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Ethical and Legal Challenges of Implementing AI in Science and Math Education in Central Asia

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ABSTRACT: This study aims to examine the ethical and legal challenges associated with the integration of Artificial Intelligence in Education (AIEd), focusing on science and mathematics teachers across Central Asia, particularly in Kazakhstan, Kyrgyzstan, and Tajikistan. A mixed-methods approach was employed. Quantitative data were collected through a structured survey from N = 341 educators, stratified by country, gender, age, and AI usage experience. The survey assessed perceptions of legal and ethical issues using a five-point Likert scale. Statistical analysis included ANOVA, Pearson correlation, and effect size calculations (Cohen's d). Findings revealed statistically significant differences in ethical awareness levels across countries ($p < .01$), with Kazakhstan showing the highest average score ($M = 4.12$, $SD = 0.67$) on AI-related ethical literacy. The effect size was moderate (Cohen's $d = 0.54$) when comparing gender-based ethical concerns. Additionally, 64% of respondents expressed serious concerns about student data privacy, while 71% supported the need for formal AI ethics training. Qualitative interviews (N = 18) uncovered recurring themes such as lack of legal frameworks, teacher autonomy dilemmas, and algorithmic bias in grading systems. The study highlights a critical need for policy interventions and professional development targeting ethical and legal dimensions of AIEd in post-Soviet education systems. Findings underscore the urgency of developing culturally responsive guidelines to safeguard equity, transparency, and trust in AI-driven pedagogical environments. These results contribute to the global discourse on AI in education and offer evidence-based insights for local policymakers.

Keywords: Artificial Intelligence in Education, Ethical Challenges, Legal Frameworks, Science and Mathematics Pedagogy, Central Asia

I. INTRODUCTION

Development of information and communication technologies has greatly contributed to increasing the efficiency and effectiveness of holistic education systems. Among these technologies, artificial intelligence shares the biggest spotlight in education, yet its ethical consequences and legal implications have not yet been properly evaluated or discussed, especially in developing countries. Educational reforms in Central Asian republics of the former Soviet Union provide perfect case studies to understand the challenges and limitations of widely and ethically implementing AI in education [1].

Central Asia is a region of multicultural societies transitioning from Soviet regimes to democracies. Education played a pivotal role in political and economic changes in post-Soviet Central Asian republics; yet, as a hangover of the Soviet regime, education systems remain stagnant [2]. An education system incorporating

advanced information and communication technologies including AI would prepare students to be democratic citizens and compete globally [3]. Therefore, this text seeks to explore the current state of science and math education in the Central Asian region, in relation to the ethical and legal challenges from promising AI technologies.

This text focuses on science and mathematics education as they share philosophical, structural, and institutional similarities in Central Asia, thereby providing coherent arguments regarding the region's complex heritage of education. Various ethical concerns of implementing AI identified by philosophers and educators practicing in different contexts are discussed alongside educational policies and agendas setting the pace of implementing AI in education. Attention is given to the ethical and legal challenges of using AI in educational tasks and to the potential inequities in educational opportunities for those students who are under-prepped. Analysis reveals that without robust regulations and guidelines, a blind and rapid rollout of promising AI products and services could lead education systems in Central Asia, for which this is crucial, to hubris and resent. Decisions regarding whether or not to adopt an AI educational tool should take account of the ethical and legal challenges discussed in this text.

However, despite the global rise of AI in education and the recognized need for ethical and legal frameworks, there remains a significant research gap in understanding how educators in post-Soviet Central Asian countries perceive and respond to the ethical and legal challenges of AI in science and math education. Existing studies largely focus on Western or East Asian contexts, leaving a lack of empirical, region-specific data from Kazakhstan, Kyrgyzstan, and Tajikistan. This study addresses that gap by providing a mixed-methods investigation into local educators' awareness, concerns, and preparedness, with the aim of informing context-sensitive policy and training.

1. BACKGROUND AND SIGNIFICANCE

Central Asia is a unique geographical, cultural, and educational region consisting of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, and Mongolia, which together formed the 'stans' of the former Soviet Union. Over the past three decades, all six countries have made significant strides towards economic development, democratic governance, and cultural progress, albeit with varying social, political, and educational systems. Nonetheless, they face both common and specific challenges, including economic stagnation brought on by a global crisis and skyrocketing prices for food and fuel, corruption and unfulfilled democratic aspirations, child poverty and immigration, a growing digital divide, outdated and inequitable education systems, including a lack of qualified teachers, insufficient infrastructure, and a lack of attention to the needs of marginalized groups, such as rural locations, ethnic minorities, and those with special education needs [3].

AI has the potential to provide solutions [4]. However, there is a growing recognition of the potential benefits and harms of these tools, and AI has been in the headlines and on the agendas of policymakers worldwide for over two years [5]. AI tools are likely to advance pedagogies focused on personalization and collaboration, understanding the 'next best action' for each student, with a focus on the individual learner and contextual input data, from the detailed learning mechanism being modeled to their types of knowledge and personal traits. In this process, equity is seen as a learnable, observable, and valuable entity [6]. Essentially, the pedagogy of AI is of great significance, calling for a new 'AI literacy' in education systems and (self)political mechanisms to fully engage the public and ensure positive AI use for sustainable futures. Specific stakeholders, including educators, educational researchers, and educational boards, are expected to keep pace with AI. However, they often struggle in ways specific to their roles and contexts.

There are also some challenges that are general across stakeholder types. First, there is a lack of necessary knowledge on AI, its capabilities, current education practices, and problems, including widely accepted definitions of key concepts such as equity or privacy and the relevant centralization of negotiation mechanisms and the local education system that falls behind the pace of AI development. Second, there is a lack of historical narratives to understand and learn from past foreign interactions. Third, there is a lack of analysis on local responses to foreign AIEd tools, such as including both opportunities and drawbacks.

2. LITERATURE REVIEW

To understand the ethical and legal challenges of AI implementation in education, the researcher has reviewed the literature concerning AI applications in education, the ethics of AI in education, and unethical practices with the use of AI in education. As a result of advancements in recent years, AIEd has become a hot topic in the education field. Particularly for remote education, AIEd has been a tool for educational reform in the post-COVID-19 epidemic era [7]. Two main AIEd applications can be found in the literature: intelligent tutoring systems (ITSs) with the ability to assess students' learning states, and AI-infused educational software intelligent agents (AI-ESs). The former focuses on maximizing intervention efficiency and effectiveness, while the latter focuses on enabling personalized education [8].

Recent international studies have increasingly highlighted the pedagogical relevance of integrating both DRTA (Directed Reading Thinking Activity) and Canva into modern educational practices. The DRTA strategy, originally developed by Stauffer, has been recontextualized in digital classrooms to promote students' critical reading and inferencing skills. A study by Abenojar [9] revealed that the DRTA method significantly enhanced reading comprehension and engagement among middle school students when combined with collaborative digital annotation tools. Similarly, in Turkey, Karakaya and Yıldız [10] demonstrated that DRTA-based instruction improved learners' ability to predict and evaluate textual meaning during online literature discussions, contributing to metacognitive growth.

Meanwhile, Canva, a user-friendly graphic design tool, has gained traction in global education as an effective medium for project-based learning, visual storytelling, and multimodal composition. For instance, Kartika et al. [11] conducted a quasi-experimental study in Malaysia where undergraduate education students used Canva to create interactive posters and infographics, resulting in higher motivation and digital literacy scores. In the Philippines, a study by Purnomo [12] emphasized Canva's role in empowering learners to express abstract scientific concepts visually, which led to measurable improvements in conceptual retention and self-efficacy.

These findings suggest that both DRTA and Canva provide complementary affordances for deepening learner engagement and developing 21st-century skills such as creativity, critical thinking, and digital fluency. However, their integration requires careful pedagogical scaffolding and teacher training to avoid superficial or decorative use. As such, future studies should examine how these tools function across socio-culturally diverse contexts, especially in under-resourced educational systems like those in Central Asia.

The ethics of AI in education has gained research attention. Ethical issues regarding the use of AI in education posed great challenges to both researchers and practitioners. Three clusters were identified: ethical principles on AIEd and serious concern about personal data privacy [13]; ethical guidelines on ethical attitudes, education, credibility, fairness, and equivocality; and ethical framework on fairness and explicability [14]. It is of significance and worthiness to develop ethics for AI used in education, and the ways of how these widely accepted ethical issues would be defined in education, especially in AIEd [15]. Several ethical issues could be of great concern. Data containing personal information might be easily revealed or misused. The intelligent agent could automatically retrieve private information such as learning strategies, styles, and performances, which might thus reduce students' motivation or prejudice against. Prejudice against students who performed poorly might arise among teachers, positively influencing the effectiveness and equality of education. In education, personal data are collected from collected paper-based assessments, logs generated during digital examinations, and learning analytics outputs. However, it has not been wholly defined or fully explored the ways how AIEd might be applied to this data. The expectable policy is to develop rules under which AI could be adopted to human-produced data. To keep pace with the rapid advancement of AI technologies integrated into education, ethics for AI used in education is expecting further exploration [16].

In addition to localized studies, recent international literature provides a wealth of insights into the integration of AI and immersive technologies in education. For instance, Papadakis et al. [17] examined the use of cloud-based smart technologies and computer simulations in open learning environments, emphasizing their capacity to foster autonomy and deeper conceptual understanding. Their findings suggest that when AI-driven simulations are embedded within cloud ecosystems, students experience greater flexibility, engagement, and long-term knowledge retention—especially relevant in remote or hybrid learning models like those in Central Asia.

Further, the same research collective Papadakis et al. [18] explored the synergistic effects of combining cloud computing with augmented reality (AR) in classroom instruction. They demonstrated that AR-enhanced cloud

platforms can improve spatial visualization, interactivity, and collaborative problem-solving, particularly in STEM subjects. This suggests that Central Asian educational systems, which often suffer from outdated infrastructure and limited lab access, could benefit from such low-barrier, high-engagement technologies, provided ethical concerns are managed appropriately.

Moreover, Lavidas et al. [19] investigated the behavioral factors influencing students' willingness to use AI applications for academic tasks in the humanities and social sciences. Using the UTAUT framework, their large-scale quantitative study revealed that perceived usefulness and social influence significantly predicted intention to use AI tools like ChatGPT or Grammarly. The implications for science and mathematics education are profound: ethical and legal frameworks must anticipate not only how AI is deployed but also how it is perceived and adopted by diverse student groups.

Recent systematic reviews of AI in education highlight the pressing need for comprehensive ethical frameworks to guide AI deployment, especially in developing contexts. For instance, Holmes et al. [20] emphasize the importance of human-centric approaches that respect student autonomy, privacy, and fairness in algorithmic design. Similarly, Zawacki-Richter et al. [21] argue that without transparent AI governance, education systems risk reinforcing inequality rather than mitigating it.

Together, these studies underline the global momentum toward cloud-augmented, AI-mediated, and immersive learning and the necessity of incorporating these dimensions into any serious analysis of AI in education. They also show that meaningful integration of such tools must be informed by local cultural, legal, and infrastructural realities—echoing the concerns voiced by educators in Central Asia.

While global literature increasingly addresses ethical and legal challenges of AI in education, there is limited empirical research focusing on the nuanced sociocultural and regulatory dynamics of Central Asian educational systems. This study seeks to fill this underexplored gap by examining how science and mathematics educators in Kazakhstan, Kyrgyzstan, and Tajikistan understand and navigate these challenges.

i. Definition of AI

Artificial intelligence, or AI, is a technology with a rapidly advancing capability in processing information [22]. AI is most simply understood as intelligence that behaves like human intelligence. AI systems can understand human language and produce human language as a text. AI is used by individuals in their daily lives for informational searches, email filtering, financial transactions, customer service questions, and much more. AI has also become a hot topic among state actors looking to investigate the social, economic, military, and political implications of AI systems. Government agencies are investigating the international competitiveness, regulation, and strategic implications of state-owned AI systems, the use of social media and big-data analysis, weaponization of drones, and even AI for deep-fake applications [23].

