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A VIRTUAL REALITY SYSTEM TO TACKLE BULLYING IN SCHOOLS

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Abstract:

The aim of this study is to conduct an analysis of the possibilities of implementing new technologies (virtual or augmented reality) in addressing the problem of bullying and cyberbullying in the school environment. The possible outcome of the project should be a VR system that will increase the empathy and emotional intelligence of pupils and at the same time improve the school atmosphere in terms of bullying prevention. VR simulations can include different scenarios of bullying among pupils in school, the application of which can create an anonymised database of pupils' behaviour and use it to address the problem of bullying using appropriate artificial intelligence tools. The proposed system can help school psychologists and teachers in dealing with critical situations in schools. Pupil safety is a key aspect in school that affects the educational process and overall development of pupils.

Keywords:

Bullying, cyberbullying, virtual reality, augmented reality, VR system for bullying.

Introduction

Several studies have shown that emotional problems from bullying can persist into adulthood and cause long-term effects [1][2]. Victims of bullying often face lower self-esteem, health problems, and depression [1]. During the COVID-19 pandemic, students spent more time online, leading to increased incidents of cyberbullying. After 2020, cyberbullying rates increased and the shift to online education correlated with more incidents of cyberbullying [3][4].

Virtual reality (VR) has shown promise in addressing bullying by creating immersive experiences that foster understanding and empathy among students. Recent publications have explored virtual reality (VR) as a tool to address bullying in schools. VR can promote empathy and understanding through role-playing simulations, thereby improving the school environment [5]. Evidence suggests that immersive experiences in VR improve students' recognition of and response to bullying [6][7]. Supporting bystander intervention is key in anti-bullying efforts [4] [8]. Olweus' bullying circle identifies roles in bullying situations, highlighting the importance of defenders. The main positions of participants in the Olweus circle of bullying that can be well simulated in VR are:

1. Bully. A bully is a person who initiates and actively participates in bullying. Tends to use his or her power or strength to hurt others.
2. Followers. Individuals who actively support the bully and participate in the bullying, even if they do not initiate it themselves.
3. Supporters. Those who support bullying but do not take an active role. They may laugh or encourage the bully, but do not participate directly.

4. Passive Supporters. Persons who approve of bullying but do not openly show it. They may be silent, but their presence and inaction encourages bullying.
5. Disengaged Onlookers. Individuals who do not participate or intervene. They may think that bullying is not their problem and therefore do not get involved in the situation.
6. Possible Defenders. Those who could intervene and help the victim, but for various reasons do not. They may fear retaliation or be unsure how to intervene.
7. Defenders. People who actively intervene and try to stop bullying. They support the victim and try to resolve the situation.

VR can be further integrated into bullying prevention through a number of approaches. First, developing more immersive VR scenarios that simulate real bullying situations can increase empathy and understanding among students. Second, incorporating training programs in VR for educators can equip them with the skills to effectively identify and address bullying. Third, creating age-appropriate VR content that addresses different types of bullying (e.g., cyberbullying, physical bullying) can cater to the diverse experiences of students. Finally, involving students in the VR content development process can ensure that scenarios are relevant and resonate with their experiences, making interventions more effective. In addition, feedback from these VR sessions can be collected to identify changes in students' attitudes and behaviours towards bullying, which can be used to refine and improve the programme. As educators and researchers collaborate to develop more engaging and relevant VR content, the potential for VR to transform bullying prevention efforts in schools continues to grow.

A study showed a significant increase in cyberbullying after the pandemic, affecting more than 60% of students [4]. Effective strategies to prevent this include promoting student empathy towards the bullied and improving communication in school [8].

1 Systematically Overview of the Issues and Methodology

To analyse the feasibility of a project to prevent bullying and cyberbullying in VR settings, we used the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) methodology for a systematic review of the literature. Combinations of keywords related to "virtual reality" or "augmented reality" technologies and bullying "bullying" or "bully" were used. Due to the rapid development of VR, publications were selected from 2021 to October 2024, using the following query for all databases: ("augmented reality" OR "virtual reality") AND ("bullying" OR "bullying") with a time frame from 2020.

