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Sexual Education and STI Prevention in High School: A Neutrosophic Analysis of the Opportunities and Risks of Generative Artificial Intelligence

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Abstract: Sexually transmitted infections (STIs) remain a critical challenge during adolescence. Given the limitations of traditional sex education, generative artificial intelligence (GAI) has emerged as a personalized and anonymous consultation alternative. This study analyzes, from a neutrosophic perspective, the scientific evidence published between 2019 and 2026 on the use of GAI to strengthen STI prevention among high school students. Through a critical integrative review of thirteen reference studies, a matrix was built that classifies the findings across four dimensions (AI-mediated learning, sexual education, STI prevention, and educational equity) according to their truth (T), falsity (F), and indeterminacy (I) components, and was quantified through single-valued neutrosophic numbers following the evidence-synthesis approach of neutrosophic paraconsistent logic: the mean triplet over the four dimensions was ⟨0.54, 0.30, 0.37⟩ and, because the components are not constrained to sum to one, the analysis separates contradiction from absence of evidence: AI-mediated learning is the most contested dimension (min(T, F) = 0.50) and educational equity the most evenly divided (⟨0.40, 0.40, 0.40⟩). The results indicate that GAI facilitates anonymous, personalized, judgment-free access to preventive information (T), while documented risks of scientific inaccuracy (hallucinations), bias, and digital-divide exclusion persist (F). Indeterminacy (I) is concentrated in the absence of longitudinal evidence on the actual behavioral impact of these tools. We conclude that GAI should operate as a complementary resource, subordinated to teachers' pedagogical guidance and to the clinical validation provided by school nursing.

Keywords: Comprehensive sexuality education; sexually transmitted infections; generative artificial intelligence; neutrosophy; neutrosophic analysis; high school; school nursing.

1. Introduction

Sexually transmitted infections (STIs) constitute a priority public health problem worldwide, one that silently worsens among the youngest sectors of society. According to World Health Organization estimates, more than one million curable STIs are acquired every day among people aged 15 to 49 [1]. A large share of these infections is asymptomatic, a clinical particularity that hinders timely detection, perpetuates community transmission, and delays the response of health systems. Against this backdrop, late adolescence—which in educational terms coincides with upper secondary education or high school—emerges as a period of extreme biological, psychological, and social vulnerability.

International and regional studies consistently show that adolescents continue to begin their active sexual lives with significant deficiencies in their knowledge about STIs, unaware of aspects as basic as non-coital transmission routes, the correct and systematic use of barrier methods, and the recognition of early symptoms [2]. Comprehensive sexuality education (CSE) has been widely endorsed by international organizations as the most cost-effective preventive strategy to mitigate these risks and foster responsible attitudes [3]. Nevertheless, the translation of these international guidelines into effective national curricula remains uneven, unsystematic, and constrained by cultural, religious, and institutional barriers.

In this scenario of educational and health vulnerability, recent years have seen the emergence and rapid expansion of generative artificial intelligence (GAI). Technologies based on large-scale conversational language models (LLMs) are transforming the ways in which young people access, process, and assimilate knowledge. By offering immediate, personalized, interactive responses free from the moral judgment or stigmatization that often characterizes interaction with adults or health professionals, these tools have become alternative consultation spaces for resolving intimate questions about sexual and reproductive health [4]. The acceptability of health chatbots as a consultation channel already has empirical evidence of its own, although it is conditioned by users' doubts about their accuracy and lack of empathy [5]. For an adolescent facing family communication barriers or school taboos, the screen of a smart device acts as a consultation channel available at any hour.

However, the use of GAI in a field as sensitive as the sexual education of minors raises complex ethical, political, and epistemological dilemmas. From an ethical standpoint, serious concerns emerge regarding the confidentiality of queries, the protection of underage users' personal data, and the risk that these systems reproduce or spread scientific misinformation. From a political perspective, asymmetry in technological access can deepen existing educational gaps, excluding students from vulnerable contexts who lack connectivity or basic digital literacy. Finally, on the epistemological plane, the validity of algorithmically produced knowledge is in question because of the tendency of LLMs to generate plausible but empirically false answers—technically labeled "hallucinations"—and to perpetuate gender or cultural biases rooted in their training data.

Faced with this coexistence of promises and risks, it becomes necessary to critically examine the available scientific evidence to determine the actual viability of GAI as a complementary educational resource for STI prevention. The current literature on the subject is markedly heterogeneous, with contradictory results and a high level of methodological uncertainty. It is at this point that neutrosophy, proposed by Florentin Smarandache as the branch of philosophy that studies the origin, nature, and scope of neutralities, acquires exceptional methodological value [6, 7]. Neutrosophic logic makes it possible to analyze the coexistence of true elements (opportunities and consensuses), false elements (challenges and contradictions), and indeterminate elements (uncertainties and knowledge gaps) without forcing a binary reduction of the reality under study.

On these premises, this study poses the following general question: what opportunities and challenges does generative artificial intelligence present as an educational tool to strengthen sexual education aimed at preventing sexually transmitted infections among high school students? Three specific questions follow: first, what scientific evidence documents the levels of knowledge, attitudes, and preventive practices related to STIs among high school students?; second, what are the pedagogical contributions of GAI to improving learning about sexuality, STI prevention, and the promotion of healthy sexual behaviors in adolescents?; and third, what ethical, political, and epistemological implications does the literature identify regarding the use of GAI in sexual education processes aimed at adolescents?