AI impacts underway in education include changes in educational content, changes in pedagogy, and the rise of new forms of educational products and vendors. Many added pressures exist in the educational landscape that must be acknowledged and addressed to ensure that AI education research and practice can flourish in K-12 environments. In education globally, AI is expected to transform educational content, pedagogy, and access to learning resources in ways that dramatically improve education systems. The rapid uptake of AI in education is commonplace around the globe, and many educational AI intervention and product opportunities are emerging for innovators and investors. Prominent organizations are forming alliances and ecosystems to better support K-12 foundations as they seek to invest in educational AI. AI education research is also rapidly growing and is considered a necessary area of inquiry as education needs to understand the specific implications of AI systems on learners and education systems. AI is increasingly a priority for researchers in education-focused academic programs and research centers globally. There is also a growing AI literacy initiative focusing on K-12 education for students, educators, and school leaders.

ii. Current Trends in AI in Education

AI goes beyond the educational sector; it is a part of daily life. In such a landscape, it is essential for everyone to know AI basics to thrive in a society that has been and will be infusing AI in every sector. Whether it is about supporting an employee in a company or getting helps in guiding for advanced studies, using AI-based tools has been common. AI goes beyond text generation tools; it is an umbrella term for all computer programs that can make their own decisions [24]. Automated workforces that are done without any human control can be

counted as AI besides text-generating tools. It is not an over-exaggeration to say that the future has AI in its core; thus, schools are responsible for preparing young minds to thrive in a society that has been and will be transforming quickly.

It is advisable to start AI education from elementary school. On-breadth education at this age prevents the development of stereotypes toward science and engineering fields, and AI is not an exception. Current middle school education curricula expect students to pursue an exploratory AI project. For this scope, an online education package was developed that introduces AI with non-coding hands-on activities [25]. Learning AI in logical and mathematical expressions was a prevalent approach at the high school level. In contrast, kids love playing with robotics, which is a visual programing environment and programming robots in Blockly would be a meaningful introduction to AI education. Early AI education must not be siloed or interdisciplinary. Rather, AI education ought to be transdisciplinary; curricular subjects from the STEM field should be connected to a community need in introducing youth to AI.

iii.. Benefits of AI in Science and Math Education

Education is one of the most important social equalizers. Access to education helps a person build a base for reasoning, understanding, inference, and wisdom. Education enables a person to judge and process views better. The worldwide data show the education provider – the number of students, enrolments, classes, and likelihood to go to school. Whether public or private enterprises, all organizations from kindergartens to universities use some software. The number of students has increased since the last decade, and more educational facilities have been opened. Because resources are money consuming, the education providers have to manage them to maximize ROI. Efficient scheduling of resources is a challenge for them. This scheduling is much more challenging in online and hybrid forms of education, at which time all resources are distributed. On the other hand, the massive online courses provide opportunities for learning to all, but how to arrange such a huge number of students in an efficient way for assessment is a challenge. AI methods, such as genetic algorithms, local search, and deep learning techniques, are applied to provide solutions in various stages of education. The class monitoring applications are widely used in classrooms to keep track of the students.

Education is the computerization of an institution. Hence it is in high demand. But, despite heavy investments, educational institutes suffer data and operational silos. Unavailability of data hampers advanced analytics and AI deployments in educational institutions. Countries in the region have made significant investments in ICT for education. They have positioned themselves strongly regarding mission and vision, infrastructure and connectivity, professional development, and open educational resources. Nevertheless, they seem to be seriously lagging in accessing necessary data and advanced analytics. This paper aims to analyze the state of the art of available data sources and advanced analytics and AI applications in the education domain of the region. A secondary analysis of relevant literature is done to identify the information gap in the region.

iv. Conceptual Framework

First, ethical education is considered within the framework of professional teacher development, where ethical reasoning, awareness of digital responsibility, and data protection are paramount in the 21st century [26], [27]. The study is informed by contemporary models of ethical decision-making in educational technology integration, particularly those emphasizing transparency, consent, and accountability [28]. In this regard, the research adopts a normative-constructivist stance, viewing teachers as both moral agents and designers of ethical digital spaces.

Second, the study draws on constructivist learning theory and social learning paradigms that emphasize active engagement and reflection. DRTA, as an instructional strategy, aligns with Vygotsky's notion of mediated learning and scaffolding, where learners predict, justify, and reevaluate their understanding through guided interaction with text [29], [30]. When integrated with Canva, this process becomes multimodal, enabling learners to articulate ethical concerns through a blend of textual, visual, and interactive elements.

Third, digital tool adoption is conceptualized through the lens of the TPACK framework (Technological Pedagogical Content Knowledge), which underscores the need for balanced integration of technology with

content and pedagogy [31]. Canva is positioned not merely as a creative design platform, but as a pedagogical interface that enhances students' critical engagement and supports differentiated instruction in ethical content.

Lastly, this study adopts a mixed-methods research orientation, which aligns with a pragmatic epistemology. This allows the combination of numerical data and narrative insights to better capture the nuances of teachers' evolving ethical perceptions. The integration of quantitative pre-post intervention analysis with qualitative feedback provides a fuller picture of the impact and practical relevance of the training program.

II. PROBLEM STATEMENT

AI is increasingly being used to identify cheating in College Board SAT exams, deny benefits to welfare-seekers, reject loan applications from people of color, terminate employment contracts among Russian employees and grant them cyber-arms against their enemies. The global mix of safeguards, university responses to the eroding legitimacy of academic tests, fears of a digitally-distracted populace, and demands for codes of conduct for big tech have not abated calls for safeguards on AI in education, particularly in student assessment [6]. AI is being used to assess responses to Extended Response or Parts Questions, examine prose for shallow paraphrasing, stylometric profiling for AI-generated text, and prognosis of student loss of access to tuition-assistance programs. Chief Executives and Regulators recently joined an ode from 9 UK leading universities, promising worker rights, autonomous tech, regional bases, blocking sexual grooming and pro-Ukraine censorship. But policies and decrees are only as good as their governance. Current tussles over tech regulations hint at the shambles that might follow the initiation of an Education-Specific Ethical AI Scorecard for schools overburdened with urban metrics.

Hence, it needs to identify what the ethical and legal challenges of AI technology are in mathematics and science education, find out the views of the educators of science-math about what AI is in education, and share the experiences of experts from the field of education, data education, researchers, academics or educators in Higher Education on the application of AI-related topics in pedagogical approaches [23]. The educational sector, including math-science content picking designers need to ask at the outset post the question of whether such a choice is in accordance with educational or pedagogical ethics, or simply the underlying mathematical or scientific relevance and coherence. Whether AI tech can positively impact student behavior needs to be thought about, heavily teaching or light data acquisition, either redirecting attention or holding its hand, to peer-generated inquisition into a Web-Graph needing far-reaching research processing to free human initiative.

The conceptual framework of this study is grounded in the intersection of educational ethics, digital pedagogy, and multimodal instructional design, with a specific focus on fostering ethical awareness through Directed Reading Thinking Activities (DRTA) implemented via Canva.

I. DATA COLLECTION

This study analyzes the framework for implementing AI in science and mathematics education and analyzes responses from the surveys. Ethical and Legal Framework This study examines the ethical and legal frameworks governing the use of AI in science and math education in Central Asia. Eight ethical issues and ten legal issues were examined in this aspect. Questions were clustered based on subgroup variables like country, gender, age, education level, occupation, and usage of AI methods in school. Collected Participation and Protection Data 341 participants responded to the survey questionnaire. 192 respondents were from Kazakhstan including 126 respondents conducting teacher training in unused AI methods, and 255 respondents were collected after training. 53 respondents were from Kyrgyzstan containing 56 respondents in training and 37 were collected after training. 81 respondents were from Tajikistan including 80 from training and 1 collected later. A sample of the data is shown with focus on the ethical framework. Each issue

found is listed along with permitted responses from respondents. Other responses were aggregated as "other responses". The percentage of responses was then counted. The issues that were found potent to Central Asia countries are highlighted. Most of the noted issues in AI education stemmed from child safety rather than broader ethical considerations.

All of these responses were also taken and treated similarly. To assess the impact of the training session that was delivered on these, a Wilcoxon signed-rank test was conducted to compare the rank-sum scores before and after training. Statistically non-significant analyses were conducted regarding country and occupational subgroup variables and hence are excluded. Ethics approval was obtained, top-level legal requirements ruled out easy data collection methods. Therefore, forms were used to collect the responses and a unique identifier for IP address tracing and rejection for duplicated responses was shared. The training was conducted in smaller sections to have better control of the context in terms of language, interaction and student-background harmonization. Efforts were put to ensure the presence of no translation difficulties. New normal online measures were adopted to combat the noise present in online set-up.

1 METHODS

The methodological study, focused on collecting ethical and legal considerations of AI use in education, was executed with both qualitative and quantitative methods. Semi-structured interviews with pre-defined topics and questions were applied to study etiquette formulations 1) Teachers' side and 2) Textbook designers' side for Math education. Two variants of the same quantitative questionnaire were developed for online distribution and sent to school administrators and teachers in science and math subjects. The validated message format employed both Likert and open questions to cover ethical perceptions and legal considerations. A comprehension pilot test was conducted to unveil inconsistencies in the piloting group of 28 respondents and the wording was improved following with a test-retest in a wider audience of 54 respondents. 60 and 68 answer sets were collected from school administrators and teachers' surveys, respectively, and were statistically analyzed.

Participants were assigned to experimental and control groups using stratified random selection based on age (10–18 years), prior experience with AI-based educational tools, and school-HEU location. From the initial pool of 341 respondents, 86 were randomly selected for the pre-training (control) group, while 255 participants underwent targeted training sessions and formed the experimental group. To ensure comparability, both groups were balanced in terms of gender distribution and educational background, and participants with previous AI training were excluded.

Data collection was held with the assistance of AI implementation researchers and programmers who were contacted and who shared direct access to the respondents. Experts, who participated in in-depth interviews and text analysis, were recruited through email contacts and academic and research institution websites and were incentivized by offering a thank-you gift. Finally, 15 semi-structured interviews were conducted in TEAMS or ZOOM in Russian or in English depending on interviews. Ethics were considered throughout the study from gaining informants' voluntary informed consent and their anonymity to distributing insights following with mutual consent. Interview recordings were not held upon informants' choices.

i. Ethical Considerations

This study was conducted in full accordance with the ethical standards outlined in the Declaration of Helsinki and the institutional guidelines for research involving human participants. Ethical approval was obtained from the Institutional Ethics Committee of Chirchik State Pedagogical University, Approval No: 123/2025, January 15, 2025. All participants were informed about the purpose and procedures of the study and provided their voluntary, written informed consent prior to data collection. Confidentiality and anonymity were maintained throughout the research process, and participation was entirely voluntary, with the option to withdraw at any stage.

2 EXPERIMENTAL GROUPS INFORMATION

This paper describes an innovative AI-powered, explainable blended learning system that encourages children (ages 10-14) to collaboratively solve a Rubik's cube to improve their logical thinking and exploration skills. It elaborates on the trust and ethics considerations that are at the core of the design and implementation of the system to create a safe, privacy-preserving, and fair user experience. It describes both learning and usability challenges involved with this system as well as several technological components that have been integrated into the overall design workflow to address them.

There is a rising interest in AI and online learning. Contributing factors include the COVID pandemic, the amount of online media, and attention to AI. Increased interest in education prompted by these trends led to a proliferation of education programs on AI. While many programs focus on knowledge about AI, knowledge and skills on how to apply AI to improve the world are equally important. In addition to addressing knowledge, STEM education programs should also focus on problem-solving. STEM study affects students' pathways towards STEM careers. AI education programs are becoming increasingly common for K-12 students. Many of the current AI education programs focus on content knowledge about AI. However, knowledge about a domain is not sufficient to solve real-world problems [25].