Only articles published in English and available in full text were included in the survey. In particular, articles relating to bullying in the context of pupils' work were included in the analysis to exclude critical situations at school level. Articles that did not contain empirical data or did not directly address the topic of VR and bullying were excluded. An initial search resulted in the identification of 74 potential articles. After removing duplicate records and applying the inclusion and exclusion criteria outlined above, 15 relevant articles remained as listed in (Tab.1).

Each of the selected articles was subjected to a detailed analysis that included data extraction of the VR technologies used, bullying, descriptive information, participants, research objectives, etc. Descriptive information included year of publication, geographic location of studies, number of participants, and of participants. The studies were divided into three main categories: bullying identification, bullying prevention, and bullying victimization. Questionnaires were also one aspect of the tracking and analysis to help better guide the direction of further research.

Table 1. Studies selected for review: author, year of publication, country, number, age of participants.

No	First autor (year)	Ref.	Country of part.	No of participants	Age of participants
1	Boboc (2024)	[5]	Various countries (combined studies)	3906 from 20 publ. avr. 195	Various studies combined
2	Yang (2024)	[9]	Taiwan	56	Fourth-grade students
3	Gayer-Anderson (2024)	[10]	United Kingdom	481	Adolescents aged 11-15 years
4	Gu (2023)	[11]	China	234	Middle and high school students
5	Liu (2023)	[12]	Taiwan	229	Eighth-grade students
6	Badger (2023)	[7]	United Kingdom	67	Female adolescents aged 11-15 years
7	López-Faican (2023)	[13]	Spain	34	Adolescents aged 12-15 years
8	Rambaree (2023)	[14]	Sweden	38	International social work students
9	Ivanov (2022)	[15]	United States	Not specified	Pilot study with a group of students
10	Fiani (2022)	[16]	United Kingdom	7	Pilot study aged 22-37 years
11	Lambe (2022)	[17]	Canada	481	Adolescents aged 11-15 years
12	Oyekoya (2021)	[18]	United States	Not specified	Focus group study
13	Barreda-Ángeles (2021)	[6]	Spain	35	Participants aged 10-12 years
14	Xue (2021)	[19]	Various countries (combined studies)	Not specified	Various studies combined (scoping review)
15	Franzen (2021)	[20]	Netherlands	45	Adolescents (24 history of bullying, 21 without)

A review study up to 2023 analysed the possibilities of using VR scenarios in conjunction with bullying [5]. The study explored the use of virtual reality and augmented reality technologies to address bullying among children and adolescent students in educational settings through a survey of 20 selected publications on the aforementioned topic of bullying.

2 Results of the Research Survey

The selection of relevant articles was followed by their analysis, in which relevant information for the research questions was extracted and synthesized: how to address the problem of bullying in school, how to use VR for students' empathy, what scenarios are appropriate in VR to achieve bullying prevention, what supportive questionnaires can monitor students' emotions, etc.

A review study up to 2023 analysed in detail the possibilities of using VR scenarios in conjunction with bullying [5]. The study explored the use of virtual reality and augmented reality technologies to address bullying among children and adolescent students in educational settings by surveying 20 selected publications similarly using the PRISMA method on the aforementioned topic of bullying. The results show that VR, in particular, has significant potential to help students understand the consequences of their actions, develop empathy, and reflect on their behaviour. VR also offers educators new ways to recognise and respond to incidents of bullying. In the following section, we mainly analyse publications that were not in the study [5].

The publication “Virtual reality or augmented reality as a tool for studying bystander behaviours in interpersonal violence” reviews 11 empirical studies using VR to simulate violent scenarios and measure bystander behaviour using the PRISMA method, with the criteria being 'avatar', 'virtual reality', 'Oculus Quest', 'augmented reality', 'bystander', 'helping behaviour' and 'witness' by 2021 [19]. They analyse the evaluation of the effectiveness of VR and AR in improving anti-bullying intervention training and examining bystander behaviour in situations of interpersonal violence. Most studies have focused on bullying in school, violence at meetings, and assaults in public. This article highlights the potential of VR to provide the most realistic and controlled setting for examining bystander behaviour, as well as recommendations for future research.

The study "Optimizing the user experience in VR-based anti-bullying education" focuses on improving anti-bullying programs based on VR user engagement scenarios and learning outcomes [15]. Key strategies include creating realistic scenarios, enabling customization, incorporating interactivity, and providing real-time feedback. A pilot study showed that optimized VR experiences increased empathy, understanding, and positive behaviour change in students' attitudes toward bullying.