Accordingly, the general objective of this study is to analyze, from a neutrosophic perspective, the available scientific evidence on the opportunities, limitations, and uncertainties associated with the use of GAI as an educational tool to strengthen STI prevention among high school students. The specific objectives are: to identify the contributions reported in the literature on the use of GAI in sexual education for adolescents; to analyze the ethical, pedagogical, and technological limitations

associated with these tools in the STI prevention context; and to determine the truth, falsity, and indeterminacy components present in the empirical evidence regarding the effectiveness of GAI as an educational resource in sexual health.

2. Theoretical Foundations

2.1. Comprehensive sexuality education and the challenge of STI prevention in adolescence

The understanding of sexual education has undergone a profound paradigmatic evolution over recent decades. Historically, school-based prevention programs adopted a strictly biologicist and biomedical approach, centered on reproductive anatomy, infection prophylaxis, and the instillation of fear of the negative consequences of sexual activity [8]. Although this traditional model provided basic technical information, it proved of limited effectiveness in transforming young people's risk behaviors, since it omitted the emotional, relational, sociocultural, and ethical dimensions that shape the actual exercise of human sexuality [3]. The saturation of campaigns based on prohibition or on mere anatomical description is now considered one of the main indirect risk factors for unsafe sexual behavior, as it distances institutional discourse from adolescents' real experiences [8].

In contrast to this restrictive approach, CSE has been consolidated—with the backing of organizations such as the WHO and UNESCO—as a systematic, evidence-based teaching and learning process. CSE goes beyond delivering information about reproduction to focus on the integral development of cognitive, emotional, and social capacities [3]. Its purpose is to equip learners with accurate knowledge, but also with life skills—consent negotiation, assertive communication, and autonomous decision-making—that allow them to exercise their sexual and reproductive rights freely, in an informed and responsible manner [9]. Contrary to conservative discourses claiming that access to information promotes licentiousness, three decades of accumulated research show that CSE does not hasten sexual debut or increase the number of sexual partners; on the contrary, it encourages the voluntary postponement of sexual initiation and promotes more consistent and correct condom use [10].

2.2. Epidemiological vulnerability in upper secondary education

Despite the solid theoretical and normative basis supporting CSE, its implementation at the upper secondary level faces complex practical challenges. Middle and late adolescence (usually between 15 and 18 years of age) represents a window of neurological development characterized by asynchronous brain maturation. While the limbic system areas linked to sensation seeking, emotional reward, and susceptibility to peer pressure are fully active, the prefrontal cortex—responsible for executive functions, long-term planning, and rational risk assessment—is still developing [11]. This neurobiological asynchrony predisposes adolescents to engage in risk behaviors, such as substance use during sexual encounters or the deliberate omission of condoms under the influence of illusory optimism.

Added to this developmental reality are biological and gender determinants that increase vulnerability to STIs. From an anatomical perspective, adolescent women are substantially more susceptible to acquiring bacterial or viral infections because of the immaturity of their cervical mucosa and the presence of physiological cervical ectopy, which facilitates pathogen entry compared with adult women [12]. Globally, adolescent girls and young women face disproportionately high rates of serious long-term consequences from untreated STIs, including pelvic inflammatory disease, chronic pain, and infertility. The lack of access to youth-friendly sexual health services and the social stigma attached to purchasing contraceptives or seeking clinical consultation for genital symptoms aggravate this situation, leading many adolescents to postpone the search for timely diagnosis and treatment [12].

2.3. Generative artificial intelligence as a disruptive learning environment

In this complex educational and public health landscape, GAI appears not merely as a technological innovation but as a new ecosystem of knowledge mediation. Unlike conventional educational technologies based on static information repositories or linear navigation flows, GAI systems built on conversational language models can process immense volumes of textual data to generate syntactically coherent responses, adapted in real time to the tone, vocabulary level, and specific needs expressed by the user [5]. This capacity for personalization transforms the student's role: no longer a passive recipient of standardized content, the student becomes an active agent who questions and dialogues with the system through an interactive process of co-construction of meaning.

In the specific field of sexual education for adolescents, the pedagogical potential of GAI lies mainly in its capacity to break down the dense psychological barriers associated with stigma, shame, and fear of social judgment. Sexuality remains surrounded by cultural taboos that make it difficult for a high school student to openly express doubts to parents, teachers, or even school health professionals [8]. A conversational AI system offers an interface perceived as neutral and free from social exposure - a perception that concerns exposure to other people and not, as discussed below, the confidentiality of the data itself -, where young people can ask direct questions about sexual practices, STI symptoms, or preventive methods without fear of being reprimanded, ridiculed, or publicly exposed. This destigmatization of consultation facilitates democratic and immediate access to scientific information, removing the need to navigate the procedures of conventional health services.

Nevertheless, this apparent democratization of information conceals epistemological and technical challenges that contemporary pedagogy cannot ignore. Lacking genuine conceptual understanding or a semantic representation of the real world, LLMs operate through the probabilistic prediction of the most suitable word in a text sequence. This underlying structure means that the system prioritizes the plausibility and formal coherence of the answer over its factual scientific accuracy, giving rise to erroneous explanations written in a tone of absolute technical authority. In an area where the accuracy of information can directly determine the adoption of a risky practice or the misinterpretation of a pathological symptom, these algorithmic "hallucinations" constitute a critical threat to users' health. Recent empirical evaluations confirm that this risk is not hypothetical: even chatbots specifically tuned for the sexual health domain generate incorrect information in a non-negligible fraction of real queries [13].