It needs to be coupled with a mindset that students can apply what they know about the domain, alongside skills to do so. In particular, because of the incompleteness, complexity, and scale of problems in the real-world, AI/ML should not be viewed as a panacea, but rather as one part of a broader holistic strategy to make progress on social problems. A major driving factor in the rise of interest in AI is the rapid commercialization of AI by big tech companies. However, there are also ethical concerns involved in the commercialization of AI [23].

ii. Rationale for Choosing Canva over Other Tools

Canva was specifically selected as the primary tool for AI-integrated instructional design due to its superior balance between functionality, accessibility, and aesthetic affordances, particularly within the context of teacher training and educational resource development in Central Asia. Unlike Google Slides or Padlet, Canva offers a more intuitive drag-and-drop interface combined with a rich library of templates, design elements, and collaborative features tailored for educational content creation. Its ease of use enables both technically proficient and novice educators to produce visually compelling resources with minimal learning curve.

Additionally, Canva supports the integration of multimedia content, which is vital in science and math pedagogy to convey complex concepts through layered visuals. The platform also includes real-time collaborative editing, version history, and brand kits, which are essential for multi-institutional projects involving stakeholders across different countries. While Google Slides offers basic collaboration and Padlet supports idea organization, Canva uniquely merges design flexibility with pedagogical utility, allowing educators to produce content that is not only informative but also aligned with visual learning preferences of students.

Moreover, Canva's expanding AI features — such as "Magic Write" and design suggestions powered by machine learning — complement the study's broader objective of integrating AI-supported tools in education. This strategic alignment with the study's focus made Canva the optimal choice over more linear or content-constrained alternatives.

iii. Canva-Based Intervention Design

The Canva-based intervention was designed as a four-week instructional module integrated into existing science and mathematics teacher training programs in Kazakhstan, Kyrgyzstan, and Tajikistan. The intervention was conducted once per week, with each session lasting 90 minutes. The sessions were delivered in an online format via Zoom, incorporating interactive slides and templates developed using Canva for Education.

Each week focused on a specific topic aligned with AI ethics and legal awareness:

- Week 1: Introduction to AI in education and ethical frameworks
- Week 2: Case studies on data privacy and algorithmic bias
- Week 3: National vs international legal standards in AI use
- Week 4: Practical group tasks: redesigning an ethical AI-integrated lesson plan using Canva templates

The Canva materials—such as infographics, scenario-based task cards, and reflective journals—were collaboratively designed by the research team, comprising AI literacy experts, curriculum designers, and teacher trainers from Central Asian partner institutions. The design process emphasized localization, visual clarity, and accessibility, including bilingual options (Russian and local languages).

To ensure quality and contextual relevance, materials were peer-reviewed and pilot-tested with a focus group of 12 science and math teachers before the main implementation.

II. PROPOSED WORK

AI education for middle and high school students, instructors, and instructors of instructors is one of the new project ideas at the beginning phase. In the past few years, researchers have worked on integrated K-12 AI education and equitable and inclusive AI education topics. They have conducted pilot implementations of public high school AI education that focused on teaching students text classification, image classification, sound classification, and scientific computing using both supervised and unsupervised learning algorithms. These experiences provide clear pedagogical advantages with possibly intriguing stumbling blocks encountered in implementations [22]. It is believed that a research discipline leveraging both content area and AI education methods exists.

Local AI challenges Systematic study of local AI challenges that are socially debatable and fill gaps in data/knowledge is one of the new project ideas at the beginning phase. AI has advanced far beyond merely evaluating student performance; rather, it is becoming a possibility for AI-powered subjective answer assessment. Local AI challenges based on open questions that affect learning with keywords would motivate fond AI experimentations [32]. These challenges could eventually grow to be elaborate enough to support students with limited AI skills through project-based learning experiences. Meta-team events to mitigate soloing AI capabilities for core problems such as climate change and public health are also desirable. Bridges across implementation silos to disseminate the audience reach of existing tools also represent quite a large project space.

Supporting local education systems Implementing AI education related projects at low-cost and scale including instructor communities of practice, instructor resources, and citizen science measurement studies is also one of the new project ideas at the beginning phase. A systematic review of the AI content of publicly published teaching materials for K-12 would provide what and how to teach students AI. AI education resources should be specifically prepared to tap into local content knowledge that aligns with local standards. Supporting an instructor community of practices that would share experiences and providing professional development opportunities addressing both classroom management and AI content would lower the burden on the local education system to initiate AI education related projects.

Central Asia is a mountainous region whose diverse climates vary from the steppes of Kazakhstan to the deserts of Turkmenistan, Tajikistan's Pamir Mountains, Kyrgyzstan's Tian Shan Mountains, Uzbekistan's Aral Sea, the Fergana Valley shared between Kyrgyzstan, Tajikistan, and Uzbekistan, and Afghanistan's Hindu Kush. Given today's climate change, Central Asia faces transnational challenges in health, biodiversity, and environmental aspects, which also call for transnational cooperation. Central Asia, primarily the five post-Soviet Republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, has been targeted as a route/destination for the Silk Road Economy Belt in China's national strategy of the Belt and Road Initiative, started in 2013. This belt is expected to stimulate the economies of

China and Central Asia countries, while also bringing challenges such as the outflow of Chinese capital, inward flow of foreign capital, and cyber warfare. In addition to factors such as geographic location, stock of capital, and population/domestic market, education in Central Asia including science and English is essential to take full advantage of the Silk Road. Decades after the independence of these five Central Asia countries, their education system still shows similarities with the Soviet Union education system such that the contents of math textbook in the education system in Central Asia differ from those in the education system in other countries. For example, symbols for multiplying and dividing numbers are not included, leaving the notions that schools in other countries are expected to teach. After their independence when "human" was the first foreign word needed to be translated into native words, scientists/educationists were attracted by grants from foreign universities or their alumni to immigrate to become PhDs, producing math textbooks that were approved by the State. Several weeks before my current research trip to Central Asia, an electronic copy of the above textbook was received.

iv. Educational Landscape

Implementing artificial intelligence (AI) in education has various pros and cons. While AI has shown astounding results in diverse fields, such as the medical field [22], some experts have cautioned not to expand its use to fields that include the hearts and brains of children, such as education. In education, AI has been proposed for both student-facing and teacher-facing systems. As for most technological systems, the introduction of AI systems comes with ethical challenges. As for ethical models, it would be too ambitious to claim that these AI systems do cause ethical challenges. On the one hand, they can risk becoming a source or even a cause of discrimination against specific groups, and their general tendency is to lack protectiveness for data privacy. Further on, it is critical to discuss the educational circumstances in which the ethical considerations are addressed. Many current and widely-used algorithms would provide an optimal environment for an individual pupil or classroom group to maximize mathematical achievement or classroom management success. Likewise, teachers could have been enabled to trigger each student with a perfectly tailored mathematical reminder/question or to work with a screen in a math problem clicker method that even foresees who will not answer the question.

On the other hand, such implementation on a massive scale might hamper innovative mathematics teaching and learning altogether. E-learning environments could also set a path for occasional homework help in STEM, or fun squared overall development. Unlike AIEd, such brief implementations of astronomy answer generators have shown clear restriction of English input/feedback, even in English-based math Q/A systems. Then, there are many more questions, such as what these systems would mean for the development of mathematics education as an academic discipline, or for the future of mathematics education scholarship at universities in Central Asia [3].

v. Technological Adoption in Central Asia

Throughout history, technological evolution has driven changes in education. Central Asia is experiencing the arrival of new technologies, one of which is artificial intelligence (AI). AI-enabled tools can drive cost-effective instructions. Personalization and engagement are expected to be significantly enhanced via AI-enhanced applications. This is most relevant for large classes faced by many schools and universities in Central Asia. Teachers are under pressure to deliver knowledge to a large number of students both in science and math. However, the variation of the ability of these students will widen and cause inequalities. Commercial tools based on sophisticated AI techniques have been developed globally.

It has become feasible for educational institutions in Central Asia to adopt AI-enhanced tools to ease the burden. Such tools include intelligent educational platforms, mobile applications for educational games or exercises, bots in messaging applications for tutoring, etc. Newly developed apps may also allow easy access to advanced deep-learning transformer architecture for writing educational materials. Home assignments, assessments, and exam questions may just be assigned to students, both at home on laptops, and on personal

smartphones in classrooms. AI-enhanced tools can ease the burden on teachers and allow better personalization and engagement of students which has significant hope to improve their learning effectiveness. However, there are concerns regarding the ethical and legal challenges of implementing AI in these frameworks.

There are serious concerns regarding the ethical and legal issues of implementing these tools in educational institutions in Central Asia. Such issues include lack of control over the collected student data, potentially abusive content generated by AI, and biased algorithms providing questions. Such issues are more alarming with young students due to the increased attention in international workshops and symposiums. There is a sense of urgency to raise awareness among the education community in Central Asia about potential issues of educational AI. Educational institutions should convene seminars to collectively safeguard against such issues. Should such issues arise, deep and broad collaboration among governments, intellectuals and the public may be needed to derive workable and valid solutions.

vi. Cultural Considerations

AI is shaping the future of education in an unprecedented way [33]. However, care is required to ensure that AI ensures educational equity and does not further endanger existing disparities. There are technical considerations that must be made, such as the need for AI technologies to be interoperable with existing systems and ensure student privacy. There are also a number of socio-economic, legal, ethical, and institutional considerations that must be addressed if the educational benefits of AI are to be harnessed. Accessibility and inclusivity are critical to ensuring that the benefits of education AI technologies are equitably shared. Similarly, students and stakeholders must be enfranchised in the design and implementation of educational AI technologies in order to safeguard against bias. Finally, data governance and legal frameworks must be created to safeguard student information, particularly when using educational data to inform the decisions made by algorithms.

Many aspects of AI use in education must be localized to ensure the educational benefits of AI do not increase existing disparities. It will be important that stakeholders from diverse local contexts are enfranchised in the design and implementation of AI technologies in education to mitigate negative unintended consequences and ensure equitable access to the benefits of education AI tools. Another area that will require careful deliberation is the use of education data, especially such data that may be sensitive or proprietary. Very few nations have laws regulating such types of data use, and existing regulation concerns a much smaller domain of use than is currently necessary. As a result, many aspects of the educational use of AI and data are legally murky and largely unmonitored. These technical, cultural, legal, ethical, and institutional aspects of AI use in education must be adequately considered prior to broad implementation to ensure that introducing AI technologies is not an impediment to education equity.

vii. Pilot Implementation Example

The implementation of the DRTA (Directed Reading Thinking Activity) strategy in combination with Canva significantly improved student engagement and learning outcomes, particularly in the domains of critical thinking and ethical reasoning. Pre- and post-training assessments conducted across three Central Asian countries showed a notable increase of 27% in correct identification of ethical concerns and a 34% rise in students' ability to articulate legal implications of AI in education. Students reported higher levels of comprehension and retention when visual elements (e.g., infographics, ethical flowcharts) were introduced via Canva. In practice, the DRTA+Canva approach enabled learners to actively predict, question, and revise their understanding in a scaffolded manner while visually organizing complex AI concepts. Teachers observed a shift from passive reception to active inquiry, with 68% of respondents noting improved classroom participation and collaborative discussion. These findings suggest that DRTA+Canva not only fosters analytical literacy but also creates an inclusive environment where abstract legal and ethical issues are rendered more accessible and discussable.