The study "Investigating the non-verbal behaviour features of bullying for the development of an automatic recognition system in social virtual reality" explores the possibilities of using nonverbal behaviour to develop an automatic recognition system for detecting bullying in a social VR environment [16]. Researchers created 3D stimuli depicting bullying scenarios and conducted a pilot study with seven participants. Findings showed that nonverbal cues such as proxemics, facial expressions, gaze, and sound contribute to the perception of bullying. The study suggests that these cues can be used to develop an automatic recognition system, but further research with larger and more diverse samples to combine nonverbal cues with verbal and physiological data is needed to increase the accuracy of the system.

Developing a virtual reality environment for educational and therapeutic application to investigate psychological reactivity to bullying assessed the psychological impact of VR bullying experiences on 67 adolescent girls [7]. Participants experienced either a neutral or a hostile (bullying) VR scenario. Those in the hostile scenario reported greater negative affect and distress. The VR experience could be used in educational and therapeutic settings to increase empathy and resilience. In addition, the study highlighted how state anger and trait empathy interacted to predict defensive behaviour, highlighting the contribution of social-emotional learning in promoting defensive behaviour.

The study “Immersive virtual reality as a novel approach to investigate the association between adverse events and adolescent paranoid ideation” examines whether experiences of bullying and other interpersonal threatening events are more strongly associated with paranoid ideation in adolescents than non-interpersonal events or adverse childhood experiences [10]. Data on exposure to adverse life events and bullying were collected from 481 adolescents (aged 11-15 years).

Linear regression was used to analyze the associations between these risk factors, which were assessed through responses following experiences with the bullying VR avatar in the school cafeteria. Bullying, particularly cyberbullying, was associated with an increased prevalence of paranoid thoughts in girls than in boys.

The study "Combating bullying in school through a virtual learning model based on a multi-task experience: Assessing empathy, problem solving and self-efficacy from a multi-stakeholder perspective" looked at a scenario-based learning model in a virtual reality setting that combined participant tasks to help students raise awareness of bullying in the school environment [9]. The study compared 56 fourth-grade students in Taipei City, Taiwan, with the experimental group using a scenario-based learning model with multiple roles and the control group using a scenario-based learning model with a single role. The aim was to analyze students' behaviour in the virtual scenario-based learning model and to understand whether changes in students' experiential processes differ when playing multiple roles in relation to bullying. For this purpose, two groups of students were formed: one group of students participated in a multi-task scenario and the other group of students participated in a single-task scenario. The teaching experiment lasted 120 minutes. Pre-test and post-test questionnaires to assess the effectiveness of bullying prevention in school were developed by the researchers to ensure their expert validity. The purpose of the questionnaires was to determine how students understood and applied the concept of improving bullying awareness in school after receiving formal instruction from teachers. The test included four main themes: physical bullying, verbal bullying, relational bullying, and cyberbullying. A virtual classroom scenario recorded students' activities in the system. After the teaching experiment, both groups completed a posttest on learning outcomes, a postquestionnaire on empathy, and a posttest on problem-solving tendencies related to bullying prevention in school. This determined whether there were differences or changes between the two groups of students after the teaching experiment. Findings indicated that the virtual role-playing instructional model was more effective in promoting student empathy and significantly increased awareness of bullying in school.

To analyse the feasibility of a project to prevent bullying and cyberbullying in a VR setting, various questionnaires were also surveyed to assess various psychological and behavioural aspects in students with a focus on bullying and cyberbullying. The available questionnaires were analysed in detail so that they could be reliably used in the school setting to better understand pupils' behaviour in school. The reliability of the questionnaires was assessed using alpha values, where the interpretation of alpha values is: if the alpha is 0.70-0.80 then the questionnaire has acceptable reliability, if the alpha is 0.80-0.90 then the questionnaire has good reliability, and if the alpha is 0.90-0.95 then the questionnaire has very good reliability; a value above 0.95 may indicate redundancy of the questionnaire items. We present two types of questionnaires for bullying and cyberbullying.

Questionnaires on bullying. The questionnaires provide a detailed picture of the prevalence and characteristics of bullying, allowing for a better understanding and addressing of the problem in school. In (Tab.2), we report the name of the bullying questionnaire, the original source detailed in the reference, the number of items, the response scale, and the reliability by alpha value. The number of questionnaire items and the range of responses are chosen appropriately for the age of the pupil so that they do not pose an additional burden, yet we have obtained sufficient information.

Cyberbullying differs from traditional bullying in several keyways: it has no time or space constraints, the content posted can reach a large number of people quickly, the perpetrator can remain anonymous, and the victim has difficulty escaping. These differences make cyberbullying a particularly serious problem that requires specific approaches to prevention and resolution. Cyberbullying questionnaires focus on different aspects of cyberbullying, including frequency, types and impact on victim behaviour. In (Tab.3), we report the name of the questionnaire, the original source detailed in the reference, the number of items, the response scale, and alpha reliability.

Table 2. Bullying questionnaires.

No	Questionnaire name	Ref.	Focus	No of items	Cronbach's α
1	Child Adolescent Bullying Scale (CABS)	[21]	Evaluating young people's experiences of bullying	22	0.97
2	Revised Olweus Bully/Victim Questionnaire (OBVQ-R)	[22]	Evaluating experiences of bullying	42	McDonald ω: 0.75, 0.81
3	Adolescent Peer Relations Instrument	[23]	Assessment of peer relationships	36	0.81-0.89
4	Bullying and Exclusion Experiences Scale (BEES)	[24]	Assessment of experiences of bullying and exclusion	18	0.79-0.85

Table 3. Cyberbullying questionnaires.

No	Questionnaire name	Ref.	Focus	No of items	Cronbach's α
1	Cyberbullying and Online Aggression Survey	[25]	Assessment of cyberbullying and online aggression	18	0.79-0.97
2	The Cyberbullying in Social Media Scale	[26]	Assessment of cyberbullying on social networks	12	0.85
3	Cyberbullying Behaviour Questionnaire	[27]	Assessment of cyberbullying in working life	20	0.76
4	The Cyber Victimization Experiences and Cyber Bullying Behaviours scales	[28]	Assessment of experiences of cyberbullying and cyberbullying behaviours	15	0.85-0.89

3 Analysis of the Design of a System to Address Bullying in Schools

The design of a VR system for the issue of bullying needs to be analysed in detail in terms of designing the technological equipment, defining scenarios, scenes for the system, as well as selecting appropriate avatars, etc. Scenarios can, for example, depict bullying or cyberbullying between pupils in different ways. The main goal, which has been analysed in the previous section, is to create as realistic as possible simulations of such scenes to help pupils develop empathy with each other, to help teachers and school psychologists understand pupils better and to show ways to prevent similar conflicts in school. Many other issues need to be analysed in more detail with school psychologists.

3.1 Technological capabilities of the VR system

There are several options for a basic VR system. The first proposed technology equipment would consist of emotion tracking using the VR HTC Vive Pro Eye along with a face tracker, which provides better information to assess the user's emotions and a more realistic environment, although it requires more complex hardware. HTC Vive Pro Eye provides a resolution of 2880×1600 (1440×1600 pixels per eye) [29].

For comparison, we propose a second newer VR device using the powerful Meta Quest Pro, which has a display resolution for one eye of 1800×1920 px [30]. The Meta Quest Pro device is equipped with five infrared eye and face tracking sensors that can capture upper and lower facial movements with 120-degree accuracy. The Meta Quest Pro weighs 722 grams is comfortable for extended wear and offers color mixed reality that enhances real-world VR participation while supporting eye and face tracking.

To create realistic scenes in VR, we need to ensure a good hardware configuration, so we propose implementation based on the available HW in our lab, e.g., a computer with a Core i9 processor, 32 GB of RAM, an NVidia RTX 2070 graphics card, and a 1 TB SSD. For the actual development, it is necessary to have suitable software, such as Unity 3D or Unreal Engine. Both engines have extensive asset stores where developers can purchase or download free assets such as 3D models, textures, animations, and scripts to help develop scenarios in VR.

For stress sensing, it is advisable to use electrodermal activity (EDA) equipment, for example, we used a biosignalsplux sensor [31]. The biosignalsplux EDA sensor is designed to sense changes in skin conductance using two electrodes that are placed on the lower knuckles of the fingers of the hand (index and middle fingers). The electrodes were connected to the sensor cable of the EDA sensor. The latest EmbracePlus device [32] can also be used to sense EDA signals, which is placed on the wrist of the hand. These EDA signals are suitable for comparison with facial emotions [33].

3.2 Design of an approach to address bullying in schools

The design of the system focuses on simulating bullying in schools with the support of virtual reality (VR), so that pupils can better perceive the complexity of the whole problem in its interconnectedness. These VR scenarios include situations of bullying between pupils. The aim is to create simulations that are as realistic as possible to increase pupils' empathy and help teachers and school psychologists to better understand and deal with these situations.

The following system design and VR imaging needs to be statistically validated in order to select the most appropriate approach from the different options. Simulations include, for example, short videos and VR animations that are intended to be viewed by pupils only with parental consent. The pupil has to express briefly how he/she perceives the situation he saw in video. Alternatively, the teacher asks him/her to respond more specifically to the problem of bullying in order to better demonstrate his/her attitude. The system automatically records the conversation so that it can be transcribed into a text document with time stamps. A similar scene is then projected in VR, where the pupil's reaction is monitored by watching the face and eyes, which are stored as an avatar in a database. Finally, the school psychologist discusses the pupil's assessment with the teacher. In addition, for the pupil's assessment, he/she stores videos of the pupil's avatar, audio recordings of the pupil, questionnaire outputs anonymously in encrypted form in a comprehensive anonymous database.

D1. Anonymous response database

Pupil reactions to simulated situations are recorded and stored in an anonymous database. This database contains data on pupils' emotional and physiological reactions that are monitored during VR simulations (audio recordings, facial and eye reactions). The data are analysed using artificial intelligence (AI) to identify patterns of behaviour and reactions.

D2. Individual short interviews

In an individual interview in the presence of a school psychologist, pupils briefly answer the teacher's questions and express their feelings about critical situations. These interviews are recorded and provide qualitative data to complement the quantitative data from the questionnaires.

D3. Questionnaires

Appropriate questions should be selected for the questionnaire, which are listed in Section 2 Examples of bullying and cyberbullying questionnaires. In addition, questions may ask about feelings about the above scenarios in VR, perceptions of support from teachers and their overall perception of safety in school. Students will complete questionnaires that assess their emotional and behavioral reactions to simulated critical situations. These questionnaires provide quantitative data that is analyzed to identify patterns of pupils.

D4. Classroom discussions

After the individual interviews with the pupils have been completed and the questionnaires have been filled in, a class discussion can take place between the pupils, the teachers and the psychologist. This discussion is used to compare and evaluate each class and provides a space to share experiences and suggestions for improving the school environment in the area of bullying and cyberbullying.

D5. Comparison of results between schools

Statistical methods and machine learning that can evaluate the generated database of bullying or cyberbullying in terms of predicting certain critical student characteristics should be used. Once certain schools have been selected, it is important to interview school psychologists to obtain objective results from the database created. From the database, a representative sample of anonymous students should be selected for presentation and discussion with outside clinical and school psychology experts.

By repeating the above procedure after a certain period of time in the selected schools, it is possible to verify from the established database whether there has been a significant change in some of the anonymous pupils in the schools. These comparative studies help to verify the effectiveness of the project in addressing the problem of bullying and to identify areas for further gradual improvement.

D6. Comprehensive Pupil Assessment Database

We anticipate that repeated monitoring of pupils in selected schools will help the emerging Comprehensive Assessment Database to more effectively address critical situations in schools and in pupils' learning. This database can serve as a valuable tool for school psychologists and educators in addressing bullying and cyberbullying in the school setting.

Similar research conducted in the context of the "Early Warning of Alzheimer's Disease" project to predict neurological diseases [34]. As part of the project, we recorded people's short responses to images on a mobile phone, which were evaluated against a database using machine learning. We generalized this approach to a utility model patent using VR and physiological sensors with natural language communication (PUV 7-2024) to a prediction model using artificial intelligence.

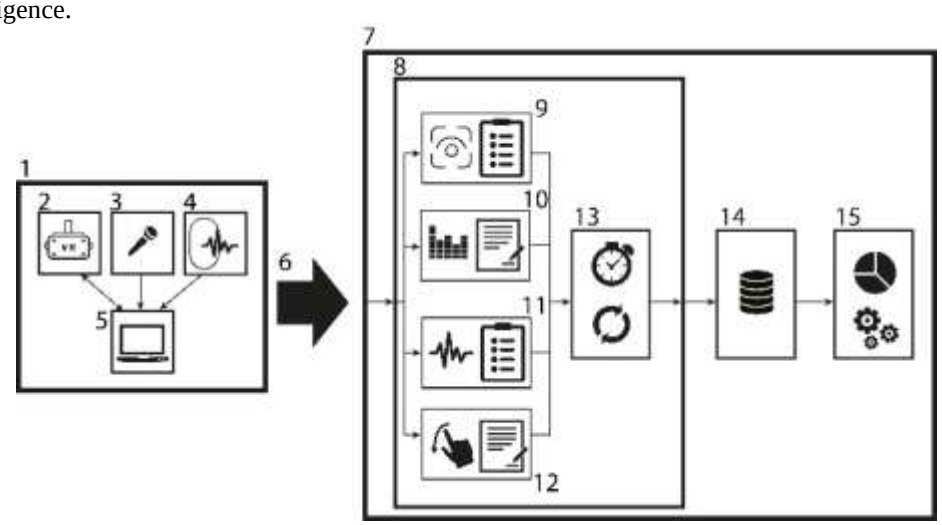

Fig.1. Devices according to the proposed technical solution for emotion analysis and speech processing in virtual reality.

The utility model of the patent is illustrated in the following (Fig.1), which schematically shows the devices and data processing in a general framework: 1 sensing device block, 2 VR device with face and eye tracking, 3 microphone, 4 physiological signal sensing device, 5 control computer, 6 data transmission, 7 execution server, 8 transcription and synchronization block, 9 facial expression and eye movement processing block, 10 audio recording block, 11 physiological signal processing block, 12 motion sensing processing block, 13 time synchronization block, 14 database created, 15 data analysis and result visualization block. Details of how the system is designed with examples are given in UV [35].

4 Discussion

The goal of the VR system is to create realistic scenarios of bullying and cyberbullying that will foster empathy in students and help teachers and psychologists understand and address these issues. Measuring empathy is a complex process that involves a variety of methods and tools. Empathy can also be measured through observation of pupils' behaviour in simulated or real situations. Teachers and school psychologists can observe how pupils react to situations such as bullying or conflicts between classmates in VR. Observations will include monitoring physiological reactions (e.g., facial expressions, eye movements, EDA signals) during VR simulations.

Initially, basic research should focus on simply creating scenarios with avatars to simulate bullying at school. The goal of the VR system would be to create realistic bullying scenarios that promote student empathy and help teachers and psychologists address these issues. The creation of a VR system for data on students' emotional and physiological reactions during VR simulations first needs to be validated on a smaller sample of, say, 100 students, in order to ascertain the analysis and determine the continuation of the applied research. Store this data in an anonymous database and analyze it using machine learning to identify patterns of behaviour and reactions.

Individual interviews with students can provide deeper insights into their empathic abilities. During these interviews, teachers can ask questions about specific situations and analyse how pupils perceive and react to the emotions of others. The questionnaires will be used to assess pupils and create a comprehensive assessment database.

This approach combines advanced virtual reality technology with psychological assessment methods to create a comprehensive system to address bullying in schools. It emphasizes the importance of realistic simulations, data analysis, and ongoing monitoring to improve the school environment and support students.

The synthesis of experiences in the cited cross-country studies enriches the research with a comprehensive view of bullying and the effectiveness of using VR, with an emphasis on cultural sensitivity and the development of inclusive programs. Bullying is a global problem and understanding it from a multicultural perspective helps to design interventions that can be implemented globally. Behaviours and responses to bullying can vary considerably between cultures. Insights from different cultural contexts can inform the development of universal anti-bullying programmes that are inclusive and effective for a wide range of participants.

Conclusion

Studies from different countries show how to help understand the problem of bullying in schools and tailor measures accordingly. The above research shows the potential of virtual reality as a tool for preventing bullying or cyberbullying in schools. By creating a suitable anonymous database from pupils' reactions, emotions and biosignals and analyzing it for critical situations, machine learning can help identify subtle nuances in reactions. This would result in a school environment monitoring system to deal with critical situations in schools and also secondarily improve empathy

and emotional intelligence of students and hence mental health of students in schools. The diversity of solutions to the problems of bullying, cyberbullying in schools encourages international cooperation which would contribute to more effective solutions to prevent critical situations in schools.

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