2.4. Neutrosophic logic as an epistemological framework for complexity

A critical analysis of the intersection between comprehensive sexuality education, STI prevention, and generative artificial intelligence cannot be effectively addressed through traditional analytical approaches of a strictly positivist or bivalent character. Classical logic, grounded in the principles of identity and the excluded middle, tends to classify technological phenomena into rigidly polar categories: technology is deemed either intrinsically beneficial (technological solutionism) or intrinsically harmful (technophobia). This binary simplification is methodologically insufficient to capture the web of contradictions, nuances, and gray areas that characterize the empirical implementation of AI systems in real educational settings, where scientific consensuses coexist with serious ethical controversies and wide gaps in empirical knowledge.

Against these limitations, neutrosophy offers an epistemological framework of high plasticity and conceptual rigor [6, 14]. Its fundamental postulate holds that any idea or conceptual notion (denoted A) inevitably coexists with its opposite (anti-A) and with an intermediate spectrum of neutrality, doubt, or indeterminacy (denoted neut-A) [6]. In the neutrosophic formulation, the conceptual triad is defined by the membership degrees of truth (T), falsity (F), and indeterminacy (I), which vary independently within the nonstandard interval $]^{-}0, 1^{+}[$ [7].

Applying this logical framework to the analysis of GAI in sexual education makes it possible to decompose the current state of knowledge into three major components. The truth component (T)

gathers favorable scientific evidence, consolidated methodological consensuses, and empirically validated benefits of the technology (for instance, the demonstrated improvement in democratic access to information and the reduction of consultation stigma). The falsity component (F) brings together unfavorable evidence, proven structural limitations, biases, and empirical risks that undermine the effectiveness or viability of the intervention (such as algorithmic hallucinations, the risk of spreading conceptual errors, or the exclusion caused by the digital divide). The indeterminacy component (I) represents the zone of neutrality, uncertainty, information gaps, or contradictory effects where science does not yet have conclusive data (such as the actual long-term behavioral impact of AI assistants on STI incidence rates or the differential effectiveness of these technologies across adolescent subgroups).

By structuring the scientific literature under this tripartite matrix, neutrosophy avoids biased polarization and allows the construction of an integrative view of technological complexity. The point is not simply to add up the pros and cons of artificial intelligence, but to map precisely the areas where uncertainty and contradiction demand innovative pedagogical responses and active teacher guidance.

3. Materials and Methods

3.1. Design and type of study

To address the stated general objective, a document-based review was designed following the integrative literature review method [15]. This methodological approach is well suited because it goes beyond a merely summative description of previous findings, enabling a deep conceptual reconstruction and a critical assessment of the quality and validity of the available evidence. By incorporating the neutrosophic logical approach, the integrative review gains the capacity to systematically identify and classify consolidated consensuses (truth), conceptual contradictions and empirical inconsistencies (falsity), and methodological gaps or areas of scientific ignorance (indeterminacy) present in the contemporary literature [7, 14].

3.2. Search strategy and corpus selection criteria

The documentary corpus was delimited through a search of international scientific databases, including Scopus, PubMed, Web of Science, and Dialnet. Thirteen reference studies published between 2019 and 2026 were purposively selected, all of which directly address the thematic intersections of comprehensive sexuality education, STI prevention in adolescents, technological mediation in educational settings, and the empirical evaluation of artificial intelligence chatbots in the provision of sexual health information [2-5, 8, 10, 13, 16-21].

The inclusion criteria required documents to be: a) scientific articles published in peer-reviewed journals or official technical reports from international organizations (WHO, UNESCO); b) studies addressing sexual education or STI prevention aimed at adolescents and young adults; c) research exploring the use of advanced technological tools or behavioral models applied to sexual health; or d) empirical evaluations of the performance of AI chatbots or language models in providing sexual health information. Purely biomedical works that did not discuss educational, pedagogical, or technological mediation dimensions were excluded.

3.3. Neutrosophic analysis procedure

The analysis of the retrieved evidence was structured through the neutrosophic content analysis technique, developed in four successive phases; Figure 1 summarizes the first three. First, four analytical dimensions were defined to evaluate the use of GAI in sexual education: AI-mediated learning, sexual education, STI prevention, and educational equity.

Second, each selected study was critically read to extract the recording units corresponding to each dimension. These units were operationally classified using the tripartite structure of

neutrosophic logic: the truth component (T), defined by evidence that unequivocally demonstrates the effectiveness, viability, or positive contribution of the analyzed technology or pedagogical strategy (favorable evidence); the falsity component (F), comprising evidence or logical frameworks that document critical limitations, confirmed risks, biases, or methodological ineffectiveness (unfavorable evidence); and the indeterminacy component (I), which captures zones of contradiction, empirical information gaps, the absence of longitudinal studies, or unforeseen consequences where current evidence remains inconclusive. Each unit was classified by the first author applying these three operational rules and reviewed by the rest of the authorial team; discrepancies were resolved by consensus.

Third, the qualitative dimensions and their corresponding neutrosophic components (T, F, I) were systematized into a neutrosophic evidence analysis matrix. This matrix served as the basis for the critical discussion of the findings, contrasting the limitations inherent to algorithmic models with the socio-educational needs of the adolescent population.