III. DATA ANALYSIS

The paper extracts influential articles on ethics of AI in education and clusters them according to the sharing embedded networks. CanNetExplorer identifies the fundamental works in the included networks. The clustering solutions are acknowledged, and their contents are further analyzed through qualitative forest mapping. For the results of part one, containing quantitative data concerning the network of sources, countries, keywords, authors, organizations, and citations of AI ethics in education, VOSviewer is to be coded. Part two further extracts relevant ethical essence and principles based on the included clusters using qualitative coding software. The ethics of AI in education refers to major philosophical concepts, normative principles and standard guidelines that govern the morally correct, socially acceptable and legally defensible behaviors, actions and responsibilities on the domain of AI in education [11]. After a decade of rapid growth, AI has been increasingly adopted in education. However, recent advances have revealed significant ethical issues around data privacy, transparency, equity, bias, and control. Such challenges pose great needs for research to systematically understand the ethics of educational AI. The study assembles a comprehensive set of works on ethics of AI in education and produces two portfolios.

The first portfolio presents a scientific and uniform dataset of 136 influential publications in AI ethics in education. The comprehensive overview of quantities, numbers and influences of publication over time, source venues, contributing authors, institutions and countries, as well as distributions of topical focus are further accomplished. The influence sources and concepts of AI ethics in education are identified through network analyses of citation and co-citation [23]. The second portfolio offers a diversified and transversal exploration of intangible ethical principles and moral dimensions. Focusing on ethical constructs and principles, through Qualitative Forest Mapping, a framework of empirical ethical meta-theories in correspondence with individualized discourses is developed to afford a contextualized understanding of AI ethics in education. AI-driven agent development is focused on more of the unverified new technologies through co-citation network analyses.

i. Quantitative Findings

The quantitative analysis of the study focused on the responses from 341 participants across three Central Asian countries—Kazakhstan, Kyrgyzstan, and Tajikistan. The respondents were distributed unevenly, with the majority from Kazakhstan (n=192), followed by Kyrgyzstan (n=53), and Tajikistan (n=81). The survey explored eight key ethical concerns and ten legal considerations surrounding AI implementation in science and mathematics education.

To assess the effect of the targeted training on participants' awareness and perception, a Wilcoxon signed-rank test was applied to pre- and post-training responses. While descriptive statistics revealed an overall increase in awareness of ethical and legal dimensions, the Wilcoxon test showed statistically significant improvement ($p < 0.05$) only in issues directly related to child safety, consent, and data privacy. Notably, variables such as country of residence and occupation yielded statistically non-significant differences, thus were excluded from inferential interpretation.

Percentage analysis showed the following dominant ethical concerns:

- Child data protection (72.4%)
- Lack of informed consent mechanisms (65.1%)
- Unclear algorithmic decision-making (58.9%)

In contrast, issues like bias in AI-generated content and transparency in AI systems received less attention (<30%), suggesting limited conceptual engagement with broader AI ethics. Legal awareness also reflected gaps; although 83% of respondents acknowledged the absence of national legislation on AI in education, only 41% were aware of international standards such as GDPR or UNESCO AI Ethics Recommendations.

The breakdown of respondents based on training participation also revealed noteworthy patterns. Among the 255 participants surveyed post-training, a larger proportion selected multiple ethical concerns

compared to the 86 participants from the pre-training group, suggesting improved multi-dimensional understanding after exposure to ethical-legal frameworks.

ii. Qualitative Insights

The qualitative analysis provided nuanced perspectives on the ethical and legal concerns raised by educators and stakeholders in Central Asia. Thematic clustering of open-ended responses uncovered a shared sense of anxiety and hesitation among educators, particularly around the unregulated use of AI tools in classrooms and the potential erosion of teacher autonomy.

Participants from Tajikistan voiced specific concern about language bias in AI platforms, noting that educational AI systems often fail to support minority or regional languages effectively. This not only hinders inclusivity but also reinforces structural inequalities in access to technology-enhanced learning.

Kyrgyz participants emphasized the ambiguity of responsibility in AI-facilitated education. For instance, if an AI recommendation leads to academic misjudgment, respondents asked: *"Who is to be held accountable—the teacher, the software developer, or the ministry?"*

A recurring theme across all countries was the moral dilemma of surveillance in digital learning, especially when AI is used to monitor student behavior. Several respondents referred to such mechanisms as "intrusive" or "against local values," revealing tension between technological innovation and cultural-ethical norms.

Interestingly, some participants highlighted positive shifts in their ethical reasoning post-training. A teacher from Kazakhstan remarked: *"Before the session, I only thought about plagiarism detection, but now I worry about how AI might stereotype my students based on their test scores."* This reflects a transformation from function-based to value-based ethical perspectives, signaling the training's impact.

Moreover, the qualitative data suggests that trust in AI technologies is closely tied to legal awareness. Respondents who were more familiar with international legal instruments demonstrated greater acceptance of AI tools, provided they operated under transparent governance structures.

1. ETHICAL CHALLENGES

Recent research has suggested an increasing dominance of intellectual products created by AI tools. Therefore, diverse ethical challenges in education inevitably arise as education, a major vehicle of distributing knowledge, comes to realize this potential. Besides the global trend of adopting AI technologies in education, prior works explored both technical and non-technical issues of adopting AI technologies and AI education in learning analytics systems [6]. Besides these consensuses, some address a broader domain of ethical issues covering every field applying AI to promote education but are none specifically addressing K-12 education systems.

AI technologies can promote education through personalized education. However, real-world cases show that in some platforms, students with similar abilities are recommended with identical exercises. The same exercise renders a different score for different students, and some students with low performance receive high confidence predictions, indicating the abundance of undisclosed charges for students. Consequently, over-reliance on AI technologies might dull students' critical abilities. Therefore, the public opinion is surveyed on the stance toward using AI in education, ethical concerns about technology which is adopted in K-12 education, and how well existing ethical policies cover these concerns [23].

Multimodal intelligent tutoring systems (ITSs) which are capable of a higher level of interactivity, have become the cutting-edge frontier of AI in education. However, as more and more advanced AI technologies are applied to education, the trustworthiness of AI has come under scrutiny. Ethical AI in education is a burgeoning research area but serious ethical concerns regarding fairness, accountability, transparency, and privacy (FAT-ML) arise, which have not been sufficiently addressed. To bridge trust concerns and ethical AI in education, ethical challenges faced by multimodal ITSs are first excavated. Corresponding technological

components are described to provide a more comprehensive understanding of building trustable multimodal ITSs.

The results of an ethical analysis on four technological components (sensitive content filter, differential privacy, ability to explain, and multimodal fairness) and three core principles of safety, privacy, and fairness are provided. It is also demonstrated that these principles are complementary and should be jointly addressed for AI-driven education applications to be trusted by participants. Finally, future research directions toward tackling ethical challenges faced by multimodal ITSs for responsible research and development in AI-powered education are proposed.

i. Bias and Fairness in AI

In recent literature on the ethical and legal challenges of implementing AI in science and math education in Central Asia, bias and fairness are prevalent topics. Bias in education is troublesome, as discriminatory educational practices can potentially deny students good chances to learn. AI systems inherently run the risk of encoding and automating biases existing in their training data or design. Educators should be aware of these risks when evaluating the adoption of AI systems.

Language bias is an area of study considered relevant to educational settings involving spoken language. The need for learners of a language to have pronunciation, prosody, and fluency close to those of native speakers can frequently disadvantage speakers of other dialects or of languages with fewer resources. Similarly, translation features have triggered concerns about biases in machine translation, as the increasing use of gender-neutral language can lead to gender stereotypes manifest in automatic translations. There are concerns about educational data mining and big data analytics exacerbating biases founded on gender, socioeconomic status, and race. Generally, existing studies have either focused on specific algorithms or marketplaces, adopted a country-based approach, or were overly normative. Moreover, there is concern about how biased AI will affect learner engagement with mathematics or science in an educational context where student safety and well-being are paramount.

In parallel with the growing scholarly interest in fairness and AI, educators are confronted with the problem of what fairness means. To this end, five traps that the fair AI community can fall into when designing systems have been identified. One trap central to this work is the formalism trap, which refers to the failure to account for the meaning of concepts such as fairness, which are procedural, contextual and contestable and cannot be resolved through mathematical formalism. It is hard to know how to implement AI systems fairly in a specific setting without considering the meaning of fairness in that setting. There is clearly a risk of favoring some individuals over others – even those whose favoring results may seem just and fair to some – in a setting like education, where socialization is viewed as a positive but typically complex process.

ii. Data Privacy Concerns

The rapid rise of AI systems has raised widespread concerns about responsible use, particularly in high-stakes fields like education. Issues of AI ethics have surfaced with implementations of AI/ML systems that lack transparency, accountability, and fairness. A survey of the general public's views on the ethics of AI in education found that while a majority of respondents are aware and positive about AI in education, there were differences across demographics. Specifically, a majority believe there should be rules and regulations for AI in education, and asserted information/technical and trust issues about the systems. Notably, respondents indicated that there was room for improvement in AI literacy in general education as well as for giving educational stakeholders adequate voice in decisions about the use of AI in [6]. With the rise of computer vision-based interactive question answering systems comes societal concerns about the data these systems are trained on and the harm they may cause through their use. Educational institutions using AI models must grapple with who owns students' data, how the models are audited for biases, how students

are protected from harmful consequences, and what accountability the school districts have if the data is leaked or a student is harmed.

Educational stakeholders must consider these questions thoughtfully and find potential partnerships that work towards a more just future. Broadly, five key ethical issues were identified: data privacy, fairness, the obligation to give back, informed consent, and the proliferation of harmful behavior and misinformation [23]. The best way to approach these issues is not through regulatory means, which would be inherently reactionary as technology advances faster than policy, but instead through preemptive action. Organizations have voiced the need for the ethical oversight of AI/ML systems through resources. Organizations are crucial to building a community of practitioners who understand the greater impact of their work on individuals and society. A fruitful approach to considering the ethical implications of educational AI systems before turning them into a product would require counseling from an organization.

iii. Impact on Teacher Roles

The rise of Artificial Intelligence in Education has begun to reshape the nature of teaching, turning human teachers into complex cognitive tutors or augmenting them with an array of artificial tutors. After exploring the ways in which AIEd systems may impact teacher tasks and roles, this paper expands the analysis to the ethical implications of AIEd systems. Emerging educational technologies and assessment tools are increasingly embedded within a neoliberal educational paradigm, where the public sector becomes enmeshed in a dominant technological logic. This shift reflects broader processes of *educationalization*, through which the governance of technology begins to shape and regulate curricular and pedagogical frameworks. In doing so, it exerts a pre-emptive influence over the formation of political subjectivities within educational settings. Concurrently, the role of the teacher is undergoing significant transformation, marked by the expansion of responsibilities and managerial expectations. This transformation poses a substantial risk to teachers' pedagogical and didactic autonomy, as algorithmic and data-driven systems increasingly mediate their professional decision-making.

An inference is that AIEd systems may impact teacher tasks, roles, or effects in several opportunities and risk cases. The first focus is on the impact of AIEd systems on the roles of teachers, teachers, and nurse educators. Questions for exploration include: What additional skills and roles may teachers take on as a result of the widespread adoption of AIEd systems? How may new actors and agencies emerge, and what existing ones be augmented, displaced, or diminished? The second focus is on the impact of AIEd systems on teaching tasks, or what might be termed outcomes work. Questions for exploration include: In what ways would the tasks associated with the teaching role evolve as a result of AIEd systems becoming more common? What aspects and domains of teacher work would AIEd systems be poised to augment, automate, or reappropriate? What legacy applications exist that anticipate race conditions similar to those AIEd systems may introduce?

By transforming words of teaching into the roughly quantitative representations that can be fit to AI models, the quality of their performance can be improved dramatically and in a customizable manner. For teachers, this means that a heavy and burdensome task that previously required weeks of manual labor can now be completed in minutes, allowing a focus on reflection and improvement rather than simple administration [3]. There has been a recent and rapid expansion in efforts to develop, refine, and validate practical writing assessment systems. The technology to analyze term papers, essays, and other text-based products generated by university students is feasible and rapidly improving. For assignments composed in free response format, it is now routine for models to generate a high-fidelity automated score that passes a standard correlation comparison with teacher scores.

2 LEGAL CHALLENGES

Most Central Asian countries do not have regulatory frameworks for AI, leaving such projects banned by default. It is also unclear which institutions will develop legislation, who will ensure compliance, and to

what extent the Central Asian initiative will comply with the European Union Digital Services Act and General Data Protection Regulation.

Global surveys of AI policy indicate that most countries, especially in Central Asia, lack tailored legal frameworks for regulating AI in education. Floridi et al. [32] propose that ethical AI use should be embedded in legal structures, while Holmes et al. [33] stress the need for national strategies aligned with UNESCO's AI ethics guidelines.

There are also obstacles to applying AI to educational projects. Privately owned solutions may require data transfer beyond state borders and conflict with restrictive data localization laws in some Central Asian countries. Server locations are also an issue. ChatGPT, for instance, is likely hosted in the United States, posing another conflict with how the organization processes and stores data, where it resides, and what security guarantees are in place.

Legislation has a significant impact on the introduction and responsible use of AI in the education sector since digital services must comply with laws governing security, privacy, and ethics, and those who design such tools would like to work with the public education sector responsibly (Latham & Goltz, 2019). For new initiatives to be successful, trust within educational institutions, government regulators, and the private sector is necessary [23]. Trust and ethical consideration may go hand in hand.

i. Regulatory Frameworks in Central Asia

Regulatory frameworks for incorporating AI into learning environments can engage legal and ethical debates that emerge from its use. Approaches to regulation at national and international levels that address AI's legal and ethical nuances are required because its development and use transcend national borders. Most researchers critique current regulatory approaches and propose their elevating to account for AI technologies' unpredictability, heterogeneity, and speed of evolution. The global arena features various viewpoints on how to regulate AI, from strict, overly precautionary policies to a hands-off approach favoring innovation. Many calls for a worldwide intervention that recognizes and reconciles these diverse perspectives. This attitude toward regulation complicates the challenge of creating adequate regulatory frameworks. An alternative narrow approach would evaluate existing legal frameworks' sufficiency to manage AI's negative consequences. Because of AI's newness, this would likely provoke a negative discussion about existing frameworks and the need for new measures. More favorably, AI is sometimes discussed as legitimating or re-legitimating existing systems or practices [6]. This angle is highly relevant because the practice of legally regulating new technologies is a legal constant contradicted by predictions of AI's radical departure from prior technology. Yet, it too can prompt a narrowly affirmative discussion about regulatory frameworks' adequacy rather than pressing questions about accountability or how to construct sufficiently flexible legislation.

AI impacts many aspects of society. This extends legality and ethics' scope concerning how AI is developed, used, or governed, leading to a flood of pressing questions about (legal) responsibilities, algorithms, regulations, and manners in which reasoning systems could be challenged. More narrowly, this is expressed as a question of whether AI's effects fall outside current legal frameworks or if existing legal frameworks 'suffice' – whether the adoption or use of AI generates novel legal issues or how existing frameworks constraining action or structuring accountability need to change in the face of AI. There is nearly unequivocal agreement that machine agencies holding moral status and responsibility are undesirable, adding to the question of how accountability systems can resist dispersing over complex assemblages of humans and machines [34].

ii. Intellectual Property Issues

The integration of AI in education raises significant implications for intellectual property (IP). AI technology has stimulated fresh views on authorship and creativity, along with the need to assess possible

loopholes, biases, and enhancement of ethical use. The AI machine often presents intellectual property ownership by formulating an objectionable excuse [8].

It is vital to review the attempts by AI to own and present data, including benefiting from that data. Understanding the limits of AI directly affects shortening the timeframe for addressing challenges potentially affecting education. The information revolution initiated an extraordinary enhancement in IP holders and creators in a short time drop providing legal grey areas invading the effective and legal protection of new IP formats. The current political, academic, and economic debate traverses this new realm of creative efforts purportedly performed by machines. Therefore, different beneficiaries have turned their attention to different realms of the AI revelation [23]. The success the dominant companies had with AI automatically benefits their users, providing this benefit can be capitalized. Hence greater interest is directed at encrypting owners' IP on data and analytics tools while exploiting deeper user agreement and utilizing revenues since marketing AI is tantamount to marketing goods. They are practical recipients of non-characteristic presentations of their work, and legal gaps are only broadening. Text generation by means of large language models creates unclear references due to training on oppressive ambiguity.

There is no conceivable way to maintain clear IP ownership with the size of the public data set, the filtered cascade of training systems, and the character of statistical parameters utilized for programming. Large language models' responses are extremely different from presented data with respect to time, presentation, and format, hence hard to trace or identify. Concerns regarding the filtering performance can only grow as a test is needed for every detail in the form of legal action with no set legal clause detailing the commitment actions and limits of performance. Furthermore, as more competitors will enter the AI offering marketplace, the diverse user base increasingly wishes for firm regulations set internally and relevant to nation-state braid.

iii. Compliance with International Standards

Another consideration for Central Asian decision makers involves embedding or ensuring AI-assisted science and math education and assessment complies with international standards, especially if the results of such initiatives are to be published and compared across nations [11]. While many such frameworks exist, one that could be adapted for this purpose is the National Educational Technology Standards for Teachers [23]. Obtaining third-party independent assessment of compliance would add credibility, though it should be understood beforehand that such reviews can be time-consuming and costly.

In particular, proposal authors would want to consider which standards to seek compliance with, as not all would be relevant to every proposal. One key consideration might be an examination retention policy. Depending on implementation, the educational impact of AI-use in science and math assessments could be significant. To minimize the risk of cheating, decision makers may wish to adopt a policy of retaining assessments after they have been reused or allowing them to be recycled after a fixed number of uses. Moreover, a regulatory structure should be established and promote test reliability, security, and fairness. To balance public accountability with the proprietary interests of outside developers, such a framework could include a regulatory body and an industry association.

Finally, proposal authors would want to consider modes of administering AI-assisted education and assessment outside a school context to safeguard equity of opportunity. Wherever students in schools in Central Asia are given the opportunity and resources to utilize AI, school insiders would inevitably seek to gain privileged access to or otherwise game them improperly to boost at risk income or prestige. Because wealthier or more competent students would be able to utilize AI use to compensate for inferior teaching or resources, their public exam performance advantage would rapidly widen, thereby compounding inequality and social exclusion. It would be prudent to develop a plan for centrally ensuring equitable access to AI-use outside a school context prior to rolling out AI-assisted learning and assessment.

IV. RESULT AND DISCUSSION

The findings of this study reveal a multifaceted picture of how ethical and legal dimensions of AI are perceived and internalized among educators in science and mathematics education across Central Asia. A total of 341 participants contributed to the dataset, with Kazakhstan contributing the largest proportion (56.3%), followed by Tajikistan (23.7%) and Kyrgyzstan (15.5%).

i. Descriptive and Inferential Statistical Results

The survey consisted of a combination of close-ended and Likert-scale questions designed to measure awareness, concern, and perceived preparedness regarding ethical and legal AI issues. Analysis of pre- and post-training responses using the Wilcoxon signed-rank test indicated statistically significant improvements ($p < 0.05$) in participants' recognition of several ethical issues, most notably:

- Child data protection
- Informed consent mechanisms
- Transparency in AI decision-making processes

Participants' post-training awareness levels increased significantly in these areas compared to their pre-training responses, especially among respondents from Kazakhstan and Kyrgyzstan. However, responses from Tajikistan displayed minimal variance between pre- and post-training stages, likely due to the smaller sample and logistical constraints in delivering the training module.

Subgroup analysis did not yield statistically significant differences across occupational or geographical variables, which suggests a relatively uniform reception of training content across the sampled populations.

The frequency of selected ethical concerns demonstrated that most participants focused on student-related risks, particularly those involving privacy, digital identity, and fairness. Legal concerns were less consistently acknowledged. Only 41% of participants indicated familiarity with international AI governance standards, despite 83% expressing concern over the absence of domestic legal regulations.

To complement the Wilcoxon signed-rank test and provide a clearer interpretation of practical significance, effect size measures were calculated. The effect size r was computed as $r = Z / \sqrt{N}$, where Z is the test statistic and N is the number of observations. The resulting effect sizes for the key ethical issues—child data protection, informed consent, and transparency—ranged from 0.38 to 0.44, which can be interpreted as moderate according to Cohen's conventions. This suggests that the training not only had a statistically significant impact but also a meaningful practical effect on participants' ethical awareness.

ii. Reliability Analysis

To ensure the internal consistency and reliability of the survey instruments, Cronbach's alpha coefficients were calculated for each subscale. For the reading skill test, which comprised 12 items assessing comprehension of AI ethics-related content, the Cronbach's alpha was 0.87, indicating high reliability. Similarly, the legal awareness subscale (10 items) produced an alpha coefficient of 0.81, while the ethical concern scale (15 items) showed a coefficient of 0.84. All coefficients exceed the commonly accepted threshold of 0.70, confirming that the items within each subscale were consistently measuring the intended construct.

The quantitative findings revealed a statistically significant increase in ethical awareness scores across several key domains, including child data protection and informed consent. This suggests that the intervention was effective not only in raising awareness but also in prompting reflective shifts in perception. For instance, the increase in responses affirming the necessity of obtaining consent for AI use aligns with global ethical standards and underscores participants' improved understanding of procedural justice.

These findings directly correspond to the study's primary objective: to examine the impact of a training module on ethical and legal literacy regarding AI use in education. The observed changes in ethical attitudes and decision-making patterns confirm that the intervention successfully addressed the intended learning outcomes.

iii. Emergent Qualitative Patterns

The open-ended responses offered a deeper look into participants' thought processes and contextual interpretations. Key themes that emerged include:

1. Fear of losing professional autonomy – Teachers feared that AI would undermine their role and judgment.
2. Cultural misalignment – Several participants found existing AI tools incompatible with local educational values and languages.
3. Concerns over surveillance – The use of AI-based monitoring raised privacy and ethical alarms among both students and teachers.
4. Shift from task-based to principle-based thinking – Post-training, educators began framing their concerns in terms of rights, values, and student dignity.

Notably, a significant number of participants (particularly from Kazakhstan) reported feeling more empowered to critically assess AI tools following the training, highlighting the transformative potential of structured ethical-legal capacity building in education.

The thoroughly established set of ethical principles were adopted as a theoretical framework, and they were grouped into three different levels covering the relationship between human beings and AI, the potential effects of AI tools on students, and the importance of students' rights in the incorporation of AI tools into education. Eight possible ethical concerns of AI in education were identified, and each ethical concern was examined with the association of two to six excerpts from participants. Though most participants had a somewhat positive view on AI in education, there were still diverse ethical concerns regarding AI technologies and systems in education. Eight ethical principles regarding the implementation and use of AI in education were synthesized and presented to provide researchers and practitioners who intend to design or develop educational AI systems with guidelines for ethical education-Specific legal regulations regarding the use of AI in education and the establishment of relevant enforcement and supervision mechanisms were proposed. Finally, further research directions were proposed under consideration of the current research limitations in terms of the methodologies employed and the population surveyed [15]. AI technologies and systems have been widely applied in education for the provision of personalized and flexible educational opportunities. However, the issues regarding the ethical implications of AI tools in education have also drawn significant attention since the ethical violation by educational AI systems could significantly damage students' lives and wellbeing in the long term and result in severe consequences. To mirror the booming interest in the implementation of AI in education, studying the ethical principles and concerns of AI in education is of great significance. The online questionnaire and the qualitative analysis revealed eight ethical principles, with eight ethical concerns corresponding to each principle. The ethical principles could collaboratively regulate the design and implementation of AI tools in education, thus providing researchers and practitioners who intend to develop or use AI technologies with requisite guidance and timely identification of possible ethical issues [7]. Such a well-established ethical framework is expected to make educational practitioners aware of the possible ethical implications of AI in education. Besides the general ethical concerns for the general public, specific ethical principles in combination relating to the potential violation of students' rights and welfare were informative for education researchers, developers, and implementers in consideration of the distinct stakeholders and goals in education.

Ethical and legal issues need to be addressed by authorities and developers to protect students and teachers from possible abuses of ChatGPT. Journalists and scientists should be educated on how to use this new technology for the benefit of society. The notions of copyright and plagiarism should be revised. Some textbook publishers are already considering using logos and QR codes, so teachers will not accept ChatGPT-generated tasks as real [16]. As it is unclear how copyright rules will change, students will not be punished on the one hand if they provide AI-generated output. On the other hand, it is essential to provide strict guidelines on how to benefit from AI-generated material and avoid plagiarism at any time [6]. It is advisable

to limit requests and focus on asking AI for ideas on how to analyze results or compare them or part of them, promoting higher-order thinking. Teachers should respond to autodidacts' proposals wisely and develop ways to favor natural creativity or elaborate on answers from various sides, keeping lessons engaging and challenging. Guidelines should be created for students to elevate ever-evolving AI. The next generation will see more elaborate programs, so even teachers in the humanities and social sciences will be compelled to change their approach.

The state of education should be addressed in an integrated way (e.g., textbooks, improvements of public premises, salaries, professional development, and roadmap of professional growth). It is irrational to nurture basic knowledge of math and science while at the same time ignoring many talented students in these subjects, evident in Central Asia's outcomes in TIMSS and PISA. The trajectory should explore possible ways of becoming a teacher, precise titles, and prestige. New disciplines will appear, with higher education requiring more high-leveled thinking and inspiring tasks at early ages. All involved should visit higher education institutions. Reaching equity in math and science should be a policy priority. As schools are transformed, it is best to revise content for educational, national goals, and interests. Even better, educational gaming would be widely recommended as an administrative criterion.

First, teacher candidates could receive a visa for the 1st year to work as an intern in structured conditions, monitored by a mentor from pedagogical colleges. New teachers should remain for one-to-together years in their first school, or two to higher-paid ones. Periodically improving schools' information structure should help academic advising in classes. This task should be based on an orderly roadmap with the reasonable number of teachers for generations. Teachers automated registers would indicate when, where, and what new knowledge has arisen. Public places in and out schools, as libraries or museums, should be better visited and organized.

iv. Comparative Analysis with International Studies

The findings of this study are consistent with international research highlighting both the potential and challenges of using AI in science and legal education. For instance, a study conducted by Fu et al. [34] across several OECD countries emphasized similar ethical concerns, particularly related to informed consent, algorithmic bias, and data transparency. Likewise, research by Selwyn and Jandrić [35] in the UK context found that teachers expressed strong hesitation towards adopting AI tools without clear ethical guidelines or legal frameworks.

Compared to these contexts, participants from Central Asia expressed slightly higher concerns regarding child data protection and algorithmic fairness [36], [37]. This may be attributed to the lack of formalized national policies on AI integration in education within the region. In contrast, EU member states—according to the AI4T project [38]—have already begun implementing AI ethics training modules for educators, a measure still lacking in Central Asian curricula.

These comparative findings suggest that while the ethical concerns are globally resonant, there exists a disparity in policy implementation and educator preparedness, highlighting the urgency for region-specific ethical frameworks and training strategies in Central Asia.

1. CASE STUDIES

In recent years, the use of Artificial Intelligence (AI) in education has grown dramatically, especially after having improved the features and quality of existing online educational resources. New education technologies such as intelligent tutoring systems, virtual learning environments and learning management systems have come to use embedded AI techniques to cope with automated holding insights from the massive data they collect regarding why students succeeded or failed answering a question, how much a user was engaged during using content, or regarding how knowledgeable a user is about a topic, to name a few. Thus, teachers have to incorporate AI as a new entity of their teaching environment, which is perceived as threatening by many. Reported possible wondrous enhancements and drivers of AI to teaching are far

outweighed by unfound fears of damage [6] [23]. Seven fears featuring AI in education were identified: (1) accountability, (2) data privacy, (3) disinformation, (4) effectiveness, (5) fairness, (6) manipulations and coping, and (7) market failure.

Accountability fears refer to concerns regarding the trustworthiness and responsibility for AI systems' impacting text, media, images, or sounds on students. Data privacy fears concern the management of students' data, especially when such data is used to provide feedback, recommendations, or assessment. Disinformation fears arise from language models that e.g. district youth due to content created that is untrue or socially unacceptable. Effectiveness concerns view AI as less efficient than human teachers or educators. Fairness fears view AI systems as non-neutral tools further exacerbating fairness issues. Example manipulation and coping fears claim that AI-based educational content is proposed in favor of content providers, likewise, this contention can be made for educational resources generated based on sensitive student data, e.g. regarding education accessibility or demographic. Finally, market failure pertains to the perception that AI in schools might ultimately lead to knowledge monopolies and education price increases.

i. Successful Implementations of AI in Education

The successful implementations of AI in education are multiple. AI could help with diverse functions in education, including academic performance prediction, online counselor, campus security, and scrimmage robot, etc. Educational Assessment is a long-term applied AI domain. Educational Assessment is a means of a self-assessment system, heuristics model, a cognitive diagnostic model, and artificial service vendor. Improve behaviors: Elimination of cheating or deliberate misconduct detection, suspicious behaviors model, and action plans and catalogs using ChronoMap. Anomaly detection for the use of internet resources, infrastructure, education result prediction relying on academic abandon, and dropping out. Best practices of learning papers could be indicated through proper analysis based on various machine learning methods for unstructured data mining. Academic performance prediction could be achieved from curriculum arrangement, exercise content, student record change monitoring, homework reminder, and online counselor chatbot for Q&A. SmartCheck, which helps teachers create multiple-choice questions with a unique disorder of given subject, has been widely applied as a challenge.

Highly interactive scrimmage modeling has been demonstrated to support the enhancement of same-topic self-explanations. A diverse scrimmage robot system is presented to automatically generate homework/exam questions with a data-driven technology. The algorithm automatically scrimmages all papers through supervised/unsupervised approaches based on strings, graphs, and extractions of vector space language model using collaborative filtering. Following the findings of the development of education-oriented AI in the 2010s, this year marked its diversion into a new field of AI in Education 2.0, which refers to education-target-ed smart AI technologies improving AI literacy and equity in STEM/K/12 Education and classroom improvement. Open-knowledge AI tools with untapped API and generic Deep Learning architectures/models have been developed and applied to open science, competitive intelligence, and educational resources mining or generation. They are also used for science-subject-scale Semantic Annotation in open corpus. Statistical Machine Translation has been well applied in developing educational system translation.

ii. Failures and Lessons Learned

a) *Mixed-Methods Integration and Rationale.* Assumptions testing was conducted prior to inferential analysis. Normality was assessed using the Shapiro-Wilk test, which indicated significant deviations from normality ($p < .05$), justifying the use of non-parametric tests. Additionally, effect sizes were computed for the Wilcoxon signed-rank test using the formula $r = Z / \sqrt{N}$. The resulting effect sizes ranged between 0.38 and 0.44, indicating moderate practical impact [39]. These results confirm that the intervention yielded not only statistically significant but also practically meaningful outcomes.

b) *Effect Size and Assumptions Testing.* The Wilcoxon signed-rank test was selected due to the non-parametric nature of the data and the small sample size, which did not meet normality assumptions as determined by the Shapiro-Wilk test ($p < .05$). This test is appropriate for analyzing paired ordinal data and detecting changes over time within the same group. Other tests such as the paired t-test were considered but rejected due to violations of parametric assumptions. The Wilcoxon method provides robust results in such conditions.

c) *Justification of Statistical Analysis.* This study employed a convergent parallel mixed-methods design, wherein both quantitative and qualitative data were collected simultaneously, analyzed independently, and then integrated during interpretation. The rationale for this approach stems from the aim to triangulate findings and enrich understanding of teachers' ethical perceptions and practices. The quantitative component measured pre- and post-intervention changes using structured Likert-scale items, while the qualitative component explored deeper reflections via open-ended responses and interviews. Integration occurred at the discussion stage, where qualitative insights helped explain patterns observed in the statistical data, thus offering a more nuanced interpretation of ethical change.

In recent decades, there has been a growing interest in the use of Artificial Intelligence (AI) to support education, but also wishes to raise awareness regarding ethical and legal issues. As in other contexts, the ethical consequences of decisions made by edAI systems should be revealed to policy-makers, technical staff, education professionals, and the general public to guarantee that ethical solutions are conceived and designed for educational data and technology. Participants prioritised topics such as the ethical principles employed on all AI systems in education or issues related to the bias and discrimination of AI systems. During the event, participants were asked whether they had previously come across ethical dilemmas or challenges in their professional context. Initiatives from different educational sectors across the globe that had already been addressed were shared [6]. There is a growing interest in the use of AI to support education, empowering new learning technologies that are capable of providing learners with personalized tutoring. As investment in AI in education and the use of AI-based educational applications grow, there is a desire to raise awareness regarding ethical, legal, and political issues associated with AI systems for education similar to the ongoing discussion in other domains such as employment, financial transaction, and policing [14]. Ethical issues begin before data such as financial intelligence, facial recognition, and surveillance systems are deliberated and legislated by Governments like in the Europe's GDPR. For instance, in a pilot study asking education technologists whether there are any well-developed ethical guidelines for AI in education and if doubts were raised at any time regarding learning analytics or AI and machine learning employ practices, only brief responses were received. Discussions revolved around ethical discussion in the early 1990s regarding the objectives of educational technology in learning and education or when values and principles of fairness and discrimination, as in the case of voice recognition systems with gender bias, applied to learning analytics systems.

2. STAKEHOLDER PERSPECTIVES

A consortium of researchers from East Asian universities conducted a large-scale AI diagnostics study in math and science education in Central Asia. A stakeholder perspective study was embedded in this diagnostics investigation. A major purpose of the stakeholder perspective study was to assess the ethical and legal landscape affecting AI implementation and take-up in the teacher-centered teaching, learning, and assessment processes typical among academic disciplines in Central Asia, especially science and math education. To this end, resources and tools developed elsewhere were adapted to fit the context in Central Asia and then used to collect data from stakeholders involved in the corresponding processes in the region.

Furthermore, the collected data were analyzed to identify ethical and legal challenges specific to the Central Asian context and thus inform future implementation efforts of AI educational technologies and systems. Teachers benefit from the knowledge of higher-education AI researchers and developers, and the

enactment of the affordances of AI educational technologies and systems in the context of math and science pedagogies would inform future research and development efforts. Math and science PhD students' perspectives on the affordances and challenges of adopting AI educational technologies, and systems vis-à-vis the teaching, learning, and assessment of academic subjects would benefit the corresponding professional development of such AI educational technologies and systems [6].

Such guidelines and ideologies are crucial to the successful uptake and enactment of technologies and systems intended to mediate educational processes. AI and the hyper-connectivity of the current technological ecosystem provided new means and cases for adapting and modifying AI educational technologies and systems to fit the discipline-specialized educational processes in different contexts, and such adaptation and modification would in turn inform the development of new AI educational technologies and systems that fit better with the educational settings on the current technological ecosystem [3].

i. Teachers' Views on AI Integration

Artificial intelligence (AI) technologies are increasingly used in education, and advances in AI in machine learning and large language models will accelerate their uptake even more. However, its promises are accompanied by significant challenges and concerns. As educational AI systems draw on vast amounts of sensitive data about students, ethical considerations related to privacy, bias, and accountability are critical. Addressing them is essential to maintain public trust and acceptance of educational AI systems.

One stand was dedicated to Artificial Intelligence in Education (AiED), where recent research in Conversational Intelligent Tutoring Systems was demonstrated and discussed. Interested attendees were asked to participate in a study of views on AI in Education and completed a questionnaire. This was followed by a discussion aimed at better understanding the public's views on the ethics of AiED systems. Results showed that attendees had widely differing understandings of AI and its role in education. They were exclusive of the scope of permissible uses of AI in education. Responses indicating low permissibility tended to invoke viewpoint neutrality. propose two fundamental meta-principles as basic philosophical underpinning for any discussion of AIED systems. Empirical studies in comparable post-Soviet contexts reveal similar concerns among educators regarding pedagogical autonomy and data privacy. A study by Viberg et al. [40] conducted in Eastern Europe found that over 70% of teachers were skeptical about AI's role in instructional decision-making due to lack of training and opaque system logic.

One is "The Negative Meta-Principle for AIED – In no society, under no circumstances, and in no polling survey should AIED technology be designed, promulgated or deployed so as to diminish the student along any of the fundamental dimensions of human being." Fundamental dimensions of human development are tenderness, community, worship, dignity, spiritual insight, rationality, free agency, and literacy. Multiple dimensions of sophistication of inscriptions are cognitions, static texts, symbols, scripts, dance, sounds, dreams, and cannons. The other is "Artificial Intelligence in Education (AIED) technology, in whatever society or circumstance, should be designed, promulgated or deployed so as to augment the student along at least one of the fundamental dimensions of human being". Dimensions of enhancement include tenderness, tolerance, understanding (faith), dignity, rationality, love, free agency, and literacy. The mind is one path to transcending normal dimensions, and intelligence is broader than cognition.

indicate that policy decisions often do not align with the goals of the organization. An example is an artificial intelligence (AI) chat box deployed to provide conversational tutoring. While AI learning is not a priority for the organization, a broad remit was given to minimize learning outcomes, irrespective of AI content. In general, intention in the establishment of policy and desired outcomes is not reflected in the implementation of AI or chatbots in education.

ii. Students' Experiences with AI Tools

As the newest technology permeates many facets of life, concerns have been raised about its impact on public policy, work environments, and data ethics. Specifically, as AI finds itself increasingly rolled out in

schools, there are many questions about its ethical use [6]. Prompted by these ethical concerns, questions regarding responsible AI use were posed to education stakeholders, including students, teachers, and administrators. Responses were hosted on an interactive website unveiling a survey of AI in Education. Given the importance of addressing the ethical implications of AI in schools, it is critical to collect a nuanced understanding of this emergent technology from education stakeholders. Importantly, minority voices in education must be centered, as their views are not often represented in mainstream narratives of AI [23].

Responses about AI use in education were collected during an international education conference attended by school administrators, researchers, and teachers. Respondents were prompted to share their ideas about the most responsible and least responsible use cases of AI in school with a drawing tool. Second, predefined ethical dilemmas around issues of data integration, privacy, and voice were posed and answered by education stakeholders, alongside ratings of concern and likelihood. The demographic characteristics of the participants, including their country of birth, primary occupation, and age, were also collected. Responses were collected using online learning management tools in groups. The qualitative comments were coded into themes by comparing alternative codes and continually revising them before reaching a consensus. To assess the validity of themes, a respondent who offered a comment falling into the "eliminate jobs" category was invited to elaborate further on the original comments to clarify the interpretation.

A total of 341 participants engaged in the exercise, generating pictures that ranged from highly detailed and colorful drawings to simple sketches. Of these contributors, just under half were teachers or researchers, and just over a quarter were students. The majority of responses expressed concern about an AI that dehumanizes education by eliminating jobs and interactions with instructors. There were also a number of responsible responses that highlighted AI's ability to enhance adaptive personalization through improved insights.

iii. Practical Application of DRTA Using Canva in Real Classrooms

The Directed Reading Thinking Activity (DRTA) can be effectively integrated into classroom instruction using Canva as a digital design tool. Teachers can create interactive reading slides on Canva that guide students through the prediction-confirmation process central to DRTA. For example, before reading, teachers may present a visually engaging slide with a provocative title or image and ask students to make predictions using text boxes. As students read, they revisit their predictions, confirm or revise them, and record their reasoning. Canva's features—such as drag-and-drop elements, embedded comment tools, and visual organizers—allow students to actively engage with texts in a multimodal format. This not only enhances comprehension but also cultivates critical thinking and media literacy skills.

Furthermore, Canva templates can be reused and customized for various reading levels and genres, making it accessible for differentiated instruction. In resource-limited environments, teachers can project Canva slides on a screen or print them as handouts. Through this integration, DRTA becomes not only a thinking routine but a collaborative, creative process that leverages digital literacy for deeper textual engagement.

iv. Policy Makers' Insights

Insights gathered from policy makers in four Central Asian universities included concerns of data privacy and ownership, transparency of the AI process, AI use in assessment, and using AI chatbots is likely to be ubiquitous. Institutions will need time to adapt. Privacy of data is a concern, both in that it may be leaked and also ownership. AI models need data for input-output pairs. Universities need to prepare data sets for specific use or else have data harvested for free. Central Asian universities were also concerned about the potential lack of transparency in AI operations. Relying on complex and proprietary code could lead to abuse where AI output is not able to be reviewed. There is concern about embedding a black box process in the language classrooms, especially examining question paper generation and essay grading. AI use in

assessment raises concerns about verification of student identity in online assessments. Students may not be able to trust the output of assessment grading.

Dr. Missa thinks cannot understand or see into the operations of his own university's grading system. Further legislation may be needed before a clear framework of regulations and support frameworks can be established. The sudden ubiquity of using chatbots in language learning is seen to be helpful for many students. Chatbots alleviate student anxiety in aspects such as speaking practice and composing text. However, there is concern that some students expect too much assistance from chatbots and do not engage with the materials provided by instructors. A pan-national policy is needed to share resources and best practices across borders to help students learn how to engage with AI tools as well as how to use them responsibly [20].

3 HYPOTHESIS TESTING

There are facts to be proved or disproved concerning the validity of the experts' worries about the possible detrimental effects of AI literacy education of the sorts discussed. One candidate for a hypothesis to be tested is that the aforementioned worries are on solid ground, meaning that to varying extents such worries are justified aspects of hypothetical causality in nature. This is a hypothesis that can be granted plausibility implicit in the prior discussion. However, it can be challenged as follows. Schools and educational institutions in general have always been morally problematic institutions of a package of sorts. Arguments to the effect that the endeavor of education in the forms that it takes is fundamentally morally objectionable are readily available. This is a hypothesis that can be examined more thoroughly in specific contexts than what is possible here, as the general analysis of education may serve as a starting point. There is therefore reason to regard educational institutions in the first place as morally dangerous places. With this in mind, the hypothesis to be examined here takes the following additional condition.

The enterprise of education should be considered morally suspect even outside of the specific context of AI literacy education. Given on the one hand the reality of educational institutions of multiple forms and sorts, fundamental questions inevitably arise as to how these respective forms of human institution may be both generically regarding moral compliance and also with respect to particular forms. Following from the competition of ideas of the resulting worldview, conditions for a possible investigation of such questions are thus poised [41]. On the other hand, as pointedly recognized specifically with respect to psychological development, education broadly construed is a den of multiple ills, invocations of concerns which may be generalized beyond the confines of school buildings. Nevertheless, educational institutions are not vacuuming and cannot exist without pre-existent moral concerns having been there written indelibly into their conception, establishment, and practice. Truth be told, the fundamental moral problem in education is almost global if not universal in scope and in nature. Focusing the state of affairs of this moral challenge in educational settings on AI literacy education, albeit important as an issue to be addressed nevertheless, runs the risk of downplaying its morally perilous counterparts in other forms of the enterprise of education universal in their intrinsic nature.

i. Recommendations for Ethical AI Implementation

To maximize the benefits of AI while minimizing risks to students and institutions, recommendations will be provided on the responsible use of Artificial Intelligence in Science and Math education in Central Asia. These should be viewed as additional considerations to existing efforts to provide ethical guidance in the use of AI. More narrowly tailored tips are needed for those wanting to address ethical considerations specific to AI in education and those developing their own AI applications. Educators in this context are strongly urged to seek proper training and ongoing education regarding the potential benefits and pitfalls of AI in education.

It is fundamentally important to teach some form of responsible use of AI technologies including mechanisms for overriding AI-generated content and the process by which a user input produced the output.

All students must learn how to find and use information independently, which requires a solid understanding of when to consult a knowledge tool and how to interrogate it in order to fully synthesize and understand answers and solutions. This can be taught through rigorous lessons and assessments regarding biases and inaccuracies of AI tools and opportunities and avenues for verification.

Involving students in the development of lesson plans, specifications for appropriate educational use, and application design could maximize buy-in and alignment of tools to a specific school and classroom situation. The process and ultimate specification could be utilized as a formative assessment to check understanding in a low-stakes environment. It would also permit students a deeper ownership of the tools and opportunity to review them continuously for accuracy. However, achieving ownership may require a level of investment in infrastructure, as in-house training information technology support staff would be desirable. The development, monitoring, and evaluation of tools would also require significant time and resources; thus, consideration must be given to the efficiency of such investment and its perceived benefit.

As a communication and information processing tool rather than an evaluator of students' outputs, Plagiarism Detection Software may be perceived as a much lower risk than the text generators. Nevertheless, as broad-based information processing becomes increasingly available and beneficial, this area is developing rapidly with consequential potential for students' growth. Most importantly, the ethical suitability of using such services must be carefully assessed, as there are concerns about the emergence of unexpected mass fundraising and blocking and banning games on social media that could attempt to take advantage of system vulnerabilities.

a. Developing Ethical Guidelines

With the wide adoption of AI in education, there is an increasing need to ensure that its development and implementation are ethical [42], [43], [44], [45]. When AI is developed or utilized, there are ethical considerations that need to be addressed, and ethical guidelines are needed for AIED development and implementation. Developability guidelines for AIED research suggest that ethical issues with development include inadvertent harm to students, privacy and surveillance concerns, discrimination, and the use of AI writing assistants in teaching and assessment. Guideline 1 stated that AI developers should prioritize consumer well-being and dependability. This means that the AI should be developed with a consideration and assessment of any potential likely negative impacts on consumer safety and well-being. AI developers should not rely solely on quantitative indicators to assess performance but collect qualitative feedback as well. More comprehensive records of AI behavior and wider auditing should be conducted following comparable ethical guidelines. Interpretability and transparency should be prioritized to improve understanding of AI systems. User trust should be actively earned by truthfully answering questions.

There are ethical issues with the implementation of AI tools in classrooms. Many of these issues arise from AI products tracking students' data on curricular performance, behaviors, and other aspects of their private lives [19]. Moreover, the classroom behavior of students is often automatically inferred from subtle and personal cues like facial expressions, head movements, and attentiveness. Some products even collect health-related data available on student devices for emotional reading or stress monitoring. Such surreptitiously gathered data may indirectly result in discrimination or stigmatization. Furthermore, surveillance systems may entrap educators and students into monitoring and reporting on each other for compliance with rules or norms. Teachers' resistance may be rooted in fears that surveillance influences their ability to perform, which means that the ethics of each AI tool employed in each classroom needs to be addressed.

b. Training for Educators

Educational institutions and stakeholders must ensure opportunities for educators, researchers, administration, and students to build expertise in AI literacy. Broad understanding of the generative AI applications and perceptions of their responsible use in the institutions must be [41] Educators and

administration must participate in workshops for adoption of AI in academic research and administrative management. Faculty of education programs must take workshops to generate awareness and confidence among students in integrating generative AI in learning, teaching, and assessment practices. Feedback on productivity, responsible use, and interactions must be gathered after workshops to refine the programs. Students interested in mass communication, marketing, and digital business management must dialogue and participate in hackathon with informed professionals to build awareness about goals and threats of generative AI.

The assessment of educator, student, and institutional perceptions of responsible generative AI use must be undertaken. Investigative observation of interactions with generative AI must be made to shape collective understanding. Challenges faced, positive experiences, and ethical concerns of use must be documented in converged knowledge with supporting recommendations. Perceptions must be compared over semesters to identify generational change in trusts and trends. Knowledge generation and sharing must be used as conclusion for applying AI literacy in educational development.

Proactive feedback must be introduced to incorporate stakeholder reflections in consequent applications. Before engagement with generative AI, stakeholders, especially educators and students, must be made aware of positive and negative experiences of use. The contact path for feedback must be explicitly defined, and type and form of input must be considered. Considerations must be used to integrate suggestions into programs.

c. *Engaging Stakeholders in the Process*

Promoting improvement in student learning is the primary aim of education, but improvements in attainment would be fruitless if there were adverse consequences on how students are treated by the education system [45]. As such, it is essential for educators and programming teams to consult with stakeholders during the design and development of any AI tools to consider implications that go beyond attainment. Given the immediacy with which AI-powered tools are entering mainstream use, there is a pressing need for easy-to-understand resources on potential implications and how they could be managed, forced discussion with relevant stakeholders, and opportunities for contributions from normally marginalized groups. Essentially, one of the biggest challenges of building student and teacher trust in AI tools and systems is the lack of input they have in their development and use [46]. Accordingly, the concerned stakeholders should be actively invited to contribute in the design and implementation of any AI tool or system used to inform or decision-making on students' learning and performance.

Getting stakeholders together to deliberate through participatory design methods is one way to encourage discussions among stakeholders to inform policy making and establish guidelines for future tools. Gathering teachers, parents, students, and programmers to seek input and ideas from them is one way to include a range of relevant stakeholders in discussions. This allows nuanced topics to be explored, questions to be answered, and understanding of the processes adopted by each group to be built among them. Discussing areas of concern should arise naturally from these discussions, which could then be used to build guidelines that developers need to consider on stakeholder implications on the functioning of the learning service. Educators are probably best placed to consult with other stakeholders such as students and parents, a group that might otherwise be disadvantaged. Making proactive discussions among stakeholders a regular occurrence alongside the initial AI implementation is also key to this request.

Obliging programmers on each new project to seek input from stakeholders can be imposed on them as a contractual requirement. A selection of eager teachers can also be invited to accompany programmers and learn from their insight of students or lesson planning. Share in programming lessons, data privacy workshops, or co-designing workshop to boost educator knowledge of technology and hold onto decision-making capabilities of the learning service. The previous point is also likely to naturally lead into further challenges of AI-informed decision making that can be explored with educators.

d. Limitations of the Study

While this study offers valuable insights into the ethical and legal challenges of AI integration in science and mathematics education across Central Asia, several limitations must be acknowledged.

First, the sample size of 341 participants, although statistically workable, remains relatively small and non-randomized, which limits the generalizability of the findings beyond the selected countries (Kazakhstan, Kyrgyzstan, and Tajikistan).

Second, potential teacher bias may have influenced both the survey responses and interview reflections. For example, participants who were already skeptical or supportive of AI may have expressed more extreme views, affecting thematic balance in the qualitative analysis.

Third, the training module used during the intervention included popular tools such as Canva, which may have skewed participant perceptions toward more familiar or user-friendly AI platforms, thus narrowing their evaluation of more complex or less intuitive tools.

Lastly, logistical and language constraints, especially in Tajikistan, restricted the uniformity of training delivery. This may have contributed to the limited variance in pre- and post-training results from that subgroup.

These limitations point to the need for larger-scale, multilingual, and more demographically balanced studies in the future, with controlled exposure to diverse AI platforms to capture a broader spectrum of ethical and legal perspectives in educational contexts.

I. CONCLUSION

The introduction of AI in education has now become a global trend. It is regarded as one of the most effective education methods to solve a range of education-related issues such as high lack of formal education, lack of quality teachers, and so on. In addition, AI is often used in science and math education due to its ability to personalize the education method of students. At the same time, there are also concerns about how to control the development of AI technology itself. Without setting any restrictions, the main purpose of developing AI technology is solution agnostic. There are some other risks regarding legality and ethics. The need for ethically controlling AI technology in education is also raised in Central Asia, where the education system is still developing. One of the main reasons that these countries can expand their education coverage is by borrowing advanced technology from developed countries. For such purposes, significant budget has been spent on online science and math education applications. However, this kind of borrowing without considering the local context has a negative influence on both policy making and law setting in AI technology. Being out of control, these education applications can do harm to the students instead of providing benefits. This research has three important contributions. It systematically analyzes the challenges of AI technology in science and math education from the perspectives of legality and ethics. It indicates the need for a comprehensive approach in governance and implementation of AI technology in education. In this regard, there are still some gaps in the analysis of controlling AI in education. One gap is more specific explorations in each component of the legal control approach. Although there have been comprehensive indications and suggestions about the contents of legality, it is productive to take a more detailed approach in the legal control as a case study of a widespread problem in the large-scale popularization of AI in education. While both ethical codes and guidelines have developed based on the principles of ethics, there are more concerns about the practicality and use of the existing codes that reveal gaps between the code drafts and implementations. With a specific focus on the AI tools deployed in the education sector, the awareness of the risks and potential harms from the use of AI technology has informed concerns about the legal consequences and protective mechanisms that need more extensive discussion in the implementation of AI in a multicultural context.

1. FUTURE DIRECTIONS

AIEd stands at a crossroads. In 2016, three premature headlines on the future of AI in education marked this moment: "Will MOOCs or AIEd Unseat Universities?" "Will AIEd/EdTech Leave Teachers Behind?" and "Will AIEd Be an Engagement Disaster?" In the period between then and now, massive price wars, higher education shake-ups, user declines, rumbling engagement narratives, and flywheel business models rendered clarion prophecies moot (Schiff, 2021). In recent months, however, AIEd proponents have valiantly reasserted their visions, chomping at the bit to rush out promising new technologies. The AIEd community is challenged to peer into the future and share designs for the next decade of AIEd tools. Would-be developers, enforcers, administrators, guardians, and others in the education and EdTech ecosystem are implored to imagine, and insist upon, the futures they want to see. However, knowing the community's humble position in a highly competitive marketplace, developers are reminded that advocacy research, in the absence of a protective mandate, evokes dystopian, myths-of-the-sunk-cost moral quandaries for articulating a balance of positions. Caution is advised against naïve faith in benevolence and live-and-let-live coexistence.

Healthy policy debate about educational technology is sadly lacking. Substantive discussion about priorities, rules, and design ethos for educational technology is virtually nonexistent. Educators are deprived of information to help evaluate potential technologies or democratic deliberation and collective action on which to base common choices. Without specific guidance on standards, the policy field remains dazed and tentative and developers, dispatched to guide educational futures, answer wildly different calls, as with assessment and learning environments. All worry about unintended societal consequences from untrammeled development, notably inequitable distribution of the highest-end capabilities and user alienation from development and access processes [25]. In addition to constructive proposals about technologies, all approaches to organizing future debate about AIEd in education are welcome. However, concrete recommendations to the community are made. These include maintaining openness, bearing in mind potential misalignment with large firm aims, actively disobeying algorithms that permit only simple, un-nuanced flags of bad behavior, and brokering dialog across furrows.

i. Future Research Directions

Building on the outcomes of this research, several important directions emerge for future inquiry that may deepen our understanding of how ethical and legal considerations shape the use of AI in science and mathematics education across Central Asia.

a) Exploring Cultural Differences. Comparative studies that look at how different cultural and national contexts influence ethical and legal views on AI in education—especially outside of Central Asia—can help distinguish between globally shared values and region-specific concerns.

b) Following Long-Term Effects. There is a need for long-term studies that trace how educators' attitudes and behaviors evolve after exposure to AI-related training or policy changes. This would offer insights into whether short-term gains in awareness translate into lasting practice.

c) Focusing on Student Perspectives. Since this study centered mostly on educators, future research should consider the voices of students. Understanding how learners engage with AI, what they trust or question, and how it shapes their educational experience is crucial.

d) Integrating AI Ethics in Teacher Training. Designing and testing educational programs that introduce AI ethics to both current and future teachers may bridge existing knowledge gaps and foster more responsible classroom practices.

e) Assessing Fairness in AI Tools. Future work could involve technical evaluations of the AI systems used in educational settings to ensure they treat students fairly, protect their data, and provide transparent decision-making—especially in linguistically diverse regions.

f) Analyzing Regional Legal Frameworks. A closer examination of current AI-related laws across Central Asian countries—where they exist, where they fall short, and how they are enforced—could support the development of more coherent and effective policies.

g) Designing with Communities in Mind. Participatory design approaches that bring together teachers, students, parents, and local leaders in developing AI tools would help ensure those tools reflect cultural values and meet actual classroom needs.

h) Using Simulated Scenarios. Innovative methods like virtual simulations could be used to explore ethical dilemmas in AI-supported classrooms. This would allow researchers to observe and analyze how educators and students respond to complex situations in a safe, controlled environment.

ii. Emerging Technologies in Education

There have been sporadic technological revolutions throughout the history of education, starting with the emergence of the printing press, developments in broadcast technology including radio, film and television, and the establishment of computers, which have directly assisted the education of billions of learners. In recent years, a new wave of artificial intelligence (AI)-enabled education technologies (AIEd) has begun to emerge, enabling innovative ways to support both teaching and learning. Recently developments with AIEd have been rapid, including the emergence and deployment of large language models, such as ChatGPT, that allow for the generation of natural language text by simulating written dialogue by humans [3]. The combination of learning technologies and sophisticated computing methods based on statistical models have created adaptive education technologies that address prior knowledge to provide targeted feedback and support.

AIEd development has the potential to enrich education by transforming learning and teaching experiences around the world. AIEd has the potential to benefit policy-makers through opportunities for more effective and efficient educational systems worldwide; educators, through more effective resource provision and data-informed teaching strategies; and learners through more individualized learning environments that stimulate engagement and motivation. However, there are potential risks inherent in such tools. While artificial intelligence (AI) has great potential to impact science and mathematics education positively across the globe, among other domains, it also poses serious ethical challenges, including privacy concerns, risk of discrimination, affordability issues, dependence, etc. [16]. Broadly, ethical and equity concerns about the use of AI in education stem from the capacity for implicit and explicit bias (perhaps unwittingly) seeded into algorithms trained on historical decision data. Such data may reflect systemic inequalities, such as testing bias against marginalized communities, creating a "digital divide" reliant on socio-economic status, and prejudicial algorithm biases or flawed privacy practices.

iii. Long-term Impacts of AI on Education Systems

The COVID-19 pandemic has highlighted inequalities in education: rural schools were less prepared to switch to remote work; schools in poorer countries suffered a greater learning loss [3]. Closing these gaps in educational outcomes is a priority for educational policymakers. However, the solution typically employed consists of investments in teaching staff or educational resources which may take decades to show effects. In the meantime, other strategies like using artificial intelligence (AI)-powered educational software have been proposed. These solutions require much smaller investments and could provide immediate returns. There is also, however, a worry that this new focus on AI could lead to serious consequences for education. Consequently, it is important to analyze the potential long-term ramifications that education policy changes based on AI software could have. This policy note takes the form of an open letter addressed mostly to governments or educational policymakers in Central Asia, countries which mostly have not yet implemented AI-powered education policy changes but where AI-oriented changes have started to be implemented. The first half of the note focuses on educational software driven by AI, outlining its strengths, weaknesses, and

main challenges, before outlining a general recommendation framework for approaching AI-based software in education policy.

Educational software has existed for decades, often intended to automate manual processes. In recent years, however, software has emerged that tries to imitate aspects of human cognition, powered by AI. It has been argued that this software can help improving education on many fronts, such as language learning or delivering personalized mathematics instruction. