of 25 (6 + 19*1) HF-LS training sessions.

These calculations illustrate the differences in HF-LS experience in that the Swedish participants have undertaken considerably more HF-LS training sessions than their Brazilian counterparts. Another important difference concerns the HF-LS training facilities at the training grounds. The Hasslum (Sweden) training ground, used by the participating FRS, includes DC, AC, and MC buildings, providing access to more extensive training in terms of the number of training sessions and complexity, while the Parana (Brazil) training ground provides only the

first two facilities. Regarding time effectiveness, at both sites each firefighter participated in a 3.5- 4-hour HF-LS session for approximately 2*15 minutes.

4.3. Experiencing presence in IVR compared to HF-LS training

The participants were asked to relate their experienced presence in IVR to a previous HF-LS training situation. In the Brazilian group, 92% of the participants rated their presence as acceptable to very high (Likert > = 3) (17% Likert 5, 45% Likert 4, 30% Likert 3, 8% Likert 2, 0% Likert 1), with an average of 3.72. In the Swedish group, 89% of the participants rated the presence as acceptable to very high (Likert > = 3) (27.8% Likert 5, 33.3% Likert 4, 27.8 Likert 3, 11.1% Likert 2, 0% Likert 1) with an average of 3.78.

When asked to rate the extent to which the tasks performed in IVR correspond to the tasks that can be performed in HF-LS, 89% of the Brazilian participants stated that it corresponds to a medium to very high extent (Likert > = 3) (9.4% Likert 5, 54.7% Likert 4, 24.5% Likert 3, 7.5 % Likert 2, 3.8 Likert 1). By contrast, only 56% of Swedish participants stated that it corresponds to a medium to very high extent (0% Likert 5, 27.7% Likert 4, 27.7% Likert 3, 38.9% Likert 2, 5.6% Likert 1).

Summarized in Table 1, the results reveal a similarly high presence in both groups compared with HF-LS, although the Brazilian group rated the task similarity higher than the Swedish group. This difference may be related to the earlier, more extensive, HF-LS experiences that were highly appreciated by the Swedish group. It may also indicate that the tasks performed in IVR settings represent more closely the two HF-LS training types available in Brazil, while the Swedish group have additional, more complex HF-LS training facilities.

Table 1: IVR experience compared with previously experienced HF-LS

IVR experience compared to HF-LS	**Sweden**	**Brazil**
Experienced HF-LS training sessions on average (n)	40	24
Acceptable presence in IVR compared to HF-LS (Likert > = 3)	89%	92%
Acceptable correspondence of task performed in IVR to HF-LS (Likert > = 3)	56%	89%

4.4. IVR experience of presence compared to real fire experiences

The participants were asked to compare their experienced presence in IVR to the feeling of being in a real fire situation. Overall, 72% of the Brazilian participants rated their presence as

acceptable to very high (Likert > = 3) (5.7% Likert 5, 28.3% Likert 4, 37.7% Likert 3, 20.8%, 7.5% Likert 1) with an average of 3.04. Of the Swedish participants, 94% rated this as acceptable to very high, (16.7% Likert 5, 44.4% Likert 4, 33.3% Likert 3, 5.6% Likert2, 0% Likert 1), with an average of 3.72.

Regarding the question "To what extent does the feeling of stress in IVR correspond to the feeling of stress in a real fire situation?", 64% of the Brazilian participants scored this as acceptable to very high (Likert > = 3) (5.7% Likert 5, 17.0% Likert 4, 41.5% Likert 3, 26.4% Likert 2, 9.4% Likert 1) with an average of 2.83. In comparison, 89% of the Swedish participants scored this as acceptable to very high (Likert > = 3) (11.1% Likert 5, 38.9% Likert 4, 38.8% Likert 3, 5.6% Likert 2, 5.6% Likert 2) with an average of 3.44. The lower score of the Brazilian group may be because they have had greater real fire experience than the Swedish group.

Regarding the realistic representation in the IVR settings, 73.6% of Brazilian participants rated the extent to which the visual appearance of the fire in IVR is realistic as high/very high (6% Likert 5, 21% Likert 4, 34% Likert 3, 30% Likert 2, 9% Likert 1) with an average of 3.17. In the Swedish group, 94.4% rated the realism of the fire as medium to very high (11.1% Likert 5, 50.0% Likert 4, 33.3% Likert 3, 5.6% Likert 2, 0% Likert 1) with an average of 3.67.

Regarding the smoke, 84.9% of the Brazilian participants rated the realism of this as medium to very high (9% Likert 5, 30% Likert 4, 34% Likert 3, 21% Likert 2, 6% Likert 1) with an average of 3.51. In the Swedish group, 88.9% rated the smoke as realistic from medium to very high (Likert 4 or 5) (5.6% Likert 5, 50.0% Likert 4, 33.3% Likert 3, 11.1% Likert 2, 0% Likert 1) with an average of 3.50.

The group reported similar scores regarding the realistic representations of fire and smoke. This may be because the participants found the representations of fire and smoke to be satisfactory and related to the scenarios (Likert > = 3), although there is room for improvement.

Table 2: IVR experiences compared with previously experienced real fires.

IVR experience compared with real fires	**Sweden**	**Brazil**
Real fires experienced on average (n)	35	114
Acceptable presence in IVR compared with real fires (Likert >=3)	94%	72%
Acceptable correspondence of stress experienced in IVR to HF-LS (Likert >=3)	89%	64%

4.5. Objectives and organizational attitudes toward introducing IVR training

The interest and motivation to explore and implement IVR training differed in the participating organizations. The head of training and other management personnel at the participating Swedish FRS have previously used non-immersive virtual reality for incident commander training, and therefore using IVR for firefighter skills training was a natural further step. Funding for the test session was provided through a project. There was no plan to purchase or implement IVR training in their own FRS introductory courses or for the annual training sessions. The study was performed to explore added value and for discussion on future utilization. Since then, there has been no purchase of this or similar technology. The main objective for exploring IVR training was expressed by the head of training as follows: "IVR gives a possibility to develop training, include new environments that are not familiar to the firefighters, as the HF-LS facilities are, and to train standard operational procedures with the same preconditions in exactly the same scenarios for all firefighters which is not possible in HF-LS". The IVR was also expected to reduce costs and provide more training in less time compared with HF-LS, although the initial cost of purchasing the technology is considered high, and thus a challenge or barrier for purchase and adoption.

In the Paraná case, the management decided to implement IVR training in the organization and the technology was purchased in 2021. The main motivation for this decision was expressed as "It's useful to evaluate firefighter's adherence to protocols". Another added value expressed by the management is the portability that enables training in locations other than the training ground.

The difference in management attitudes and decisions regarding IVR training may be explained by the value of such training being more urgent in the Brazilian case where HF-LS training is less widely available.

5. Discussion

Fires occur when there is the right mix of combustible material, oxygen, and heat. This is often referred to as the fire triangle, and fires start in these same preconditions everywhere on earth. However, after ignition, fires in buildings are never the same, even if they occur in the same neighborhood. Fire development and smoke behavior depend on the layout of the building, the building material, the furniture, and the climate. An apartment fire in a Nordic country, with the building constructed out of wood and insulation material, with plastic floors and wallpaper

would generally exhibit more material pyrolyzing when heated than an apartment in a subtropical country with tile floors and plastered walls. The experience of real fires may differ for firefighters from various regions and countries which may differentially affect which aspects are perceived as "typical" between the Swedish and the Brazilian group.

Differences in the format and meaning of standard operational procedures and compliance with these can also affect how training in IVR is received and experienced. For example, in Sweden, the Work Environment Authority's Statute Book (2022) will only allow BA entry if there are lives to save; if not, external methods for cooling and extinguishing are to be used. BA entry is always performed in pairs. In the IVR scenarios employed in this study, there were no external extinguishing alternatives. It was not possible to work in pairs and there were not always persons to be rescued inside. This required the instructor to roleplay the BA leader, informing the trainee that there may be people inside to be rescued, and also to play the second BA firefighter to add to the realism of the task. When there was a person (avatar) to rescue, this was only marked as "rescued" and not undertaken. The trainee was then supposed to continue extinguishing the fire inside the building. This may be perceived as not realistic in relation to the task and procedures. Compliance with procedures is not explicitly measured by the technology, but can be observed and assessed by the instructor in closer detail compared with HF-LS which was appreciated by the managers for both groups and was a key motivation for implementing IVR in the Brazil FRS.

The scenarios employed in this study were general and not adjusted to represent the context of the country which would allow investigation of how differences in previous real fire experience influence the IVR experience.

The general experience of real fires was higher in the Brazilian group, while the HF-LS training experience was higher in the Swedish group. The differences in the experience of real fires (high) and the amount of HF-LS training (low) indicate that the Brazilian participants can relate their experiences in IVR to real fire situations to a higher degree than their Swedish counterparts. Conversely, the Swedish participants can relate their experience in IVR to HF-LS to a higher degree.

Both groups report a similarly high presence in IVR compared with HF-LS. However, the similarity of the stress level experienced in IVR compared to real fire situations was rated higher by the Swedish group who have less experience of real fires. Regarding the realistic representation of fire and smoke, this was rated similarly in both groups.

To summarize, the IVR used reveals high presence and acceptance, albeit not adjusted to the different contexts of countries. Further work could investigate whether context-specific, country-adjusted scenarios (e.g., a typical Swedish apartment and a typical Brazilian apartment) would enhance the sense of presence and the perception of realism. Furthermore, the participants in these studies were all first-time users of the IVR and the results should be viewed from this perspective. When training in IVR on a regular basis, experienced presence may increase as it becomes a familiar training format. Alternatively, users may start focusing on details that disturb presence and make higher demands in terms of graphical representations. As demonstrated in previous studies, the difference in IVR experience between novices and experienced firefighters may need to be considered in the design of training tools intended for different groups.

IVR training allows a new supplementary training format which may not be instantly motivated by the organizational goals and learning objectives. The well-established and accepted practice-based training format (HF-LS), viewed as the most realistic training format possible, involves real fire and smoke, but also imposes limitations; for example, the fire cannot spread and the building does not resemble what it represents which limits fidelity. The realistic representation of objects and the realistic feeling of being and acting in the situation has been questioned regarding IVR training. Yet a sufficient level of fidelity is believed to contribute to training transfer. Further investigation is required to increase knowledge regarding the training transfer of IVR, as well as the traditional and accepted HF-LS which will enhance our understanding of how these two formats effectively supplement each other.

6. Conclusion

The primary aim of this paper is to investigate the similarities and differences in experienced firefighters` perceived presence and attitudes toward IVR training in Brazil and Sweden. The initial hypothesis, that both the experience of presence and attitudes toward IVR training would differ considerably among the two groups, was only partially confirmed. The experienced presence in IVR training was high in both countries, as was the perceived realism of representations. The results indicate that differences in previous experience of HF-LS training and real fires may influence the realistic experience of the task performed compared with HF-LS, and the stress levels in comparison real fire situations. The group with less previous HF-LS experience rated the task as more similar to HF-LS, while the group with less real fire experience rated the IVR stress level as more similar to real fire situations. Furthermore, the

results corroborate earlier findings in that experienced firefighters rate perceived presence in IVR training from high to very high.

The authors acknowledge that in both countries the organizational objective and motivation to introduce IVR training and instructors' attitudes toward this technology and the new training format may influence the individual acceptance of IVR training which, in turn, requires the acceptance of instructors and organizational support.

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The history of chatbots: the journey from psychological experiment to educational object

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Abstract: *Chatbots represent a strong and distinctive theme in the current literature on technology in education. What is lacking, however, is an analysis of them in terms of historical development or deeper historical-discursive classification. This paper focuses on the history of chatbots and places it in the context of a critical reflection on studies focusing on chatbots as educational objects between 2006-2021. It offers an analysis of each study and places them in the context of the development of the field as a whole. The study identifies three vital discourses that can be identified in the development of chatbots from a historical perspective - Turing-oriented, Searle-oriented and educational interaction-oriented.*

Keywords: *chatbot; chatbots; conversational agent; dialogic methods; artificial intelligence; Turing; learning objects; history of education technology*

1. Introduction

Dialogue-based learning (Reznitskaya, 2012; Lyle, 2008; Shi et al., 2021) is known from ancient China and, in the Occidental cultural circle, mainly from the region of ancient Greece. Socrates' "grandmotherly obstetric" method, as captured by Plato in his dialogues, consisted of systematically asking questions (Fisher, 2013; Hajhosseiny, 2012). Socrates raises the topic, and the whole process of his teaching consists of asking educated questions to reveal what exactly he means by the subject. What is essential about this method is listening, caring, and, above all, active interest in the one with whom the dialogue is being conducted. Much of the philosophical tradition can be said to be associated with this method of systematically inquiring into what has been uncovered (brought out of hiding - ἀλήθεια) by a previous answer (Grondin, 1982; Campbell, 2017).

The dialogic teaching approach has been in pedagogy for a significant part of history. We can see Socrates, Plato and Aristotle building their teaching methods on it. Jesus chooses to work with parables as the primary didactic method, the goal of which is that actual individualisation

change. Augustine of Hippo (1853), as a teacher of rhetoric, understands conversation as a fundamental means of knowing and thinking, in his book *Confessions*) are conceived as an introspective conversation with oneself. He then builds on this method in the Meditations of Descartes (2013). Descartesasticism, we can see dialogue or disputation as a fundamental method of university education at the latest with the expansion of Peter Lombarsky's Sentences (2007) at the turn of the thirteenth century Thomas Aquinas's *Theological Summa* (1981) (like his other textbooks) based on the idea of dialogue between student and teacher or between student and educational object, i.e., the textbook. In this respect, scholastic textbooks can be academic ideological precursors of chatbots. Among scientific works having the character of an educational dialogue, one should mention at least the Dialogue of Galileo Galilei (1990) from 1632, which is the most famous, though not the only, example of a systematic explanation of a scientific problem in the form of a dialogue to persuade and educate the reader. Dialogues follow Galilei or Alfred Rényi (1980), which follows the dialogical method in the first part, or Three Dialogues on Knowledge by Paul Karl Feyerabend (1999).

This enumeration only illustrates that dialogue is irreplaceable and integral in the learning process throughout the occidental concept of education from antiquity to the present. This is also evident in the considerable number of studies that have appeared in recent years on (Meijers & Hermans, 2018; Ruhalahti, 2019; Kloubert & Dickerhoff, 2020; Carvalho, 2022).

This study aims to outline at least the primary line of construction of chatbots as educational objects based on the theoretical concept of dialogue as an educational tool. The study will offer insight into their conceptualisation and development over the last 70+ years. We will show how a device designed primarily for psychological or computational experimentation has been shaped into an educational tool that can relate to the cultural context we have outlined above. As such, the definition of a chatbot is ambiguous (Sánchez-Díaz et al., 2018; Xu et al., 2017) - in the context of this study, we will understand it as a dialogic system that seeks to interact with the user through natural language in written form. It has no material body or similar "material structure", so it can be considered an autonomous software agent.

1.1. From Turing to the first chatbot

The beginning of chatbots is usually associated with Alan Turing's 1950 article (Turing & Haugeland, 1950). Turing formulates, among other things, the hypothesis that a machine indistinguishable from a human in its communication through text input and output could be considered intelligent. This idea is based on the premises of Ludwig Wittgenstein, who argued

that the limits of thought are the limits of language and vice versa (Hintikka & Hintikka, 1983; Wright, 1998). Wittgenstein thus represents the intellectual apex of a movement that George Lakoff would refer to as objectivism, which argues that thought is a conceptual matter and, in Wittgenstein's case, even a linguistic matter. Turing takes these premises seriously and applies them to engineering practice, setting out the primary field of research in artificial intelligence primarily up to the present day (Coniam, 2008; Neufeld & Finnestad, 2020).

The Chinese peace argument offers the most famous critique (Warwick & Shah, 2014; Shieber, 2004), formulated in 1980 by John Searle (1984, 1990). His basic idea is that simply manipulating dictionaries and databases, or even controlling a conversation, does not necessarily mean that a given person understands the content of that communicative act. In some ways, Searl modifies Saussure's belief (Harris, 1990) that simple translation is not a trivial matter because it is not a matter of translating labels in a muse but of the need to understand concepts in the context of the signifier and the signified. Turing, however, takes a position in which he argues that the communicative practice is crucial, not the proper understanding of the concepts, which is more a matter of philosophy than a shared understanding of intelligence (Jacquet et al., 2021).

Although Turing's assumptions are not trivial and could be significantly challenged with more careful discussion, they have the advantage of establishing a practical, workable concept for developing dialogue systems that can strive for intelligent interaction. The developer and user may need to be more relevant whether or not the object they are interacting with is intelligent. What is critical is the quality of the dialogue and the experience (Jacquet et al., 2021). This impact of Turing's article was realised by Weizenbaum (1966). In his article, he describes in quite some detail how he constructed the first chatbot called ELIZA. It was a simple program that could create a question from a user's announcement sentence, thus mimicking the work of a psychotherapist using the principles of pure language methods. ELIZA (Thorat & Jadhav, 2020; Natale, 2019) had the advantage that it did not introduce any evaluation, self-reported turns of phrase, or anything of the sort into the conversation with the client. At first glance, it was clear that she did not understand the content of the interview, but at the same time that she was, in some ways fulfilling the ideal of a psychotherapeutic interview. At the same time, the application was able to work with specific schemes of complementary questions that completed the whole interview.

In his article, Weizenbaum points out that this is nothing more than a question of computing natural language, in which English plays more of a role as a model or illustrative example, but

a chatbot could similarly work with other languages, from machine code to algebra. The choice of psychotherapeutic conversation still contains a specific ethos:

> *"The above remarks intend to further rob ELIZA of the aura of magic to which its application to psychological subject matter has to some extent contributed. Seen in the coldest possible light, ELIZA is a translating processor in Gorn's sense; however, it has been specially constructed to work well with natural language."* (Weizenbaum, 1966, p. 43).

It is historically remarkable that the development of chatbots is going in precisely the opposite direction of Weizenbaum's thinking - we are trying to design chatbots that, on the contrary, work with an aura of magic because they enable authentic and functional conversations with real users. The second dimension of this magic is that ELIZA has become part of the cultural milieu, and chatbots based on it can be found in films in literature - from the late 1960s (the film THX-1138) to the present day.

The problem with ELIZA was that the psychologist or psychotherapist is educated with extraordinary verbal skills and the ability to understand the broad context of what the client is saying. It was almost impossible to simulate it using a simple algorithm, so the believability of such an application was low. In addition to efforts to improve the dialogue environment, there has also been a gradual search for scenarios that would significantly reduce such requirements on the chatbot - this is the path that led to the creation of PARRY (Shum et al., 2018; Thorat & Jadhav, 2020).

PARRY is conceived as a patient with schizophrenia characterised by a limited ability to communicate, loss of sensitivity to context and commonly understood insight into context. It was developed in 1971 by Colby et al. In their article, the authors introduce the issue as follows:

> *"Within the paradigm of computer science, distinctions are sometimes drawn between the activities of computer simulation and artificial intelligence. Yet in constructing models of psychological processes, the distinction can become blurred in places where overlaps emerge, as evident from our account of a model of artificial paranoia."* (Colby et al., 1971, p. 1).

Interestingly, even in Weizenbaum's article, the whole construction is different - the authors first carefully examine what the communication of a person with schizophrenia looks like and then carefully model the entire scenario. Thus, the focus is not on the question of computer processing of natural language and the search for universal scenarios but on working on a

specific, very sharply defined topic. The paper also includes an initial test that shows that it was not easy for the psychologists (five psychologists) to make the distinction between human and machine in this form of imitation game (Colby refers directly to Turing) and shows that it can be relatively easy to succeed in this specific area. The general ambitions of such a project could not have been grand. Still, they showed that a well-thought-out script embedded in particular situations could create compelling and functional dialogue.

Jabberwacky was created in 1988 and later saw several other versions. Its concept is groundbreaking because it was the first to use structures that can be understood as elementary artificial intelligence. It had dialogues with users and tried to learn based on dialogical patterns (McNeal & Newyear, 2013). Its content domain was entertainment.

In terms of education, a significant milestone was reached in 1991 when the chatbot appeared in the game TINYMUD. It was a multi-user text-based game, so communication through text was seen as usual and familiar. In this virtual environment, it was possible to create a relatively simple chatbot that is highly believable because users do not expect to interact with a machine and not a human (Masche & Le, 2017; Adamopoulou & Moussiades, 2020). Only an utterly fundamental error can give it away.

The approaches PARRY and the chatbot in TINYMUD show a fundamental design approach. The chatbot did not need to be an all-encompassing, one-size-fits-all tool. Still, working with the appropriate scenario and context in which the chatbot is situated is essential to its design. The evaluation of individual chatbots should always be coupled with thinking through the ecosystem of other information and social interactions in which they are involved.

Clippy (Dale, 2016; Baez et al., 2020; Illescas-Manzano et al., 2021) was an attempt at dialogic and contextually designed user education when working with an office suite, which Microsoft first integrated into its office suite in Office 97. The basic idea was that an office paperclip (gradually supplemented with other appearance variations) tries to find out what the user is doing and offers help and assistance. The fundamental problem was the overly deterministic conception of the whole assistant concept, which could not perform individual functions but only tried to guide (teach) the person how to deal with a particular problem. The overly mechanical concept led to significant inaccuracy and little understanding of what the user needed, which is why Clippy became the subject of various parodies and satirical comments. Crucially, chatbot development worked with pre-prepared dialogues, and the user could only select a response option, which was trivial but valuable because the system was supposed to

react to events in the application and start a dialogue accordingly. The second important dimension was that it was a chatbot deployed in a ubiquitous and essential application in a form that could not be overlooked or ignored.

With the development of instant messengers, there is also the emergence of chatbots, which can easily apply in their environment. In 2001, applications such as StudyBuddy and SmarterChild (Molnár & Szüts, 2018; Madeira et al., 2022) were developed to support informal learning. Students could write with the chatbots, and the chatbots used data from publicly available search engines for their work. The focus was on conveying information and working in an environment that expects quick and easy textual interactions.

ALICE was a system created by Richard Wallace, which was launched in 1995 and has undergone many changes and improvements over time (Sharma et al., 2017; Shawar & Atwell, 2002; Wallace, 2003; 2009). Program A (1995-1998) worked with the concepts of a few contributors who were involved in the mathematical models built by the program. Program B (1998-2000) began using an XML structure to format its knowledge data and has worked with over 300 contributors. Program C in 2000 entailed porting the code to C, to be replaced by Program D (based on Program B) in 2000. Program D used JAVA as the programming language. These improvements brought technological change and were always linked to developing the chatbot's capabilities in question.

In 2000, 2001 and 2004, he won the Loebner Prize, which focuses not on the appreciation of artificial intelligence (on which ALICE is based), but on the ability to design dialogue to appear as natural as possible. The Loebner Prize is a concept based on what Searle criticises in his argument with the Chinese Room. ALICE works with artificial intelligence, an open-source chatbot that other users can enhance, customise, or change. The whole concept makes no secret that the underlying motivation was to use artificial intelligence to improve the ELIZA concept (Wallace, 2009).

1.2. Personal assistants

Since 2010, there has been a rapid development of systems functioning as personal assistants built primarily on verbal communication. These are dialogue systems that can be integrated into special devices (Google Nest, Amazon Echo) or used in the operating system of a computer (Google Assistant, Microsoft's Cortana) or a mobile phone (Siri, Google Assistant) or as a specific program (IBM Watson). However, the range of individual solutions is much more comprehensive. The essential features of these systems are the absence of a visual form

(absence of humanisation by face), the attempt to use artificial intelligence, integration with other services (smart home, online services), voice control (limitation of typing) and emphasis on natural language dialogue. The term personal assistant is apt as it clearly shows the aim and purpose of developing these dialogue systems. In the following review, we focus on four products - Siri, Alexa, Assistant, and Cortana (Nobles et al., 2020; López et al., 2017) - that are among the most widely used.

Apple Siri was created in 2010 as a comprehensive voice assistant designed to make controlling Apple devices more convenient. It is currently available in most devices that Apple develops (Aron, 2011; Kepuska & Bohouta, 2018). Siri primarily has a female voice and attempts to communicate in natural language. Nevertheless, some users only use it for simple tasks such as finding their phone. She can control the phone, look up facts, manage devices, or work with navigation. Unlike Google, it works with the concept of a person who speaks with a name in a conversation, which is reflected in pop culture terms when Rajesh Ramayan Koothrappali interacts with her as a woman in The Big Bang Theory. The system uses several advanced algorithms for learning and processing user data, even where it heavily invades their privacy. The fact that the chatbot invades privacy is the most common criticism of Siri (Schönherr et al., 2020; Sharif & Tenbergen, 2020).

Alexa was launched in 2014 as a voice assistant for Amazon Echo systems, i.e. smart speakers (Lopatovska, I., & Williams, 2018; Lopatovska et al., 2019; Zwakman et al., 2021). At the same time, it is a multi-platform system that works on iOS and Android. Like Siri or Cortana, Alexa works with the concept of a dialogue with a person having a name (albeit partially suppressed and gender diversity in the case of Amazon). Alexa builds on Amazon's ambition to offer solutions for smart homes (and cars). It emphasises multimedia control, home automation and working with basic information (sporting events, traffic, weather, etc.). Alexa is also available through AWS to other developers who can integrate it into their products without paying fees. Thanks to Amazon Lex (as of 2017/2018), developers can define their responses by incorporating the artificial intelligence and learning system used by Alexa (Abualsamid & Hughes, 2018). This technology makes the voice assistant an accessible interface for development by more users.

Google Assistant was introduced in 2016, but its predecessor Google Now (Sullivan, 2009; Canbek & Mutlu, 2016), predates it by four years. Google Now aimed to change the paradigm in search and information access. Its designers believed that users had much information they could not access or needed to learn about, which is what this service was intended to provide.

The result was a broad ecosystem of tools capable of searching for information about traffic, movies, calendar reminders, or finding places to park. Google Assistant has brought two significant changes. It was tied to the Android operating system and the Google Home (now Nest) smart speaker, which gave it a whole voice interface. From the beginning, the app's goal was to access information through voice input (possibly through typing on a keyboard) and to perform individual actions with smart homes or devices. Google believes the dialogue system represents a unique way of mediating and retrieving information (Coates, 2019). There are currently many studies on using this technology in education (Lancioni et al., 2020; Chen et al., 2020; Sing et al., 2019; Tai & Chen, 2020).

Google considers its LaMDA tool, which combines various AI tools and pathways with a tremendous amount of training data, to be the best chat tool today (O'Leary, 2022; Griffiths, 2022; Grossman, 2022). While "regular" chatbots are based on the idea that specific dialogue scenarios can be developed and refined in development, Lambda aims for a universal dialogue system capable of discussing anything and has no such preferred set of initiation scenarios.

Microsoft's Cortana was a personal assistant (2014-2020) that was integrated into Microsoft's operating systems (Kim et al., 2016; Elwany & Shakeri, 2014). Cortana was (like Siri) female but needed to gain more popularity. This personal assistant supported simple activities (texting, emailing, calendar management), but the typical dialogue could have been more problematic. Its main weakness was the considerable time lag in development behind competitors from Apple, Amazon and Google.

Like Amazon, Microsoft is also trying to offer solutions developers could use in natural language computing. Since Cortana is no longer developmentally active, these are tools from the Microsoft Azure platform that can be implemented in third-party applications. Google also offers similar solutions to TensorFlow and DialogFlow. Besides, many environments are emerging where chatbots (whether using AI or not) can be exported, such as Tidio, Chatfuel, ManyCahts, Snachbot.me, Wit.ai, Aivo and many others. Chatbots have become an essential marketing and communication tool in the last few years and can also have many uses in other areas.

2. Chatbots in education

So far, we have focused on the historical development of chatbots as such. In this section, we would like to follow their application directly in the educational environment. Analysis will be incomplete and systematic but aims to show the broader possibilities of implementing this

technology in education in a broader pedagogical context. In this research, we will work with the SCOPUS database, from which we will select one study each year (the first available result is from 2006) according to the parameters of citation and relevance. On their selection, we will illustrate the gradual evolution of chatbots in education.

At the same time, it should be stressed that this is a partial analysis. Shawar and Atwell (2004), for example, discuss the possibilities of accessing information systems through chat tools. Heller et al. (2005) work with a chatbot, Freudbot, which models dialogue with Freud as an educational tool. The beginnings of the systematic use of chatbots for educational purposes can be linked to around 2005.

The query was used for the search:

```
TITLE-ABS-KEY ( chatbot OR chatbots AND education ) AND ( LIMIT-
TO ( LANGUAGE , "English" ) )
```

Figure 1 shows the gradual increase in studies over time, where it is clear that we can see massive growth from 2017 onwards. The drop-off in 2022 is because not all analyses for this year are published (this study was due in October 2022). The overview study ends in 2021 in selecting texts. Figure 2 shows that although the topic of chatbots in education is fixed on computer science and computer science, it is fundamentally interdisciplinary. Figure 3 then offers a glimpse of some of the cultural limitations of this research, as many languages, regions and cultures are not represented in the research. The English-speaking environment (USA, India, UK, Australia) is dominant. A closer examination (but not the focus of this study) would show that region also influences the thematic focus of each study.

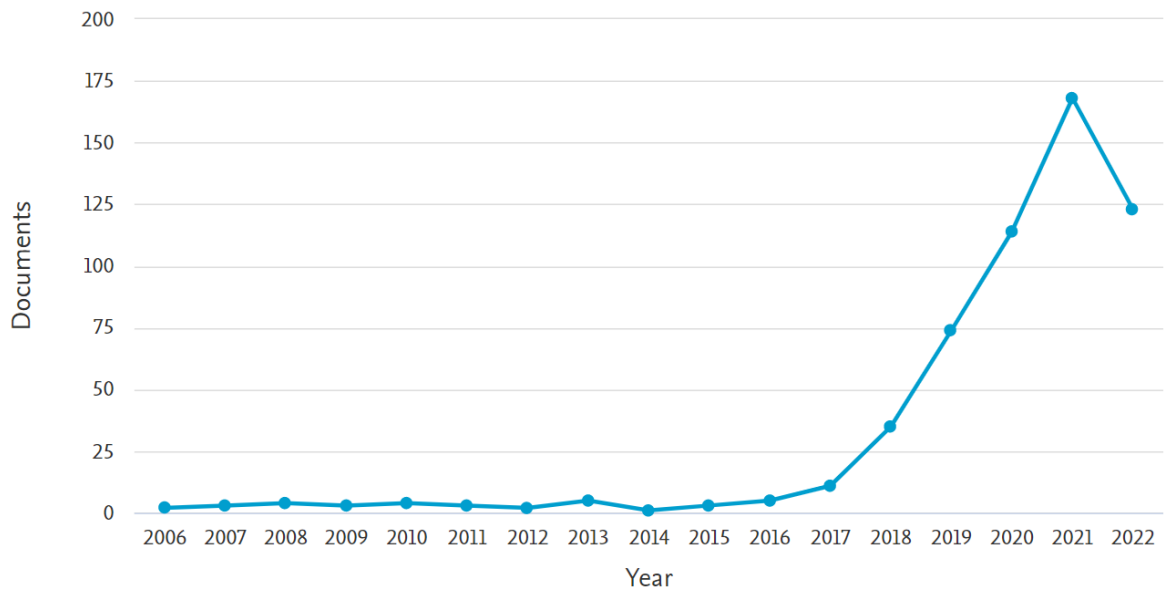

Fig. 1. Data from the SCOPUS database shows the number of documents indexed when working with a search query over time.

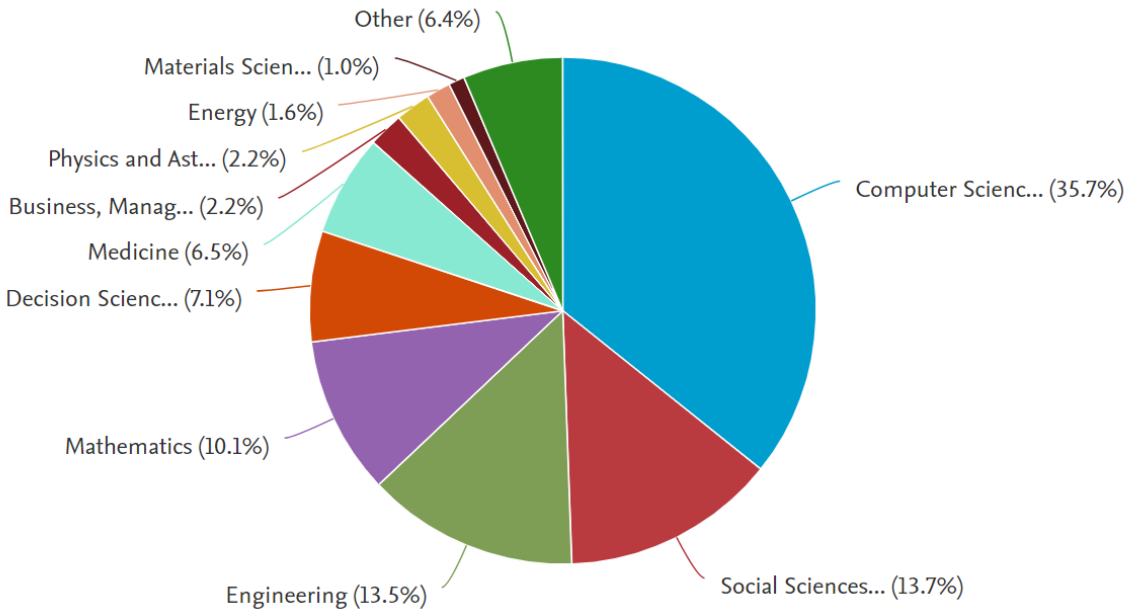

Fig. 2. Data from the SCOPUS database show the thematic affiliation of individual studies.

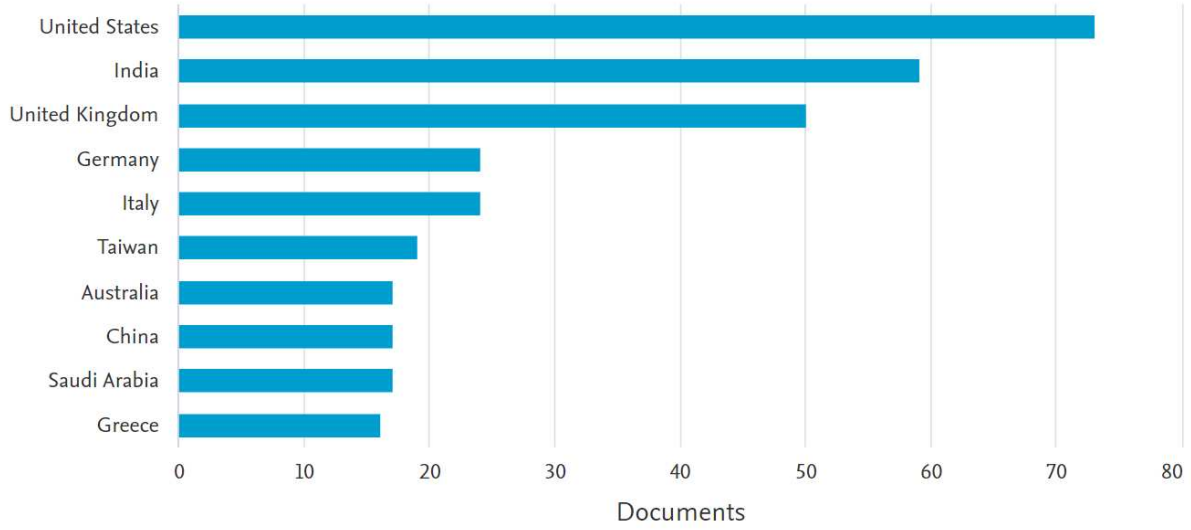

Fig. 3. Data from the SCOPUS database shows countries according to the affiliations listed in the individual documents.

The search product 438 documents. For each year, we selected one most cited paper, listed below. Within each year, we selected the paper with the highest citation rate and, at the same time, relevant to the study being conducted. Results start from 2006, the first year in which results are available in the Scopus database. Technically, we have always restricted the results to one specific year and ranked the results by citation. We did this for all years - from 2006 to 2021.

Lu et al. (2006) focus on developing a chatbot for teaching English as a second language. Their chatbot is based on the paradigm anchored in instant messing and combines working with computer processing of natural language and pre-prepared responses. It is on these that most of the dialogue is built. The authors work with the TutorBot chatbot, which serves, on the one hand, to support students in synchronous communication but also provides the teacher with information about individual student progress.

Kerly et al. (2007) highlight the importance of chatbots for adaptive learning that adapts to students' needs. They define the principles that such a chatbot should meet in its development - the ability to keep the learner on topic, manage data on learner behaviour, respond to and learn from previous records, web integration, and a body of knowledge of semantic reasoning. The chatbot is treated in this paper primarily as a technical problem, but one that may - if mastered - have significant practical implications.

Bigham et al. (2008) describe chatbots as integrating and activating blind students. As part of the project, blind students programmed the chatbot themselves, increasing their code-generation competence and affinity for the information. On the other hand, they created a chatbot designed so that other blind users could interact with it. Text input in an austere environment can be a prerequisite for universal design. At the same time shows that a chatbot can be an available assistive technology and an educational object that blind users can work with.

Jia (2009) presents a chatbot for learning English that works with natural language-based dialogue. The author tries to create an environment that will simulate a chat with a natural person, leading to an educational interaction. It strives for dialogue's semantic and syntactic analysis, making it more persuasive and context-working than ELIZA. The study concludes with a statement that we consider significant for the development of chatbots before the massive emergence of artificial intelligence in the likes of neural networks and publicly available frameworks for NPL:

> *"Solely in NLP, many problems are still hard to be solved, such as the textual ambiguity and entailment. How to overcome these problems with current available technologies is still a great challenge to us. The contradiction between the high response speed and complex, deep, syntactic and semantic analysis should also be paid great attention, especially in the web environment. "* (Jia, 2009, p. 255)

Lokman and Zain (2010) work with a chatbot to educate people with diabetes to simulate a doctor. They point out a typical problem related to simple chatbots working with individual responses in isolation, leading to less relevant responses and less convincing and natural dialogue. Therefore, their chatbot works in the context of previous questions and answers in the dialogue. This relatively simple procedure does not require sophisticated technological techniques, leading to a rapid improvement in the quality of the outputs.

Crutzen et al. (2011) focused on the information sought by adolescents on the topics of sex, drugs and alcohol. The study worked with a chatbot that dialogically answered students' questions. The research showed positive student interaction with the content and student perceptions. The conversations were relatively long and showed greater satisfaction with information needs than other sources of information, including hotlines. The study's authors show the great potential of chatbots in topics associated with shame, fear, or other social-psychological barriers.

In their study, Niranjan et al. (2012) work with a chatbot as part of an e-learning environment in which questions, usually of an organisational nature, need to be answered. The authors draw attention to the fact that even though online courses are being developed, they require the constant presence of a live teacher to answer students' questions. In the case of this study, the chatbot uses a naive Bayesian classifier to understand the question and evaluate it and a database of answers to questions authored by the teacher. At the same time, the teacher receives information from the chatbot about which questions are the most frequent, which allows him to modify the educational process.

Lundqvist et al. (2013) investigated ontology models that can be used for developing chatbots or modelling their dialogues. The study's authors point out that their model using AIML and the OwlLang scripting language achieves high satisfaction with users' information needs.

Gulenko (2014) describes a design approach to chatbot development. The first step identified essential cybersecurity topics relevant to the target audience. In the second step, a chatbot was created to work with the three most important ones. From this data and pedagogical analysis, sub-goals were constructed, with each goal being accompanied by a problem that prevents its saturation and a suggestion of what needs to change on the user's side to bring about a behaviour change. The study is interesting because it emphasises the development of the chatbot as an educational object rather than a technical solution.

In their theoretical historical study, Maggy et al. (2015) argue that providing an emotional interaction between the chatbot and the user is crucial to the feeling of learning. Combining this inspirational design with a sense of authenticity and personalisation is a fundamental prerequisite for a functional concept of the chatbot as a learning object. The study shows that education is a complex psycho-social process and that a good chatbot for marketing can be something other than an excellent educational object. Focusing on the feelings that chatbots evoke in users is a crucial pedagogical input that needs to be systematically worked with at the level of theory. Maggy et al. (2015) highlight that chatbots are important learning objects, but they need a broader theoretical background for their development.

Pereira (2016) creates a chatbot @dawebot that focuses on practising knowledge for a test in the form of an interactive dialogic test. A relatively simple implementation working with predefined questions on the test and feedback is tested on computer science students. It shows that students would welcome more such chatbots in other courses and feel more engaged and better prepared for the test. The study shows how a relatively simple tool can be further scaled

up (implemented in other courses) to help students. The author points out that chatbots can have many advantages, but one of the key ones is the interaction environment, which is fundamentally more pleasant and better than an LMS.

Frey et al. (2017) analyse the results of an experiment in foreign language teaching. One group had a live tutor, the other a chatbot. The authors analysed the course's decline in interest and motivation for both target groups. Although the sample size was limited (n=122), and the data is strongly dependent on the chatbot and the tutor's specific configuration, human motivation is essential for a course that lasts for a more extended time. A chatbot is a good tool for occasional activation or as a supplement to the broader learning ecosystem. Still, it is less effective a motivator for students than a live human teacher.

Io and Lee (2018) offer an extensive bibliometric analysis studying the current (2018) state of chatbot development. The authors point out that since 2015, we can identify a sharp increase in studies focusing on chatbots, which they argue is related to a significant shift in the development of artificial intelligence. Still, most of the studies analysed use AIML, which is consistent with the studies analysed above. At the same time, it shows that breakthroughs can be expected in the process of chatbot development and its methodology. According to this analysis, the main area in which chatbots will be applied is in the field of education and implementation in mobile devices.

Shorey et al. (2019) are only the seventh most cited study in the SCOPUS database for 2019 search queries but the first entirely relevant to education. The authors used a chatbot to simulate a virtual patient. The chatbot was complemented with a voice and virtual interface in the UNITI environment, aiming to increase the educational experience's authenticity. Here, the chatbot plays the role of a patient with whom nursing students try to converse and solve specific problems according to selected scenarios. The study notes that despite the relatively small sample of students and the initial stage of development, it can help with feelings of confidence and develop communication skills.

Kramer et al. (2020) is the sixth study in order of sensitivity, and the relevance to education is Perez et al. (2020), the fifth but only a general overview study. The authors focus on the specific phenomenon of embodied chatbots aimed at developing healthy lifestyles. These are animated conversational systems that change user behaviour through conversation. It shows that a chatbot in education may not only be focused on cognitive development and knowledge-based learning, but the study suggests great potential in coaching, personal development, lifestyle change, etc.

The study continues the inclination, evident in the last few years, towards an emotion-oriented emphasis on the design of chatbots as learning objects.

Chocarro et al. (2021) is the fourth most cited paper in this overview study but the first relevant to the content of the study. They focus on teachers' perceptions of chatbots. The study yields several essential findings - willingness to use chatbots is not related to teachers' digital competencies, so it does not represent a relevant barrier in this area. Secondly, the actual quality of chatbots is also not a determining factor for the willingness to implement chatbots in the educational process. The authors state, *"Our results confirm a positive and substantial impact of the perceived usefulness for using the chatbot on teachers' technology usage intention. Improving the performance and usefulness of chatbots is a critical determinant for teachers when considering adopting this technology for their jobs."* (Chocarro et al., 2021, p. 11) These results should be used when looking for suitable implementation schemes for integrating chatbots into education - it is in actual implementation that chatbots play a crucial role.

3. Discussion

The study aimed to analyse some aspects of the development of chatbots as learning objects. Currently, there are a large number of overview studies (Hwang, G. J., & Chang, 2021; Pérez et al., 2020; Cunningham-Nelson et al., 2019; Kuhail et al., 2022) that focus on the topic of chatbots, but a more systematic or comprehensive grasp of the historical development is lacking, except for a general study by Adamopoulou and Moussiades (2020). Methodologically, this study works with two pillars - the first part analyses the evolution of chatbots as such in a brief historical outline, and the second offers a specifically constructed historical overview study focused on scientific studies. At this point, we would like to identify some developmental landmarks or trends that can be analysed in understanding chatbots as educational objects.

The first trend that we can identify is a gradual transformation in the understanding of what a chatbot is - the Turing tradition seeks to develop a system capable of discussion in a way that is unrecognisable from a human (Powell, 2019; Qaffas, 2019). It works with the notion that indistinguishability is key to communication. This will create a dimension of trust that can be applied to the learning environment. Increasing the quality of dialogue (Abdul-Kader & Woods, 2015) represents a significant turning point in how the possibilities of working with chatbots are changing and evolving. At the same time, however, we must stress that the significance of its impact on the educational process is not only linked to its indistinguishability. Two inherently present concepts in dialogue systems development are juxtaposed here.

The first is related to the question of whether the requirements for a dialogue system used for education should be higher - Black Lemoin has worked for Google on testing LaMDA, the company's most advanced language generative neural network, and has come out in the media with a statement that he believes this neural network has self-consciousness (Tiku, 2022). This path of development and reasoning is towards developing artificial actors that are meant to be as human-like as possible.

On the other hand, it is possible to encounter applications that try to emphasise that the goal of development is not the "other person" but a dialogue partner with whom it is possible to interact through natural language, but at the same time, knowing that it is not a human. Such interactions allow for the design of significantly different educational activities and lead to varying experiences of interacting with the chatbot. A specific (extreme) branch of this research is the development of systems without artificial intelligence (Tamayo et al., 2020).

Studies in recent years by Kramer et al. (2020) and Shorey et al. (2019) show that the direction of development is not only related to actual dialogue based on the written word or voice work but that the goal is to model a virtual actor that has a digital "somatic" structure - face, emotions, expressions, gestures. On the one hand, such a conception leads to a higher authenticity of the chatbot. Still, it also highlights that textual communication constitutes only one part of understanding the information communicated. The findings of Frey et al. (2017) show that the awareness that the communication partner is a chatbot and not a human is not negligible in the education process.

Even systems with such a high degree of believability, such as the LaMDA chatbot, which would feature a graphical interface in Unity as described by Shorey et al. (2019), will face a psychological barrier in terms of long-term interaction. However, the short-term effect of activation is indisputable. Equally indisputable is the positive effect of chatbots on learning when they become part of a broader ecosystem. Their goal is not and cannot be to replace the teacher as a living actor but to complement the educational structure with an educational object that brings specific benefits.

The clear trend is to change the inherent mechanisms on which chatbots are based. We can observe a shift from simple conversational frameworks and models working with keywords (Tamayo et al., 2020; Satyanarayana, 2019) to complex tools using artificial intelligence and neural networks. An unmistakable trend in educational applications is using frameworks that

allow leveraging technical solutions developed by a third party and focusing on the actual educational implementation.

Much attention has been paid progressively to the design of educational interaction (Topal et al., 2021; Stuij et al., 2020; Vázquez-Cano, 2021) - while for the first studies we analysed, the dialogue needed to be made believable, current solutions focus much more their attention on how to use chatbots in a specific educational domain, how to set up the chatbot behaviour and the whole educational process so that the chatbot forms only one particular part of a broader educational interaction.

The fact that the chatbot has gradually become a learning object (FAO, 2021) clearly illustrates the above shift - the goal is no longer to work with the chatbot per se but to find areas in which it can be used, fulfil explicit educational purposes, and function as part of a broader ecosystem of learning objects. In this area, a clear trend can be identified of a gradual focus on "how to build a chatbot" to find areas where its implementation is effective and meaningful.

Although the development of chatbots in education has been systematic since 2006 at the latest (as this study shows) and has been overgrowing since 2017, there still needs to be a more systematic, empirically oriented set of clear recommendations or methodologies for working with chatbots. Individual studies and methodologies tend to be eclectic, and we expect this is where basic pedagogical research will be applied (Chang et al., 2021; Mendoza et al., 2020). A gradual transition needs to be made from an overview study to comprehensively analyse specific aspects of chatbot design.

Typical applications for current applications are in school subjects; history (Noh & Hong, 2021), health education (Hwang, G. J., & Chang, 2021; Palanica et al., 2019), languages (Hwang & Chang, 2021; Sung, 2020; Haristiani, 2019) and many other areas. Alternatively, in specific areas of learning support, such as intelligent feedback (Lundqvist et al., 2013; Lee & Fu, 2019), immediate assistance to the student (Berger et al., 2019; Okonkwo & Ade-Ibijola, 2021) and alternatives to learning management systems (Tamayo, 2020; Villegas-Ch et al., 2020).

4. Conclusion

Chatbots as technology have made significant developments in recent years and have become part of the educational environment. They can now be used for motivation, feedback, as a substitute for information systems, and as a tool to practice knowledge or develop

competencies. They constitute a tool - almost unlimited in terms of the list of possible applications. Nevertheless, the historical development that we have tried to outline in this study shows that the future of technology lies not in replacing all other educational objects but in developing the ability to integrate them effectively into educational environments and developing methodologies for their appropriate use. The chatbot is (perhaps more than other forms) very sensitive to working with language, and students may experience frustration or arrogance when interacting with it, which may be due to minor stylistic problems or the chatbot's inability to accept the correct answer.

In this study, we uncovered three critical historical discourses that have been applied to chatbot development and that frame the developer's approach to chatbots:

a) Turing - the goal is to create a conversational agent indistinguishable from a human in its expressions.

b) Searlean - the goal is to create a conversational robot with consciousness or at least a specific understanding of itself.

c) Technological - the goal is to create an entity that will be different from humans and allow performing interactions inaccessible to humans with a transparent layer of communication in which dialogue will be used. Still, at the same time, it will be evident that it is not an imitation of humans.

The first is the most represented discourse. The second is that many theoretical studies drawing attention to the problem of Turing discourse begin to apply technically. However, from an educational point of view, the third discourse is the key. It allows not to replace the teacher but to extend the range of educational possibilities and complement it. For example, the future of chatbots in online courses may involve a close collaboration between tutor and chatbot on joint comprehensive learner support.

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Environmental awareness perception of senior high school students in Ghana, the case of the Bolgatanga Municipality

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Abstract: *This research examines environmental awareness perception among senior high school students in Ghana using socio-demographic indicators and the Environmental Awareness and Active Participation Scale. The research topic hinges on the notion that the attainment of the environmental components of sustainable development depends largely on the youth who are the future generation, and the custodians of the earth. Data for the research were obtained through a quantitative approach. Survey questionnaires were distributed to the three senior high schools in the Bolgatanga Municipality. The findings of this research show a high score on the Environmental Awareness and Activive Participation scale. This is an indication of the high environmental awareness perception of students via the educational system and by the media. The results also show that the major socio-demographic factor that influences the environmental awareness perception in senior high school students is their mothers' level of occupation. This finding has both theoretical and practical implications.*

Keywords: *Sustainable development; Environment; Education; Bolgatanga Municipality*

1. Introduction

Sustainable development as defined by the Bruntland Commission is the development that meets the needs of the present, without compromising the ability of future generations to meet their own needs (Sustainable Development Commission, 2011). The Bruntland Commission heralded the era of sustainable development and charged governments to account to ensure the needs of society, the economy, and the environment were completely balanced in the decision it makes and the way they ran themselves. Unfortunately, the quest for economic emancipation is always higher than the desire to protect the environment. This is illustrated by Gareth Hardin in his famous work on the tragedy of the commons. In the tragedy of the commons, Hardin asserts that individuals neglect the well-being of society and the environment in the pursuit of personal gains (Frischmann et al., 2019; Hardin, 1968).

Our planet faces various forms of environmental problems such as water pollution, air pollution, soil pollution, solid waste, nuclear waste, global warming, earthquakes, and floods (Dunlap & Jorgenson, 2012). These environmental problems coupled with the increasing human population have resulted in an ecological imbalance that may have further repercussions for our planet.

The increase in the global population has increased the number of youth. According to the United Nations, in 2019 there are approximately 1.2 billion youth aged 15 to 24 years in the world, and this equates to approximately 16% of the global population (United Nations, 2019). It is projected that the number of youth is expected to grow by 7% to 1.3 billion by the year 2030, which is the target year for achieving the Sustainable Development Goals. Considering the youthful nature of the world's population, it is paramount that environmental awareness among especially senior secondary school students is emphasized. A high level of environmental awareness among senior high school students will go a long way to help achieve the environmental component of sustainable development.

Ghana's population is also youthful. For instance, Ghana's Statistical Service reported in its 2021 population census that over 11 million (out of approximately 32 million Ghanaians) are aged under 15 years old (United Nations Department of Economic and Social Affairs: Population Division, 2022). The average age for students to complete senior secondary school in Ghana is 17 years of age (Iddrisu et al., 2017). This research, therefore, targets senior high school students because they form an integral part of the youthful population in Ghana and the world.

The target population for this research is the Bolgatanga Municipality. Bolgatanga is the regional capital of the Upper East Region of Ghana. It is adjacent to the border of Burkina Faso. A report released by the Ghana Statistical Service with support from the United Nations Development Program (UNDP) implies that with the current population of 31 million, 14 million Ghanaians are estimated to be multi-dimensionally poor (UNDP, 2020), and the Bolgatanga Municipality is one of the poorest municipalities[1]. The activities of the youth in the Bolgatanga Municipality pose great environmental threats. For instance, after completing senior high school, the majority of students, especially males engage in tricycle riding (locally known as pragia or candu) to make a living. The oil spills from the tricycles pollute the land. Also, the worn-out tires from the pragia are not disposed-off properly. The females sell fried

[1] The Northern, Upper East, and Upper West Regions of Ghana continue to have the highest poverty rate of about 44% (Ofori-Boateng, 2015; UNDP, 2020)

rice on the streets (locally known as check-check). The plastic bags used to serve the check-check are not disposed-off properly and ends up in the open drains. These activities of the tricycle operators and the check-check operators are sources of environmental pollution. Hence a sample of the youth environmental awareness would help inform policy.

Few studies have also examined environmental awareness among senior high school students. For instance, Sudhakar et al. (2020) examined environmental awareness among secondary school students in the Guntur District. They investigated six schools in the Guntur district using a random sampling technique. They found that the level of environmental awareness did not vary between the schools. Danielraja (2019) also studied the environmental awareness of students in High Schools and found that environmental awareness differs between students in different disciplines. For instance, science students have high environmental awareness than vocational skills students. This current research adds to the already few studies on environmental awareness among senior secondary school students.

Given the above, this research would seek to achieve the following objectives:

i. To determine the level of environmental education in senior high schools.
ii. To determine the role of the media on environmental education among senior high school students.
iii. To measure senior high school students' perception of environmental issues using the Environmental Awareness and Active Participation Scale (EAAPS).
iv. To determine the socio-demographic factors that influence the environmental perception of senior high school students.

The remainder of this manuscript is divided into four sections. First, we discuss the role of the school and the media in creating environmental awareness among senior high school students. Second, we describe our methodology. We used a survey questionnaire for our data collection. There are three senior high schools in the Bolgatanga Municipality, and we distributed the questionnaires to the three schools. Third, we discuss the results and analysis. Finally, we concluded by suggesting that the level of environmental awareness in senior high schools in the Bolgatanga Municipality is adequate, and the major socio-demographic factor that influences environmental awareness among senior high school students is the mother's educational level.

2.0 Role of the school in environmental education

Environmental education aims to encourage public awareness of environmental issues, problems, and solutions. Environmental education provides the opportunity for people to acquire the knowledge, attitudes, values, commitment, and skills to protect and improve the environment (Ardoin et al., 2020; *Belgrade Charter*, n.d.; Erhabor & Don, 2016; Fang et al., 2023). Because of this, environmental education seeks to develop an active and well-informed citizenry that is committed to the prospect of environmental protection (Fien, 1993, 1995). Research shows that there is a high level of student concern about the environment (Dunlap et al., 1993; Jusoh et al., 2018; National Environmental Education and Training Foundation, 1994), and environmental education in the formal education system is vital in the quest to empower students since they are tomorrow's leaders and stewards of the earth.

There is a strong argument for the need to educate future environmental stewards to ensure sustainable utilization of the earth's natural resources, as many environmental problems especially in the developing world are desperately in need of attention (Sutherland & Ham, 1992, 2010). Arguably, students, parents, community elders and other adults in a community are better placed to help address environmental problems. However, there are many challenges associated with educating adults in a community. A primary challenge is the lack of time for involvement in environmental education and projects (Ballantyne et al., 1998; Kimaro et al., 2022). The need to educate students as a catalyst for environmental change is very important (Danielraja, 2019; Sudhakar et al., 2020). The youth are agents of intergenerational influence, hence the need to educate especially secondary school students to help protect the environment is paramount (Brothers et al., 1991; Ryan, 1991).

Education for Sustainability

The role of the school in environmental education towards the attainment of the sustainable development goals (SDGs) is very vital. Education for sustainability allows every person to acquire the knowledge and the requisite skills, attitudes, and values needed to shape the environment by ensuring that natural resources are utilised wisely (UNESCO, 2018; Wamsler, 2020).

Education for sustainability requires schools to use participatory teaching and learning approaches that motivate and empower students to change their behaviour and take actions that ensure the protection of the environment. Education for sustainability, therefore, promotes

competencies such as critical thinking, imagining future scenarios, systemic thinking and analysis, and collaborative decision-making (UNESCO, 2018).

The educational system needs to adapt its teaching and learning approach to adhere to the ideas of education for sustainability. This will ensure that the environment and available natural resources are utilised sustainably.

3.0 The role of the media in environmental education

The media plays a vibrant role when it comes to informing the general public about environmental issues, their consequences, and remedies put in place (Blum, 1987; Robelia & Murphy, 2012; Salaudeen & Onyechi, 2020). Various media such as radio, TV, newspaper, and the internet play two major roles concerning environmental awareness. On the one hand, the media helps to disseminate and explain environmental policies, regulations, and plans, and on the other hand, they help to reflect the concerns of the public concerning environmental problems (Maurya, 2019).

The role of the media in forming environmental perceptions among the youth, especially, senior high school students is very vital in the current technological age. The youth spend most of their time on social media. Research by Lenhart (2015) indicates that 92% of the youth are active on social media and that the age group of 13-17 years are heavy users of social media. There are many negative impacts associated with the use of social media (Keles et al., 2020; Tripathi, 2017), and its role in creating environmental awareness among the youth has been widely studied (Hamid et al., 2017; Mallick & Bajpai, 2019; Ors, 2012).

4.0 Materials and Methods

To measure environmental awareness perception among senior high school students in the Bolgatanga Municipality, we studied all three senior high schools in the municipality. The schools are Bolgatanga Technical Institute (located at Yekene), Bolgatanga Girls Senior High School (located at Zare), and Zamse Senior High/Technical School (located at Bolgatanta Estate).

The Bolgatanga Municipal is situated in the Upper East Region of Ghana. It contains a landmass of 729 km^2, bordered to the north by the Bongo district, south and east by the Talensi and Nabdam districts, and to the west by the Kassena-Nankana municipality (Abanyie et al., 2016). It has a population of 139,864 out of which 73,257 are females and 66,607 are males

(Population and Housing Census, 2021). Farming is the main occupation of the people of Bolgatanga. They engage in subsistence farming of millet, maize, guinea-corn, rice, beans, groundnuts, and sweet potatoes during the rainy season and irrigation farming of onions, tomatoes, and pepper during the dry season (Abanyie et al., 2016).

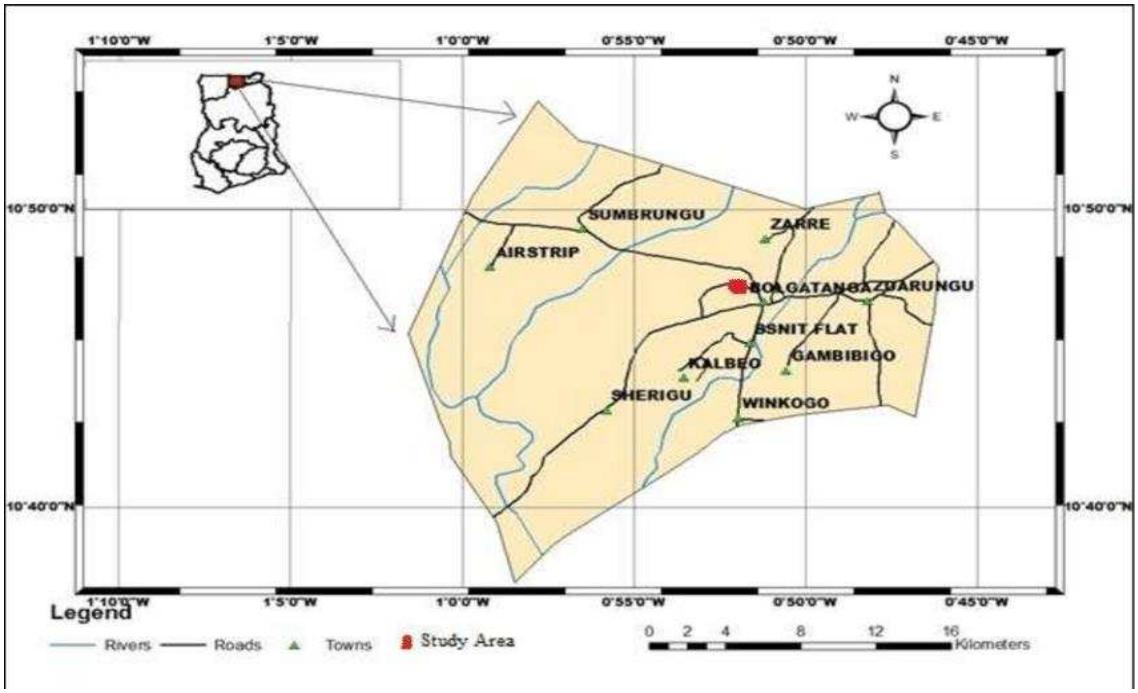

Figure 1: An outline of the Bolgatanga Municipality, located in the Upper East Region of Ghana

Quantitative Survey

To answer the four objectives, we use a quantitative survey questionnaire to gather the necessary data. As stated above, three senior high schools in the Bolgatanga Municipality were surveyed. The survey questionnaire was divided into three sections. Section I is the socio-demographic indicators, section II is the socio-media indicators for measuring environmental awareness, and section III is the environmental awareness and active participation scale EAAPS.

The EAAPS is a survey instrument developed by Altin et al. (2014) that is used extensively in environmental awareness perception studies. It is a 5-point Likert-type scale consisting of 11 questions. The first 7 questions measure the environmental awareness of students and the remaining 3 questions measures participation levels in environmental organizations/activities (Altin et al., 2014). The EAAPS is such that responses are rated 1 for ‘strongly disagree’, 2 for ‘disagree’, 3 for ‘neither disagree nor agree’, 4 for ‘agree’, and 5 for ‘strongly agree’.

The survey questionnaires were delivered by hand to each school after seeking the permission of the school's principals. A total of 600 questionnaires were delivered to the three schools. Each school was given 200 questionnaires. A total of 150 students responded to the survey, making a response rate of 25%. The socio-demographic variables suggest that the percentage of females in the sample is 53.3%. This is fairly representative of the female population in the municipality i.e., 52.38% in the 2021 population and housing census (Bolgatanga Municipal Assembly, 2022). About 48.32% of the respondents are aged below18 years and 51% are aged between 18-24 years.

5.0 Results and Discussion

In this section, we answered the four objectives by analyzing the available data. We analyze the data based on the objectives of the study. It is worthwhile to note that with a 10% margin of error, a responds rate of 16% is statistically enough to draw a conclusion (Aryee et al., 2020; Graglia, 2022).

Objective one:

The first objective is to determine the level of environmental education in senior high schools in the Bolgatanga Municipality. To answer this objective, we asked the following questions:

i. Is the environmental course in your school an elective or core (compulsory) course?
ii. How well do you take advantage of environmental education in your school?
iii. Is there an activity in the school that seeks to educate the local community about the dangers of environmental degradation?

Question 1 asked students whether the environmental course in their school is an elective or core course. This question was coded 1 for an elective environmental course, and 2 for a core environmental course. All 150 respondents answered the question. Out of the 150 respondents, 114 representing 76% said environmental education in their schools is a core or compulsory course while 36 students representing 24% said environmental education in their school is an elective course, i.e., they are at liberty to choose it or not.

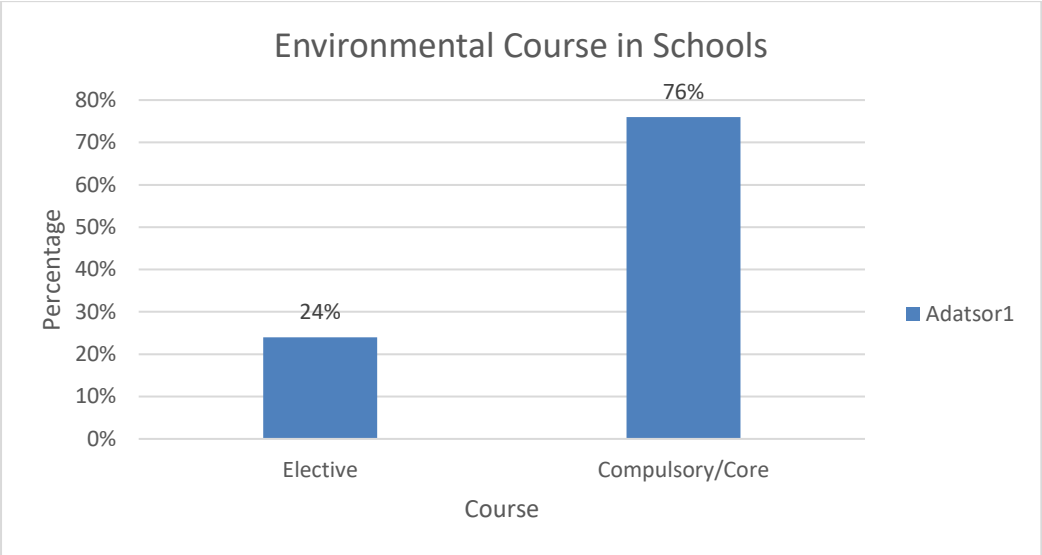

Figure 2: Environmental course as an elective or core subject in senior high schools (n=150).

In the Ghana education system, environmental education is incorporated into the Integrated Science and Social Studies courses. Integrated science and social studies are compulsory modules, so it is expected that every senior secondary school student should have basic environmental knowledge after completion of high school.

The second question asked how well students take advantage of environmental education in their schools. This question was coded 1 for 'not at all well', 2 for 'slightly well', 3 for 'moderately well', 4 for 'very well', and 5 for 'extremely well'. All 150 respondents answered this question. Over 72% of the students admitted that they take advantage of environmental education in their schools.

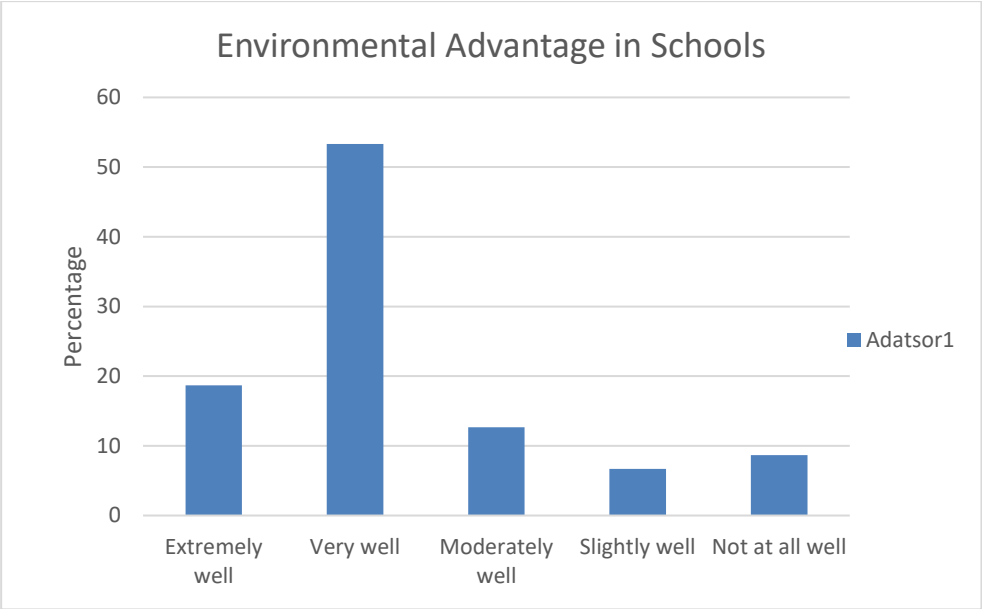

Figure 3: How students take advantage of environmental education in senior high schools (n=150).

The third question asked respondents if there is any activity in their school that seeks to educate the community members on the dangers of environmental degradation. The question was coded 1 for 'yes', and 2 for 'no'. This question is intended to find out whether environmental education in the school has any bearing on the community. All 150 respondents answered this particular question, and about 76% say there are no such programs that seek to educate the local community about environmental degradation.

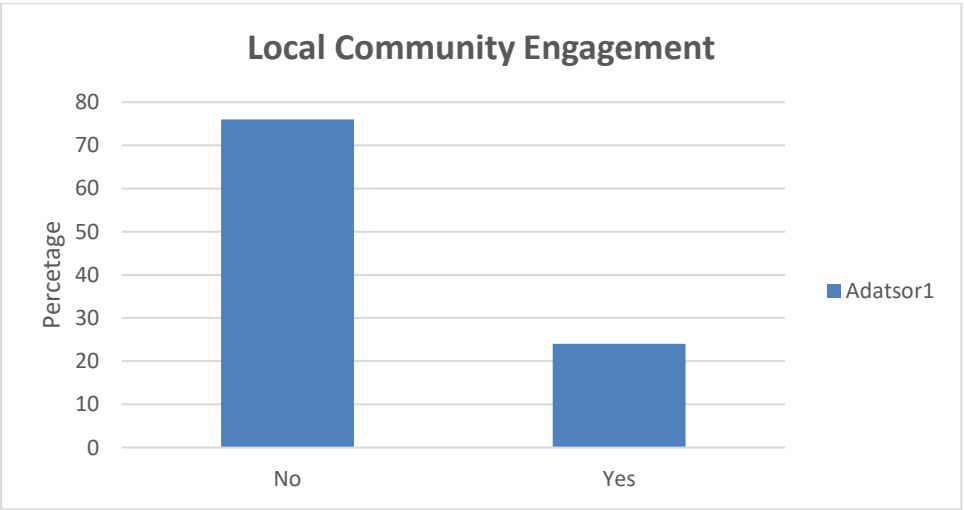

Figure 4: Activities in senior high schools that educate community members on environmental education (n=150).

Objective two:

The second objective is to determine the role of the media in environmental education among senior high school students in the Bolgatanga Municipality. To answer this objective, we asked the following questions:

i. On average, how many hours do you watch TV every day?
ii. Do you try to follow publications and broadcasts about environmental issues?
iii. Mass media (newspaper, radio, TV, etc.) has contributed to the development of my environmental awareness.

Question one asked: on average, how many hours do you watch TV every day? This question was coded 1 for 'up to 2 hours', 2 for 'between 2 – 4 hours', 3 for 'between 4 – 6 hours', and 5 for 'more than 6 hours'. 150 respondents answered this question, and the results are indicated in the graph below.

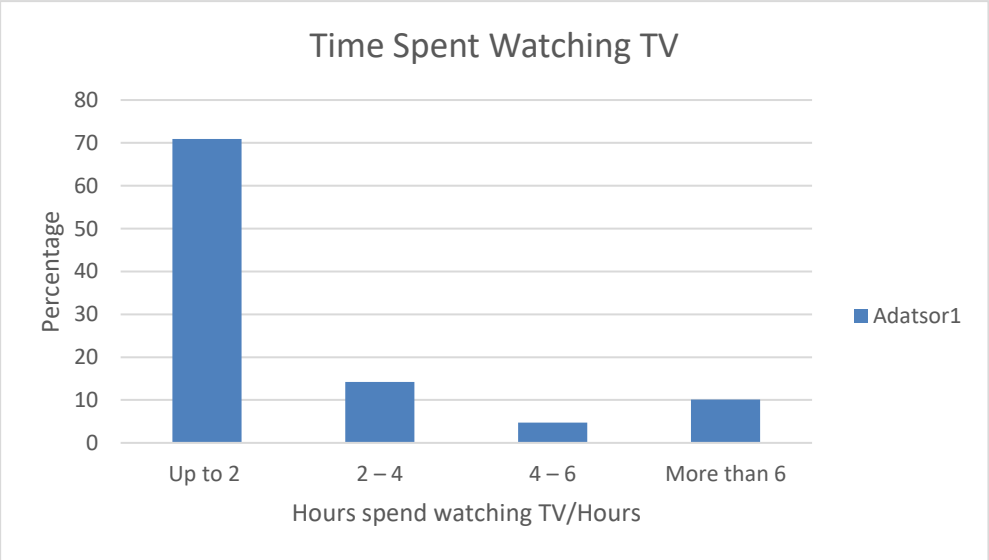

Figure 5: Time senior secondary students spend watching television (n=150).

From the bar graph above, approximately 70% of the respondents watch TV for up to 2 hours a day. Since the respondents are secondary school students, most of the students are in boarding schools and do not have access to television (Abdallah et al., 2014). Secondly, most students prefer to spend time on social media than to watch mainstream television (Asare-Donkoh, 2018; Salaudeen & Onyechi, 2020; Tsfati et al., 2020).

Question two asked students whether they follow publications and broadcast about environmental issues. This question was coded 1 for 'no', and 2 for 'yes'. 150 respondents

answered this question. 110 respondents representing approximately 73% admitted that they followed publications and broadcast on environmental issues.

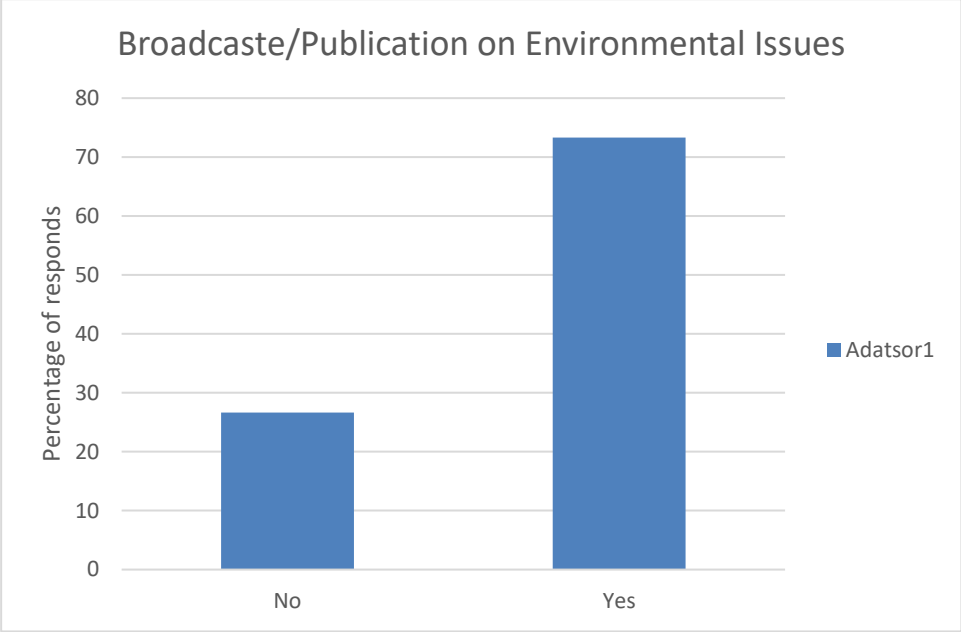

Figure 6: Senior high school students who follow broadcasts and publications on environmental issues (n=150).

The second question asked respondents to agree or disagree with whether social media has contributed to the development of their environmental awareness. This question was coded 1 for 'strongly disagree', 2 for 'disagree', 3 for 'neither agree nor disagree', 4 for 'agree', and 5 for 'strongly agree'. 149 respondents answered this question and 127 respondents corresponding to approximately 84.3% agree and strongly agree that mass media has played a major role in shaping their environmental awareness.

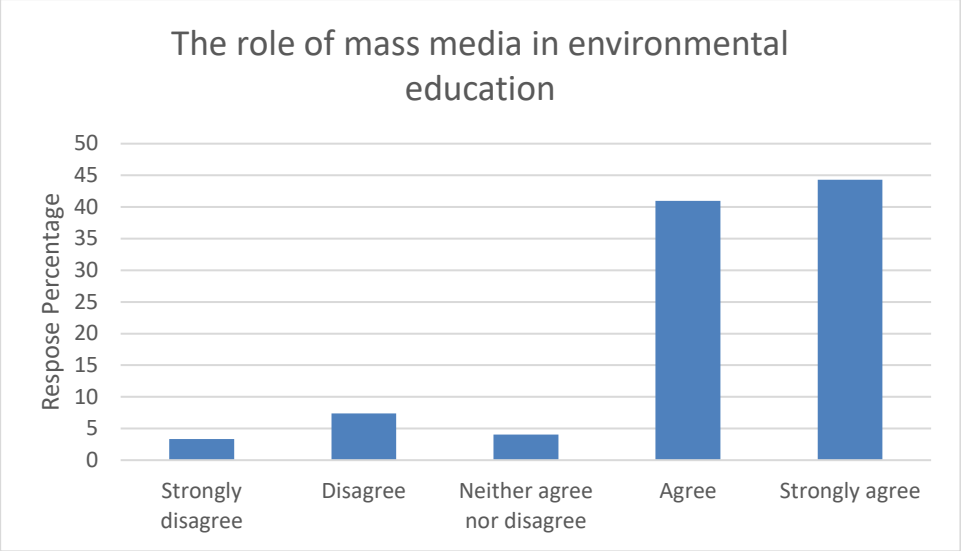

Figure 7: Whether mass media has affected senior high school students environmental education (n=150)

Objective three:

The third objective is to measure senior high school students' perception of environmental issues using the Environmental Awareness and Active Participation Scale (EAAPS). As noted above, the EAAPS is a 5-point Likert scale (Appendix A) and the questions were coded '1' for responses that strongly disagree with these statements, '2' for responses that disagree with these statements, '3' for responses that neither agree nor disagree with these statements, '4' for responses that agree with these statements, and '5' for responses that strongly agree with these statements, and blank for blank responses. Table 1 below is the average (mean) score of the respondents on the EAAPS.

Table 1: Environmental Awareness and Active Participation Scale (EAAPS) Score Distribution

		No of Students	Mean Score	STD
1	I have sufficient information about environmental problems.	150	4.11	1.06
2	If people keep producing and consuming like this, would there be a serious raw material shortage?	150	3.47	1.33
3	Economic growth and technological developments have dangerously damage nature	150	2.94	1.41
4	There should be limitations on economic growth in order to prevent destruction of the nature.	150	3.65	1.28
5	Developed countries are more responsible for environmental pollution and destruction of nature	149	3.20	1.50
6	We do not inherit the earth from our ancestors; We borrow it from our children	150	2.29	1.32
7	Development of personal environmental awareness is an important feature for protection of the environment.	150	4.37	0.86
8	I am aware of activities of environmental club in my school	150	3.65	1.29
9	I do recognize environmental non-governmental organizations	149	3.14	1.24
10	I know government agencies that deal with protection of the environment.	150	3.91	1.25
11	I have participated in an environmentalist groups or organization	150	3.31	1.23

Analysis of the first 7 questions which measure environmental awareness indicated a high mean score on the EAAPS scale. Questions 1 and 7 had the highest average scores.

Question 1 asked: I have sufficient information about environmental problems. 150 respondents answered this question and 124 respondents representing approximately 83% agreed and strongly agreed that they have sufficient information about environmental problems.

Table 2: EAAPS QI: I have sufficient information about environmental problems n=150.

EAAPS Q1	Frequency	Percentage	Cumulative Frequency
Strongly disagree	4	2.67	2.67
Disagree	15	10.00	12.67
Neither agree nor disagree	7	4.67	17.33
Agree	58	38.67	56.00
Strongly agree	66	44.00	100.00
Total	150	100	

Question 7 also asked: Development of personal environmental awareness is an important feature for the protection of the environment. 150 students answered this question and 138 out of the 150, representing approximately 92% agreed and strongly agreed with the statement that the development of personal environmental awareness is important.

Table 3: EAAPS Q7: Environmental awareness is an important feature for environmental protection n=150

EAAPS Q7	Frequency	Percentage	Cumulative Frequency
Strongly disagree	4	2.67	2.67
Disagree	3	2.00	4.67
Neither agree nor disagree	5	3.33	8.00
Agree	60	40.00	48.00
Strongly agree	78	52.00	100.00
Total	150	100	

Objective four:

The fourth objective seeks to determine the socio-demographic factors that influence the environmental perception of senior high school students. The specific socio-demographic indicators used to measure environmental perception were analyzed using Ordinary Least Square Regression (OLS) where the total EAAPS is the dependent variable and the socio-demographic variables are the independent variables.

The socio-demographic indicators that were considered are the gender of respondents, age of respondents, mother's education level of respondents, father's education level of respondents, household monthly income, mothers' occupation, and fathers' occupation. We tested the reliability of these seven socio-demographic variables on STATA-13 and found that the variables are internally consistent (alpha = 0.71). As a result, we specifically hypothesized that as the socio-demographic indicator scores increase, the total EAAPS will also increase.

Table 4: Ordinary Least Squares Regression Coefficients (*b*) and Standard Errors (SE) for the Total EAAPS and the Socio-Demographic Variables

	Total EAAPS	
Socio-Demographic Variables	*b*	SE
Gender	1.45	1.04
Age	0.18	0.93
Mother Education Level	-0.18	0.41
Father Education Level	-0.16	0.35
Household Monthly Income	0.11	0.34
Mother Occupation	-0.80*	0.41
Father Occupation	0.62	0.39
Constant	37.69	2.51
N	111	
Adjusted R^2	-0.0121	

Note: ***p<0.001, **p<0.01, *p<0.05 significance (two-tailed).

The results in Table 4 indicate that only the mothers' occupation is significant. All the other socio-demographic variables are insignificant. This result implied the significance of the relationship between the mother's occupation and the level of environmental awareness of senior high school students.

From Table 4, a unit increase in the mother occupation score corresponds to a 0.80 increase in the EAAPS score. This increase is significant, and as a result, we reject the null hypothesis that there is no relationship between the mother's occupation and the total EAAPS. The hypothesis

that as the socio-demographic variable (mother's occupation) increases, the total EAAPS score would also increase is supported by the data.

This finding is supported by the literature. For instance, research by von der Lippe (1999) found that educated working mothers' have a positive influence on their children's decisions making capabilities, as compared with the fathers'. Other studies also found a positive relationship between a mother's occupation and the development of environmental awareness among children (Altin et al., 2014; Hampel et al., 1996).

6.0 Conclusion

Achieving the sustainable development goal by the stipulated year of 2030 is very vital to the sustainability of the Earth. A vital component of sustainable development is the protection of the environment. The youth as a major component of the earth's population and future custodians of the earth has a significant part to play in ensuring environmental sustainability. This research aimed at measuring the environmental awareness perception of senior high school students in the Bolgatanga Municipality of Ghana. An instrument called the EAAPS was used to measure environmental awareness perception.

It was found that the level of environmental education in senior high schools in the Bolgatanga Municipality of Ghana is acceptable. However, this does not translate in the local community as 71% of the respondents did not have any knowledge of programs or projects run by their schools that seek to educate the local communities on environmental issues.

The mean score on the EAAPS also indicated that the level of environmental awareness and participation of senior high school students in environmental education is high. This is highly recommendable.

Finally, we found that the socio-demographic indicator that is responsible for the high environmental awareness perception among the senior high school students in the Bolgatanga municipality is the mother's occupation variable. This is a clear indication of the role of mothers in inculcating environmental education in their children.

Theoretical and Practical Implication

This research has two theoretical implications. First, the research adds to the literature on the role of senior high school and the media in environmental awareness perception study. A few research has examined the role of schools and the media on environmental awareness

perception among students. This research, therefore, improves the literature in this regard. Second, a significant finding of this research is that the factor that improves environmental awareness perception among students is the mothers' occupation. This research is one of the few research available that has explicitly confirmed the impact of a mother's occupation on students' environmental awareness perception development.

Practically, this research informs policy on the need to make environmental studies a core (compulsory) subject in senior high schools. Although the level of environmental awareness in senior high school is adequate, this research found that it is not reciprocated in the local community. There is therefore the need for senior high schools to occasionally engage in outreaches and other projects that promote environmental awareness in their immediate community.

Acknowledgement

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Appendix A

The Environmental Awareness and Active Participation Scale (EAAPS).

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
I have sufficient information about environmental problems.	☐	☐	☐	☐	☐
If people keep producing and consuming like this, would there be a serious raw material shortage?	☐	☐	☐	☐	☐
Economic growth and technological developments have dangerously damage nature.	☐	☐	☐	☐	☐
There should be limitations on economic growth in order to prevent destruction of the Nature.	☐	☐	☐	☐	☐
Developed countries are more responsible for environmental pollution and destruction of Nature	☐	☐	☐	☐	☐
We do not inherit the earth from our ancestors; We borrow it from our children	☐	☐	☐	☐	☐
Development of personal environmental awareness is an important feature for protection of the environment.	☐	☐	☐	☐	☐
I am aware of activities of environmental club in my school	☐	☐	☐	☐	☐
I do recognize environmental non-governmental organizations	☐	☐	☐	☐	☐
I know government agencies that deal with protection of the environment	☐	☐	☐	☐	☐
. I have participated in an environmentalist groups or organization	☐	☐	☐	☐	☐

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Possibilities of using mobile phones in the educational process

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Abstract: *M-learning offers countless opportunities to develop students' key 21st century competences, such as the development of problem-solving skills, cooperation, communication skills and creativity. The aim of our research is to learn about the opinions of secondary school teachers regarding mobile devices, as well as their attitudes towards their use. The one-sample T-test and Chi-square test were used to analyse the responses to the questions in the questionnaire, and the non-parametric Mann-Whitney test was used to compare the averages of the Likert scale after testing the normality of the responses. Based on our results, it can be said that teachers take advantage of the opportunities offered by mobile phones, and a significant proportion of those interviewed regularly include them in the teaching process, enriching the lessons with the use of innovative applications. According to the conclusions of our study, there is a positive, forward-looking trend in Hungary for the integration of m-learning into the learning-teaching process, in which further training aimed at developing the digital skills of teachers can be of particular importance.*

Keywords: *digitization; m-learning; mobile devices; motivation*

1. Introduction

In the information society, theoretical knowledge, technology, and information have become the most important commodities (Bell, 1979). Its main engine is the rapid development of computer technology and telecommunications, its most important milestones are the spread of personal computers and the emergence of broadband data transmission networks, and its symbolic technological innovations are the Internet and the mobile phone (Molnár, 2018) (Molnár et al., 2022). The quality demand of education sets the target of having and acquiring the actual skills, competences to meet the XXI. Century expectation for the employees to guarantee the continuous development and the existence of up-to-date knowledge. (Mészáros, 2013)

1.1. The history, concept, and connections of m-learning

The history of m-learning goes back to the end of the 1970s, when Alan Curtis Kay, the inventor of the "Smalltalk" programming language, created the Dynabook concept. His goal was to design a small, compact, portable computer that children could use and carry instead of paper (Kay, 1972). Although the device itself was never put into production, the concept played an important role in the design of smartphones and tablets.

At the beginning of the 2000s, the term mobile learning covered the personalized, connected, and interactive use of handheld computers in classrooms (O'Malley & Stanton 2002; Perry, 2003). In Brown's paper M-learning is showcased as a natural extension of e-learning, i.e. an opportunity to make learning more widely available than in the usual e-learning environment. From this aspect, m-learning is a subset of e-learning. E-learning is the macro concept that includes online and mobile learning environments (Brown, 2005).

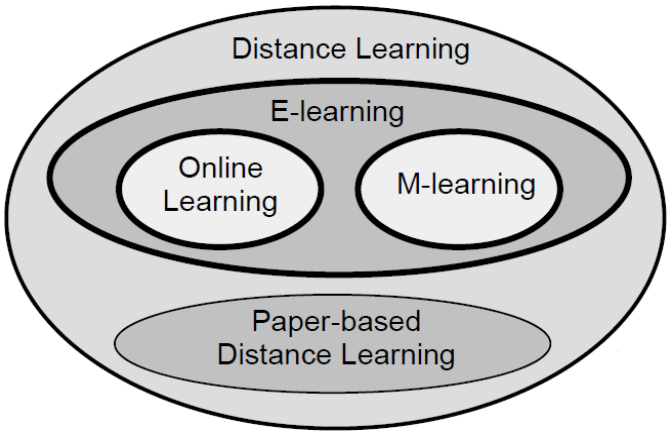

Fig. 1. The subsets of flexible learning

Source: Brown (2005)

It follows from the above that mobile learning is certainly not merely the conjunction of mobile and learning; it has always implicitly meant mobile e-learning and its history and development have to be understood as a continuation of conventional e-Learning (Mehdipour- Zerehkafi, 2013).

Molnár goes even further, and under the concept of m-learning, in addition to accessing learning-related content accessible anywhere - on any mobile device - he also includes related learning activities. (Molnár, 2018) It is; therefore, clear that today the mobile phone is no longer just a technology, a tool offered to span physical distances, but that it reveals new methodological dimensions of knowledge transmission (Molnár et al., 2017).

In addition, we assume that this conscious use of e-learning can help the students consciously prepare not only for the specific vocational employment but their own personal developement and they can acquire professional knowledge besides getting the applied knowledge. (Mészáros & Baróti, 2017)

1.2. Student's mobile phone usage habits

According to data from the Hungarian Central Statistical Office (KSH), 2021. III. at the end of the quarter, the number of active SIM cards was more than 13 million, of which four-fifths handled call traffic and two-thirds handled data traffic in the third quarter of 2021. The data traffic of the mobile network is constantly increasing. In the third quarter of 2021, it exceeded that of the previous year by 35%. The 4G network maintains its leading role, 96% of the data traffic took place via the 4G–LTE system. The data traffic per such active SIM cards which provide Internet access was close to 25 GBytes (KSH, 2021).

79% of the Hungarian population aged 16–74 are connected to the World Wide Web daily. The use of ICT tools is an almost indispensable part of the life of 16–24-year-olds, 97% of whom use the Internet every day.

More than 86% of domestic Internet users accessed the World Wide Web via a mobile device, and four-fifths of them used it every day or almost every day. In 2020, the restrictions introduced due to the pandemic, which affected all age groups, also led to the spread of the use of the World Wide Web in education, remote working, and communication between people (KSH, 2020).

From the above-mentioned data, we can conclude that the use of mobile phones is part of the everyday life of young people since almost all of them have in their pocket a device that is also suitable for data networking.

1.3. Application of mobile phones in education

Furthermore, researchers have indicated mobile learning as a promising way of improving students' competencies (Hwang et al., 2011; Sung et al., 2010). The use of mobile phones in education significantly improves students' academic performance and increases motivation (Chang – Hwang, 2019).

In their research, Hwang and Lai examined the effects of mobile learning on students' cooperation, communication, complex problem-solving, and creativity. According to their

results, those students who spent a long time on mobile learning activities displayed significantly better skills in communication, complex problem-solving, and creativity. This implies that participation time as well as learning strategies or tools could play an important role in improving these competencies (Hwang-Lai, 2014).

Kukulska-Hulme (2010) highlights the following key ideas regarding m-learning

- Learning outside the classroom: m-learning is a set of new communication tools and opportunities which make learning accessible outside of the school.
- Possibility of contact with distant (absent) students: a shared learning tool that provides an opportunity for the exchange of information and question-and-answer interaction in practice with students who, for some reason, cannot participate in classroom education.
- The students are the creators of knowledge and the controllers of the learning process. Due to their comments and the sharing of their content, they are given an interactive role. The traditional role of the teacher is increasingly shifting toward that of a collaborator and mentor.
- Experience fixation: formal and informal (non-formal) learning become connected.
- Lifelong learning: Over time, students will be able to acquire the habit of lifelong learning (Muhi – Kőrösi – Estzletecki, 2015) (Molnár, 2015).

2. Research

2.1. The purpose of the research

The purpose of our research was to explore the opinions of secondary school teachers regarding mobile devices, as well as their attitudes towards their use. Within the framework of the study, our goal was to learn how often teachers used mobile phones and tablets in their classes, and to what extent they used the opportunities afforded by digitalization. Our further aim was to map how teachers felt about the use of mobile devices in terms of their positive and negative effects, and at the same time to approach the aspects of applicability and trialability. Exploring the opinions and attitudes of teachers can provide guidelines for the necessary changes and improvements.

2.2. Methodology

Our research was based on a survey of 104 people, for which we collected the data in October 2021. With the help of an online questionnaire, we asked the teachers of the secondary schools

of six counties; participation in the study was voluntary, and the questionnaire was filled in anonymously. The sample is not representative, due to the online interface and the short time interval of the research, but our goal was not primarily to draw general conclusions, but rather to learn about the attitudes of teachers about mobile devices.

The questionnaire consisted of three parts, closed and semi-open questions, and also included a 4-point Likert scale. After the questions about the teacher, we examined the characteristics of the use of mobile phones and tablets in the classroom, and then in the third part of the questionnaire, we tried to explore the opinions of the teachers regarding the use of mobile devices for educational purposes.

The following methods were used during the analysis of the results:

- We used a one-sample T-test for examining the answers given to the questionnaire.
- We made use of a chi-squared test to examine the correlation.
- After having tested the normality of the answers given, we used a non-parametric Mann-Whitney test for comparing the average of agreement.

2.3. Sample characteristics

The majority of teachers who filled in the questionnaire were women, with the proportion of male respondents being 31%. According to the age structure, the proportion of those between 46 and 55 years old was the highest, and there were no teachers younger than 25 years old at all (*Fig. 2*).

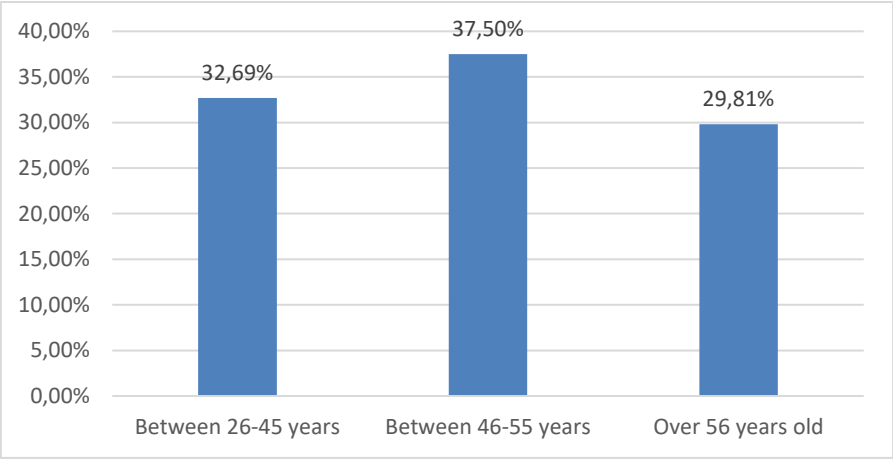

Fig. 2. Age distribution of the sample

From a training type perspective, the majority of those who completed the questionnaire taught in high school education (*Fig. 3.).* Taking into consideration the lower proportion of teachers

teaching in vocational education, we did not examine the attitude of teachers towards mobile devices divided according to different types of education.

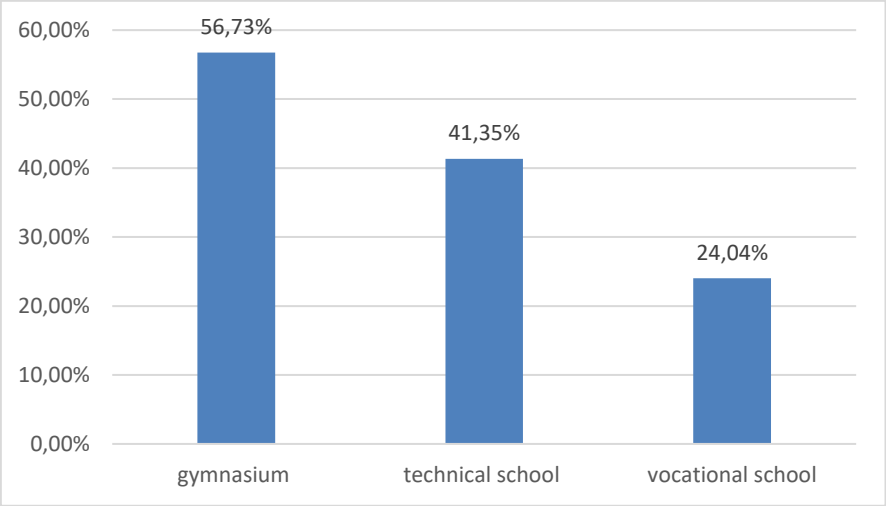

Fig. 3. Distribution of the sample by school type

The largest proportion of participants were teachers in Bács-Kiskun and Jász-Nagykun-Szolnok counties, while it was in Békés county that the questionnaire was filled in by the smallest amount of respondents (*Fig. 4*).

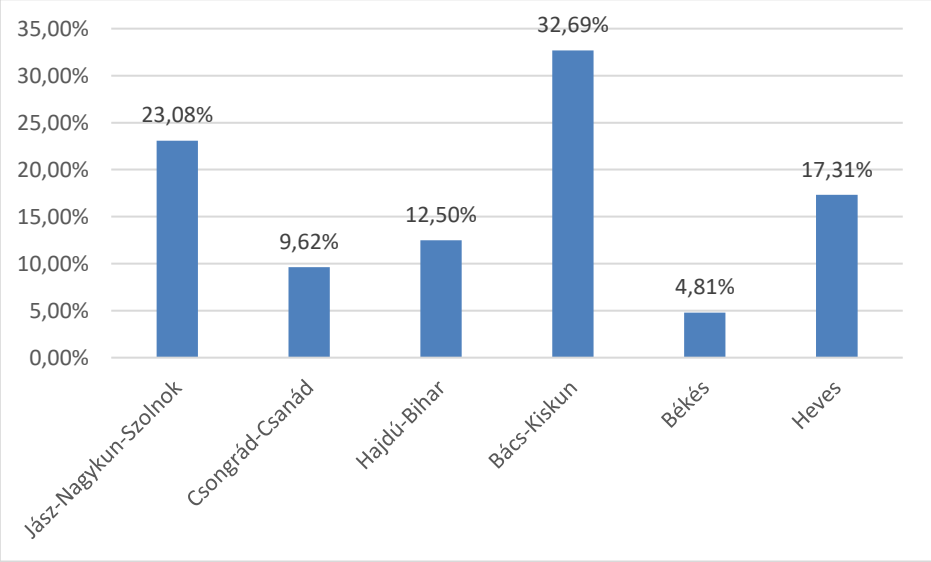

Fig. 4. Distribution of the sample by counties

3. Results

3.1. Results for the use of mobile devices

Regarding the frequency with which teachers use mobile phones in the classroom, we examined the difference by gender. The largest proportion of the women included the use of mobile phones in their lessons once or twice a month, while 26% stated that they used them more often, at least 1-2 times a week. In the case of the men, most of them integrated mobile phones into their lessons once or twice a week, although this proportion was almost the same as that of those who used them only a few times a month. From the point of view of both men and women, relatively few teachers used mobile phones daily, but at the same time, there was a similar proportion among those who used them only once or twice a year. There was a greater difference between men and women among teachers who did not use mobile phones at all, with 19% of the men not using them at all, or only on a try-out basis, while in the case of the women this proportion was 8% (*Fig. 5.*).

Given that the study did not only refer to the period of online education, we asked the teachers who included mobile phones in their lessons whether they had been open to using the device in the teaching-learning process before. 71% of the teachers who used mobile phones indicated that they had already been open to using them in class.

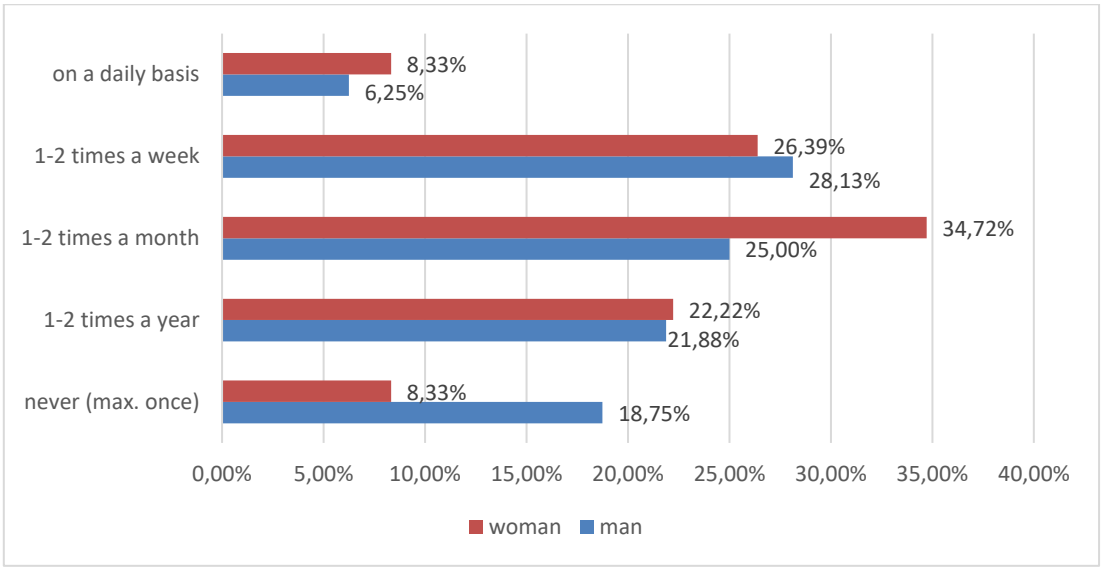

Fig. 5. The frequency of using mobile phones in class among teachers

We asked the teachers who filled in the questionnaire what applications they used to facilitate the learning process. Interactive presentations, LearningApp tasks, and learning games were selected in the largest proportion; however, Redmenta's interface was also used in a large proportion of blogs, and podcasts are also used in the teaching process to a lesser extent. Within other categories, it was also possible to select other applications that had already been tried, where the participants primarily indicated programs and interfaces that support learning specifically related to the subject as well as supporting materials (e.g., Geogebra, Photomath, smart textbooks). (*Fig. 6.)*

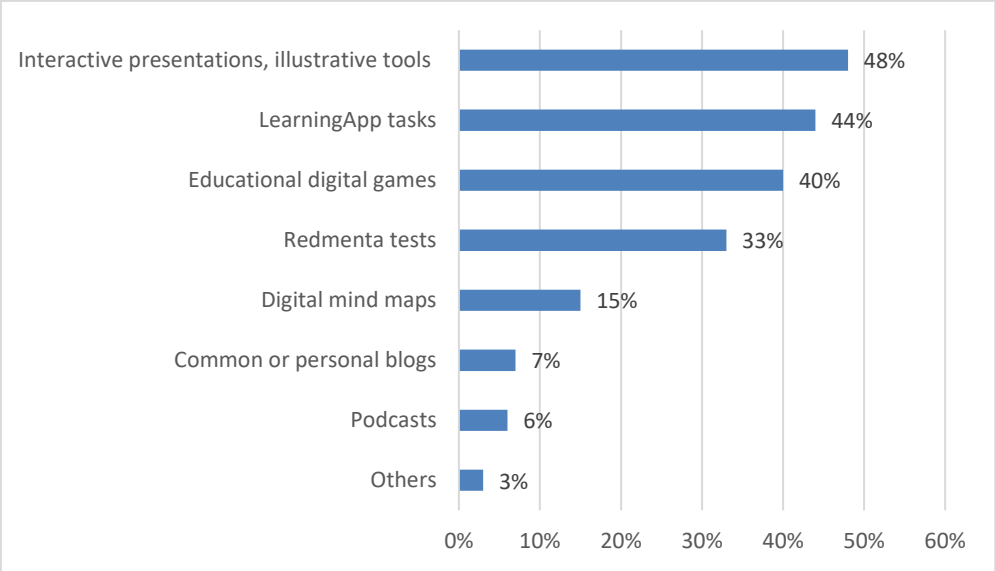

Fig. 6. Applications used by teachers

The frequency of tablet usage in class did not show significant differences between the men and the women, they were mostly used once or twice a month. That being said, it is important to note that the proportion of those who did not use tablets at all in class was significantly larger compared to those who used mobile phones. This ratio was almost the same between the men and the women (*Fig. 7.*). We can conclude from this that the provision of technical equipment in the schools might differ, that is not all institutions had tablets available for students to use in class. At the same time, mobile phones had spread much more widely among students, which contributed to their easier integration.

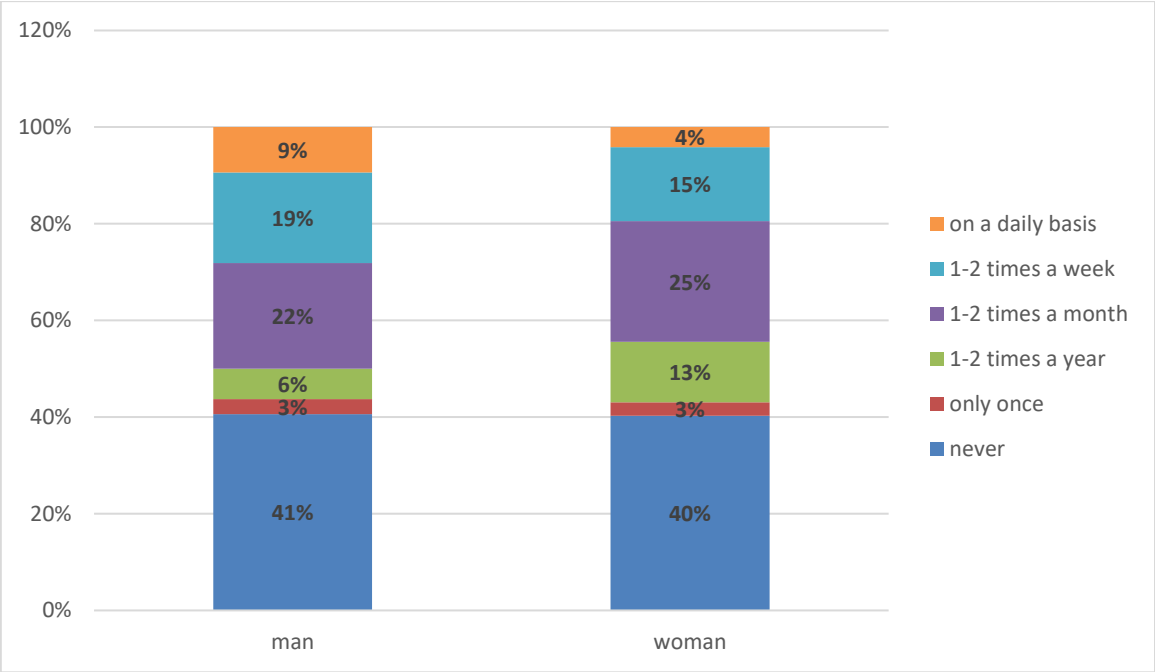

Fig. 7. The frequency of using mobile phones in class among teachers

3.2. The results of teachers' opinions regarding the use of mobile devices

In the second part of the research, we examined the attitude of the teachers, the exploration for which we formulated 11 statements. In the case of the 11 statements, we tested the average opinion of the teachers about them. Because we used a 4-point Likert scale during the survey, the theoretical value of the neutral answer is 2.5; thus, we compared the sample averages to this.

Teachers did not agree that mobile devices distracted students from learning; consequently, they were not of the opinion that these tools should not be used often (average:1,94; p<0,001). However, they agreed that they would try a new application even if they know that it would take time to make use of it at first (average:2,74; p=0,018), also by saying that the use of mobile devices and the accompanying creative activity motivated them as well. (Average: 3,03; p<0,001). Regarding the claim as to whether they were willing to search for new applications even at the expense of their free time, the average of teachers' answers does not differ significantly from the value indicating a neutral response (average:2,63; p=0,206), therefore, the average verdict tends neither towards agreement nor disagreement (*Table 1.*).

Table 1. The opinion of teachers regarding the use of mobile devices (1 - completely disagree, 4 - completely agree)

	Min	*Max*	*Mean*	*Std. Deviation*	*t*	*p*
In my opinion, it tends to distract students from learning, so these tools should not be used often.	1.00	4.00	1.9417	0.96837	-5.850671698	0.00000005963
I am willing to search for new applications in my free time.	1.00	4.00	2.6300	1.02154	1.2725937	0.20614292541
I try out a new application even if I know that it will take time to discover first.	1.00	4.00	2.7353	0.98430	2.414264791	0.01756682616
The use of mobile devices and the accompanying creative activity also motivate me.	1.00	4.00	3.0294	0.91690	5.831367706	0.00000006637

The values given to the variable were also compared according to the two genders, for which a non-parametric Mann-Whitney test was applied; since the number of male respondents in the sample is relatively low, normality cannot be assumed (*Table 2*.). From the perspective of average answers, two statements differed significantly between the two genders.

Table 2. The opinion of teachers regarding the use of mobile devices (1 - completely disagree, 4 - completely agree)

	Mann-Whitney U	***Wilcoxon W***	***Z***	***Asymp. Sig. (2-tailed)***	***Asymp. Sig. (1-tailed)***
I think it is important nowadays to include mobile devices in the educational process due to the students' changing needs of learning	968	1496	-1.353373499	0.175936339	0.08796817
In my opinion, it tends to distract students from learning, so these tools should not be used often.	831	3387	-2.308303251	0.020982276	0.010491138
Their application can be a great help in developing independent learning and problem-solving skills.	1048.5	1576.5	-0.67827684	0.49759618	0.24879809
Students can be motivated much more if they are allowed to use their own mobile phones during class.	912.5	1440.5	-1.693146745	0.090427538	0.045213769
I can also include those students in the lesson who are difficult to motivate and whose attention is hard to maintain.	847	1375	-1.990105609	0.046579303	0.023289652
I would like to use these tools in my classes if I could observe how to use them during demonstration classes.	924	1420	-1.34589447	0.178336552	0.089168276
Completing tasks using these applications is too time-consuming, so I rarely use them.	1026	3582	-0.564107892	0.572680707	0.286340354
The reason I do not use mobile devices in class is that there is no suitable device system for them	943	1439	-0.8817266	0.377924673	0.188962336
I am willing to search for new applications at the cost of my own free time.	1031	1527	-0.298945009	0.764982004	0.382491002
I also try out a new application even if I know that it will take time to create it first.	1031.5	1527.5	-0.523207911	0.600829577	0.300414788
The use of mobile devices and the accompanying creative activity also motivate me.	952.5	1448.5	-1.150369292	0.249991802	0.124995901

One of the statements related to the fact that the use of mobile devices distracts students from learning, so they should not be used often (*Fig. 8.*). In the case of the women, there were twice as many teachers who did not agree with this at all, and three times as many of the men felt that they completely agreed with this, as compared to the women. The largest proportion of the men only partially agreed with this statement. This clearly shows that the women were more open to the inclusion of mobile devices in the learning process and were less likely to agree that they should not be used in class.

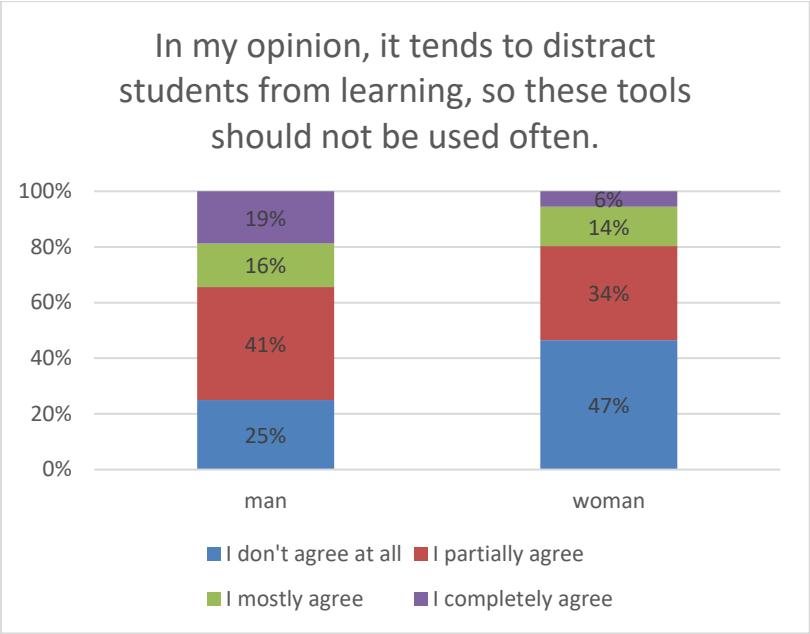

Fig. 8. Teachers' opinions on the use of mobile devices regarding students' attention

The other statement shows a significant difference related to the fact that by using mobile devices, teachers could also involve students whom they otherwise find difficult to motivate and whose attention is hard to maintain during the lesson (*Fig. 9.*). In the case of the women, the proportion of those who completely agreed with this statement was three times higher than that of the men.

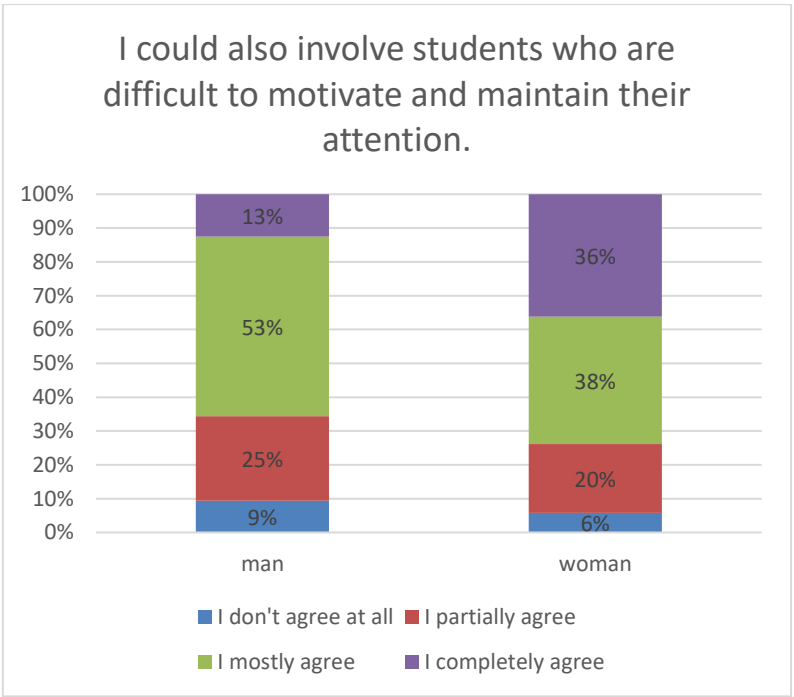

Fig. 9. Teachers' opinions on mobile devices about its effect on motivation

5 percentage points more of the men partially agreed, and 3 percentage points more did not agree at all as compared the women. Half of the men mostly agreed with this statement. It can be said in this aspect as well that women tended to experience the positive, motivation-promoting effect of mobile devices, while men only partially did.

4. Summary, conclusions

Overall, it can be said that teachers take advantage of the opportunities offered by mobile phones, a significant proportion of those interviewed regularly involved them in the teaching process, and there were relatively few who did not at all. Compared to mobile phones, the use of tablets lagged significantly, and a large proportion of the participants in the study stated that they did not use tablets at all during class.

The teachers primarily used mobile phones in class to share and use presentations, LearningApp tasks, and learning games, but also tried innovative applications, created blogs, podcasts and used a special subject-related application. As teaching methods affect each student differently, the observed methodological diversification helps to engage and motivate students. (Mészáros& Baróti, 2015)

According to the teachers, these devices did not distract students from learning; therefore, they did not think the frequency of using mobile devices should be reduced. The use of mobile devices and the accompanying creative activity motivated teachers, and they were willing to try out a new application even if they knew that it would take time to discover it at first. So, developing teachers' skills in information and communication technologies (ICT) requires a whole new set of methodological procedures. (Baróti & Mészáros, 2011; 273 p.)

Opinions differed between the women and men teachers, with the men tending to think that mobile devices distracted students' attention from learning, while women were more likely to say that using these devices could also motivate students whose attention was hard to maintain.

These results are not suitable for generalization, since our research is not representative, but our goal was not to draw general conclusions.

We believe that, based on the conclusions of our study, there is a positive, progressive trend in our country to integrate m-learning into the learning-teaching process. Although in today's practice in Hungary, the use of mobile phones is generally still prohibited in schools, this will soon change in our opinion.

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