Fourth, the qualitative matrix was quantified through single-valued neutrosophic numbers (SVNNs) [7, 14], following the evidence-synthesis approach of neutrosophic paraconsistent logic (NPL) [22], which derives degrees of evidence for and against a proposition from a corpus of studies and admits the coexistence of contradictory evidence without logical collapse. Each dimension is treated as a proposition annotated with the triplet resulting from the count. For each dimension d, we counted the number of corpus studies contributing units of favorable (nT), inconclusive (nI), or unfavorable (nF) evidence—the same study may contribute to more than one component and more than one dimension—and the neutrosophic triplet of the dimension was obtained according to Equation (1), where Kd is the number of distinct corpus studies eligible for dimension d, that is, those contributing evidence of any type to it:

$$\langle T_d, I_d, F_d \rangle = \langle \frac{n_T}{K_d}, \frac{n_I}{K_d}, \frac{n_F}{K_d} \rangle \quad (1)$$

As a scalar summary of each dimension we report the net favorability defined in Equation (2), where a positive value indicates predominance of favorable evidence, a negative value predominance of unfavorable evidence, and a null value a tie between the two, while Id separately measures how open the debate remains:

$$\delta_d = T_d - F_d, \ \delta_d \in [-1, 1] \quad (2)$$

Finally, the global state of the corpus is summarized by the mean triplet over the four dimensions, according to Equation (3):

$$\langle \bar{T}, \bar{I}, \bar{F} \rangle = \frac{1}{D} \sum_{d=1}^{D} \langle T_d, I_d, F_d \rangle, \ D = 4 \quad (3)$$

Because the denominator counts eligible studies and not assignments, the three components are not forced to sum to one: a study supplying both favorable and unfavorable evidence raises Td and Fd at the same time, so Td + Fd may exceed 1. This is deliberate. It preserves the independence of the components, which is the property that separates neutrosophic and annotated paraconsistent frameworks from probabilistic or compositional ones, and it makes observable two states that a normalized triplet cannot tell apart: contradiction, measured as min(Td, Fd), and absence of determining evidence, measured as max(0, 1 - Td - Fd). The study-component coding underlying each count is exactly the one referenced in the cells of Table 1, and the computation script is available from the corresponding author to guarantee reproducibility.

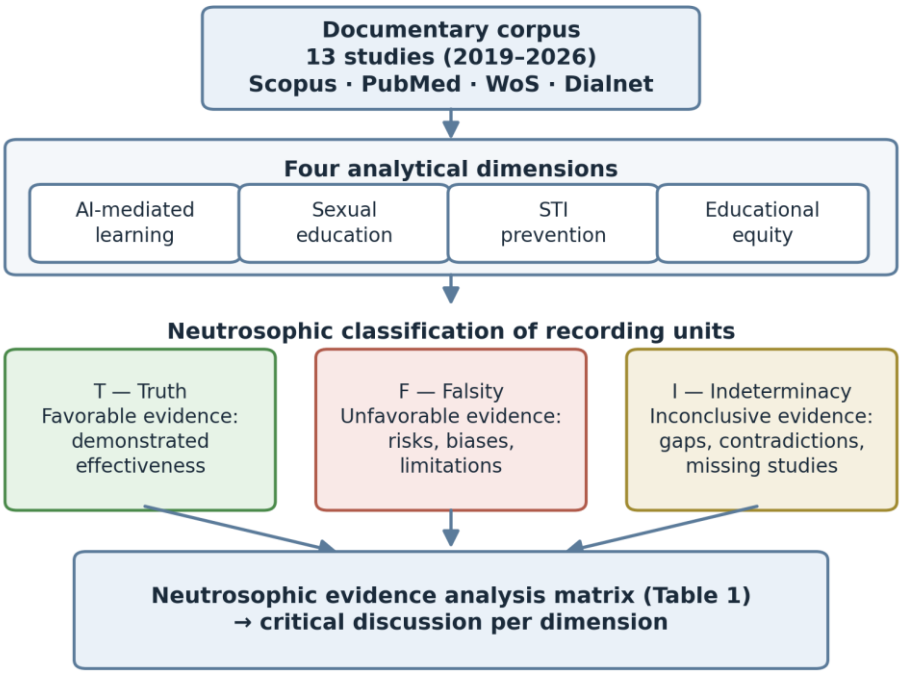

Figure 1: Phases 1 to 3 of the neutrosophic content analysis procedure; phase 4 (SVNN quantification) is defined in Equation (1). Source: authors' elaboration.

4. Results and Discussion

4.1. Neutrosophic analysis matrix of the scientific evidence

The systematization of the retrieved evidence reveals that the current literature presents markedly heterogeneous and dynamic results, far from any absolute consensus. Table 1 synthesizes the neutrosophic analysis of the evidence, structured according to the four key dimensions of the study.

Table 1: Neutrosophic analysis matrix of the scientific evidence on the use of GAI in sexual education and STI prevention.

Dimension	Favorable evidence (T)	Unfavorable evidence (F)	Indeterminacy (I)
AI-mediated learning	Improves personalized, self-directed access to scientific information [4, 5, 13, 21].	High risk of factual errors and hallucinations on sensitive topics [5, 13, 21].	Unknown long-term cognitive and formative impact [16, 20].
Sexual education	Enables anonymous consultation and reduces social shame [3, 5, 8, 10, 17].	May spread incorrect or culturally biased information [4, 13, 21].	Insufficient empirical evidence focused on high school adolescents [16, 18].
STI prevention	High potential to reinforce immediate preventive knowledge [2, 13, 17, 21].	Does not guarantee behavioral change or the	The effectiveness of the digital medium in reducing

		adoption of safe practices [19, 20].	actual infection rates is still uncertain [16, 20].
Educational equity	Broadens access to knowledge for youth in settings without formal CSE [3, 4].	Perpetuates and deepens the digital divide and the exclusion of vulnerable sectors [4, 5].	The differential pedagogical effect across diverse socioeconomic contexts remains understudied [18, 21].

Source: authors' elaboration; bracketed numbers indicate the references supporting each cell.

The integrated analysis of this matrix shows that the truth (T), falsity (F), and indeterminacy (I) components are intricately interconnected in each of the analyzed dimensions. For example, in the AI-mediated learning dimension, the favorable value of personalized, self-directed access to information is immediately weakened by the presence of algorithmic hallucinations (F), generating a state of pedagogical indeterminacy (I) that requires constant supervision by teachers or professionals trained in sexual education.

The SVNN quantification sharpens this picture. Table 2 presents, for each dimension, the counts of studies contributing evidence to each component and the neutrosophic triplet resulting from Equation (1); Figure 2 displays them graphically.

Table 2: SVNN quantification of the matrix: study counts per component and triplet per dimension with independent denominators (Equation 1).

Dimension	**nT**	**nI**	**nF**	**K**	**⟨T, I, F⟩**	**δ = T − F**
AI-mediated learning	4	2	3	6	⟨0.67, 0.33, 0.50⟩	+0.17
Sexual education	5	2	3	10	⟨0.50, 0.20, 0.30⟩	+0.20
STI prevention	4	2	2	7	⟨0.57, 0.29, 0.29⟩	+0.29
Educational equity	2	2	2	5	⟨0.40, 0.40, 0.40⟩	0.00
Corpus mean	—	—	—	—	⟨0.54, 0.30, 0.37⟩	+0.16

Source: authors' computation according to Equation (1); the study-component coding is the one referenced in the cells of Table 1.

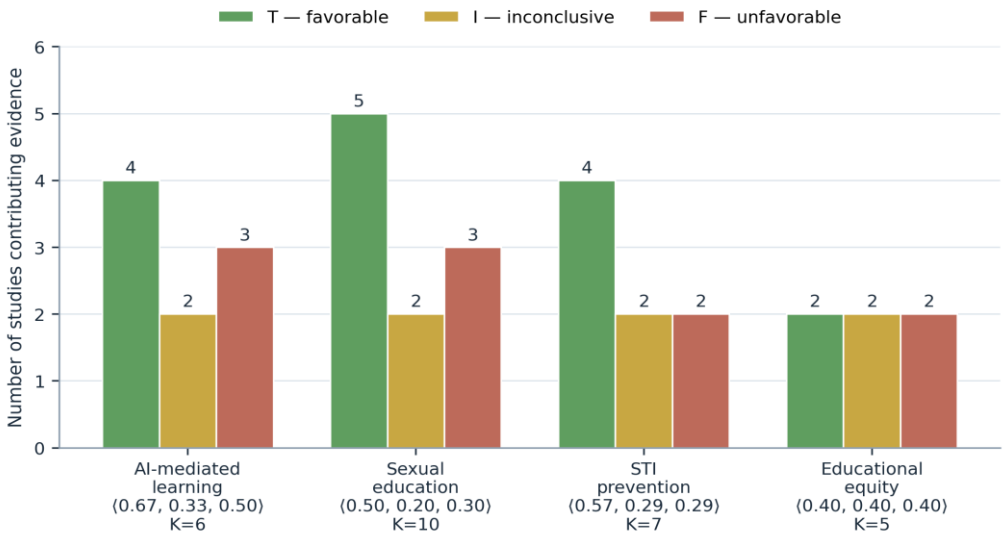

Figure 2: Count of studies contributing T, I, or F evidence per dimension, with the resulting SVNN triplet. Source: authors' computation according to Equation (1).

Three readings emerge from Table 2. First, because the components are computed against the number of eligible studies and not against the number of assignments, the triplets are not constrained to sum to one: in AI-mediated learning ⟨0.67, 0.33, 0.50⟩ sums to 1.50, and in educational equity ⟨0.40, 0.40, 0.40⟩ sums to 1.20. That excess is not a rounding artifact: it is the signature of studies that supply favorable and unfavorable evidence at once, namely [5], [13] and [21] in AI-mediated learning and [4] in educational equity. Second, the most contested dimension is AI-mediated learning, with min(T, F) = 0.50: half of its eligible studies support the pedagogical claim and half oppose it, and both readings are documented within the same corpus. Under a normalized triplet this dimension looked merely moderate, since the constraint T + I + F = 1 absorbed the conflict. Third, STI prevention retains the highest net favorability ($\delta = +0.29$, Equation 2), driven by recent empirical evaluations of chatbots [13, 21] and by standardized education [17], while educational equity is the only dimension with null net favorability: its balanced triplet indicates that the debate over whether GAI narrows or widens gaps is tied, and min(T, F) = 0.40 shows that the tie comes from opposing evidence rather than from absence of evidence. In NPL terms [22], this is an epistemic contradiction - evidence for and against in comparable degree, which new evidence can resolve - rather than an irreducible ontological indeterminacy, which makes it the natural priority for future research. Overall, the mean triplet over the four dimensions (Equation 3), ⟨0.54, 0.30, 0.37⟩, describes the thirteen studies purposively selected here, and not the field as a whole, as moderately favorable but internally contested, with a mean contradiction of 0.37.

4.2. Analysis of the pedagogical dimension and educational narratives

Regarding the first research question, the corpus documents that upper secondary students enter their active sexual lives with deficient knowledge about STIs [2], with attitudes and subjective norms that mediate preventive behavior more than the information available to them [19], and with limited sexual communication practices with parents and partners [23]. Against this baseline, the differential contribution of technology-mediated interventions is examined below.

Examination of the documentary corpus allows a deeper look at the nature of technology-mediated educational interventions and their psychological grounding. One of the most consistent findings in the literature of the last three decades is that increasing factual knowledge about the reproductive system or pathogen transmission mechanisms, although necessary, is insufficient to modify adolescents' risk behaviors [8]. This phenomenon is explained by the theory of planned

behavior (TPB), a recurrent frame of reference in research on young people's safe sexual behavior [19].

According to the TPB, the adoption of a preventive behavior (such as consistent condom use) does not depend exclusively on the information available in the individual's memory, but on the configuration of the behavioral intention, which is determined by three factors: personal attitudes toward the behavior, perceived subjective norms (the social pressure or opinion of the peer group), and perceived behavioral control (the young person's self-perceived confidence to demand and correctly use a condom in a real context) [19].

It is precisely in modifying these subjective norms and personal attitudes that traditional expository methodologies tend to fail. For this reason, the literature identifies entertainment-education (E-E) narratives as one of the most promising digital didactic typologies for genuinely influencing adolescent behavior [20]. E-E narratives embed specific educational objectives within fictional stories, media dramas, digital role-playing, or structured dialogues, allowing students to connect emotionally with virtual characters facing realistic sexual dilemmas.

The meta-analysis by Orozco-Olvera et al. [20], which evaluated the effectiveness of these narratives in youth interventions between 1985 and 2017, offers by analogy two findings relevant to the design of GAI as a didactic resource, even though the meta-analysis did not evaluate chatbots or generative systems. First, it demonstrates the high persuasive capacity of structured stories to modify risk behavior patterns compared with merely clinical brochures or talks. The strength of these narratives lies in their capacity to generate "narrative transportation," a psychological state in which the user becomes immersed in the plot and naturally lowers critical cognitive defenses, facilitating the assimilation of preventive messages that would otherwise be rejected out of fear or psychological reactance [20].

Second, the study warns of a clear methodological indeterminacy: despite the potential observed in the interactive platforms analyzed, a larger base of rigorous empirical evidence is still required to determine the direct and lasting behavioral impacts of personalized digital narratives [20]. Likewise, the literature suggests that, to preserve their persuasive effectiveness in today's highly digitalized contexts, these narratives must be constantly updated to respond to emerging challenges, notably the proliferation of casual sexual encounters facilitated by geolocation apps and the normalization of risk behaviors associated with misinformed digital discourses [4].

4.3. The clinical dimension and the role of school health infrastructure

When analyzing STI prevention among high school students, the pedagogical dimension cannot be dissociated from the care and clinical dimension. The literature stresses that the school environment represents the most democratic space for deploying public health interventions aimed at adolescents, since it allows universal access to populations from diverse socioeconomic contexts [18, 20]. However, the actual effectiveness of school CSE programs depends not only on curricular design but on the strength and articulation of the health infrastructure within educational institutions.

In this regard, the incorporation of school nursing is identified in the bibliographic corpus as a critical success factor for ensuring that sexual education transcends the conceptual plane of the classroom and becomes an everyday, safe, clinically validated practice [8]. The nursing professional in the educational environment acts as a bridge between public health services and the student body, with three documented structural benefits. First, it serves as a pillar for the continuous implementation of systematic prevention programs: the physical presence of a nurse ensures that information on contraceptive and barrier methods is constant and that students' intimate consultations are attended to immediately, safely, and under professional ethics and confidentiality [8]. Second, early clinical accompaniment has a demonstrated impact on the quality of adolescents' future sexual experience: young people who received personalized counseling from school health professionals during secondary and upper secondary education report higher levels of sexual

satisfaction, better self-protection capacity, and more mature risk management as they transition into young adulthood [8]. Third, the presence of school nursing transforms schools into health-promoting environments, complementing teachers' work: while classroom teachers usually lack the clinical training to give precise guidance on genital pathology or to properly refer cases of violence or suspected infections, the school nurse has the technical competence to provide care support and coordinate referral to specialized centers [8]. On this basis, this paper proposes that school nursing also take on the curation and validation of the digital content that young people consult autonomously, including content generated through GAI tools.

The use of structured didactic support tools has also proven effective in this field. The standardization of educational resources, such as visual guides and slides validated by scientific societies of infectious diseases and pediatrics, provides a safe framework for educators to address sensitive topics without falling into misinformation or personal moral bias [17]. Arakawa's study [17] highlights the effectiveness of delivering systematic education based on standardized visual materials from the age of 15 or 16, preferably before most young people begin their active sexual lives, showing that this structured approach increases factual knowledge and promotes a favorable attitude change toward early STI diagnosis.

4.4. Dimensional analysis of GAI in sexual education

4.4.1. The truth component (T): pedagogical opportunities and accessibility

Evaluating the truth component (T) within the neutrosophic spectrum identifies the elements where scientific evidence positively validates the incorporation of GAI as a viable educational resource. The main strength of these technologies lies in their capacity to offer real-time personalization [5, 13]. Unlike traditional methodologies, where content is designed for a hypothetical average student, conversational language models allow adolescents to modulate the pace, depth, and complexity level of the informational exchange. This favors an autonomous, self-directed learning model, essential for consolidating preventive competencies among high school students. Empirical evidence partially supports this strength: in the evaluation by Latt et al. [13], a domain-tuned chatbot answered 85.2% of 195 real sexual health queries correctly, and in the study by De Vito et al. [21] an expert panel rated most of ChatGPT's answers on HIV prevention as accurate (88.4% scoring ≥ 5 out of 6).

Likewise, the anonymity and technical confidentiality perceived by the user constitute a substantial pedagogical advance for the destigmatization of sexual health. The research of Navarro-Prado et al. [8] shows that fear of moral judgment, shame, and social sanction from parents and teachers are the most significant barriers preventing adolescents from seeking guidance on STIs or requesting contraceptive methods. When interacting with a conversational AI system, students place themselves in a comfort zone free of coercion and power asymmetries. This absence of stigma increases their willingness to ask diagnostically sensitive questions and to honestly explore essential preventive concepts, such as the correct use of male and female condoms, which would otherwise remain in the territory of silent doubt.

4.4.2. The falsity component (F): ethical, privacy, and hallucination challenges

In contrast to the opportunities, the falsity component (F) of the neutrosophic matrix brings together the intrinsic weaknesses of the algorithmic model and the empirically documented risks that undermine the intervention's viability. The most critical problem from the standpoint of learning and public health is the generation of inaccurate or pseudo-scientific answers delivered in a formally correct tone (so-called “hallucinations”) [13]. Operating through probabilistic processing of large volumes of data that may include biased or outdated sources, the AI lacks genuine semantic understanding and scientific discernment. Consequently, a high school student who consults a chatbot about a genital symptom may receive erroneous guidance that downplays an active

chlamydia or gonorrhea infection, delaying the search for medical care and perpetuating the spread of the disease.

Additionally, the training of these models often incorporates gender, racial, or heteronormative biases stemming from asymmetries in the original datasets. If a GAI system automatically reproduces discourses that stigmatize sexual minorities or associate STI acquisition exclusively with certain population groups, it not only fails scientifically but frontally contradicts the inclusion and diversity guidelines promoted by CSE [3]. These deficits are not speculative: the expert panel of De Vito et al. [21] documented that ChatGPT's answers on HIV, although mostly accurate, used outdated terminology and omitted the representation of some communities. Moreover, the absence of real-time quality control and scientific validation by experts in sexology and school public health substantially limits the use of these resources as independent or self-assisted pedagogical tools.

4.4.3. The indeterminacy component (I): epistemological and methodological uncertainties

Analysis of the indeterminacy component (I) maps the zones of knowledge where science and pedagogy do not yet have conclusive empirical data to validate or absolutely dismiss the effectiveness of GAI. The deepest indeterminacy lies in the methodological gap between the acquisition of informational knowledge mediated by the chatbot and the actual modification of the adolescent's preventive behavior [20]. Although the evidence shows that virtual interactive environments increase factual retention about STIs and improve students' theoretical attitudes, it is unknown whether these improvements translate directly into consistent use of barrier methods during real sexual encounters of high emotional tension or under the influence of substances.

This uncertainty is aggravated by the scarcity of longitudinal studies and randomized controlled trials in the contemporary literature. Most current research on the impact of technology in sexual education is limited to evaluating short-term outcomes, using self-reported satisfaction questionnaires or cognitive tests applied immediately after the intervention [16]. Therefore, the lasting effect of these technologies on community sexual health—measured through real clinical indicators such as HIV, syphilis, or chlamydia incidence rates in adolescent populations—remains in a zone of neutrality and scientific uncertainty that urgently requires methodological attention from the research community.

4.5. Ethical, political, and epistemological implications of AI for minors

4.5.1. The ethical dimension: data privacy and confidentiality in high school

Deploying GAI systems aimed at high school students raises ethical questions that go beyond ordinary consumer technology. Since this population consists mostly of minors consulting on extremely sensitive topics—their intimate practices, their sexual orientation, or suspicions of STI infection—information confidentiality and personal data protection are first-order ethical imperatives [24]. Many current commercial GAI systems operate under monetization models based on collecting and analyzing user behavior for continuous algorithm training or personalized advertising, which violates the right to privacy and exposes minors to serious risks of digital privacy breaches.

The unauthorized collection and storage of these intimate conversations can lead to scenarios of digital harassment, stigmatization, or discrimination if the information is leaked or publicly exposed. From an ethical approach that respects the minor's autonomy, any conversational AI tool designed for pedagogical purposes and integrated into an educational institution must strictly guarantee the anonymization of user profiles, the encryption of interactions, and the automatic deletion of query histories [24]. Comprehensive sexuality education must be built on a solid foundation of trust; if students suspect that their intimate questions are being monitored by third parties or technology corporations, the communication channel will fracture immediately, forcing them to seek information in informal networks with no scientific validation whatsoever [3].

4.5.2. The political dimension: digital divide and reproduction of inequalities

From a political and distributive justice perspective, the accelerated incorporation of artificial intelligence into educational environments threatens to deepen the equity gaps existing in the school systems of developing countries. Access to and effective use of conversational AI assistants require basic material and infrastructural conditions: internet connectivity, ownership of smart devices with sufficient processing capacity, and a level of digital literacy and reading comprehension that allows analytical questions to be formulated assertively [4]. In marginalized or rural socio-educational contexts, these elementary conditions are simply not met.

Consequently, an exclusion bias arises that systematically reproduces pre-existing inequalities in sexual and reproductive health. While an adolescent from a favored socioeconomic stratum can immediately resolve preventive doubts and access personalized virtual counseling, a young person from a vulnerable sector—often lacking both high-quality school CSE programs and access to the internet or stable mobile devices—will be marginalized from empirical knowledge [4]. Implementing GAI tools in health education therefore demands public policies aimed at guaranteeing equitable technological access, democratizing school infrastructure, and training teachers in information literacy competencies, ensuring that technology becomes a vehicle of emancipation rather than a new form of pedagogical segregation.

4.5.3. The epistemological dimension: scientific validity and the hallucination problem

On the epistemological plane, critical analysis must address the nature and validity of the knowledge algorithmically produced by GAI. It is essential to understand that the information generated by a large language model lacks the peer validation, rigor, and evidentiary support of the reviewed scientific literature underpinning official CSE curricula [16]. The machine's apparent grammatical coherence and eloquent style can easily mislead a high school adolescent into accepting scientifically untenable or obsolete preventive premises as true.

For this reason, the information provided by GAI should under no circumstances be considered a substitute for in-person pedagogical accompaniment or direct scientific documentary sources. The role of artificial intelligence in high school sexual education must be strictly subordinated to that of a complementary support resource for initial information seeking, in line with the empirical conclusion that chatbots work as adjuncts to human providers and under their oversight [13]. The constructive process of autonomous, responsible learning about one's own body and the safe exercise of sexuality requires the affective, ethical, and scientific mediation of a properly trained teacher, a school nurse, or a health professional with the competence to mediate between the machine's probabilistic response and the student's real lived needs [8].

4.6. Limitations of the study

This study has limitations that bound the scope of its conclusions. First, the corpus was built through purposive sampling of thirteen studies rather than a PRISMA-type systematic protocol, so the mapping should be read as an exploratory cartography of the state of the art and not as an exhaustive systematic review. Second, the SVNN quantification was performed at the study level with one principal coder: all studies weigh equally, with no adjustment for methodological quality or sample size, and no inter-coder agreement measures were computed. Third, much of the available empirical evidence on sexual health chatbots comes from adult or university populations [13, 21], so its extrapolation to high school adolescents must be made with caution. Fourth, the temporal window of the corpus (2019-2026) combines studies prior to and after the massive expansion of generative models, which introduces heterogeneity in the object under evaluation. Double coding with agreement indices, evidence-quality weighting, and coding at the recording-unit level are the natural next steps to strengthen the quantification presented here.

5. Conclusions

The accelerated incorporation of generative artificial intelligence into education demands a critical, multidimensional reassessment that transcends both the naive optimism of technological solutionism and the unfounded rejection of pedagogical conservatism. Through this integrative analysis, structured under the conceptual rigor of neutrosophic logic, it has been possible to systematically map the consensuses (T), the structural limitations (F), and the wide methodological gaps (I) that characterize the use of conversational language models as didactic tools for STI prevention among high school students.

The results indicate that the truth component (T) of GAI is manifested mainly in its democratizing potential for personalized access to information. By providing an interactive, accessible, and anonymous dialogue interface, these technologies mitigate the psychological barriers associated with social stigma, shame, and fear of adults' moral judgment, allowing adolescents to resolve intimate doubts privately and confidentially. However, this positive value is immediately conditioned by the falsity component (F), represented by the persistent risk that algorithms fall into scientific "hallucinations" and spread biased or factually incorrect medical misinformation, devoid of peer validation and of genuine conceptual discernment about STIs.

The indeterminacy (I) identified in the literature reveals a substantial methodological gap between the increase in factual knowledge that a chatbot can facilitate and the effective modification of the adolescent's actual behavioral intentions, which are regulated by the psychosocial variables described by the theory of planned behavior. There is no longitudinal empirical evidence showing that the use of these tools directly reduces community STI transmission rates. Consequently, GAI should not be conceived as a substitute for the classroom teacher or the school health professional, but as a complementary didactic medium, strictly subordinated to in-person, clinically validated pedagogical accompaniment.

Finally, mitigating the ethical, political, and epistemological risks analyzed requires the design and implementation of institutional regulatory frameworks and public policies that guarantee the protection of minors' data and promote students' critical digital and algorithmic literacy. Consolidating CSE in high school also requires strengthening, as a priority, the health infrastructure within schools, recognizing the role of school nursing as a central actor for guiding, with scientific grounding and human closeness, the healthy and responsible development of students. As future work, we propose to strengthen the quantification presented here along four lines: a reproducible systematic search that widens the corpus beyond the thirteen purposively selected studies; independent double coding with agreement indices such as Cohen's kappa; weighting of each study by methodological quality and sample size, so that a small study and a meta-analysis do not carry equal weight; and a sensitivity analysis of the triplets with respect to the coding decisions. Empirical validation with students and teachers of the Mexican upper secondary level, together with the systematic exploitation of the conflict and ignorance measures that the independent denominators make available, completes this agenda.

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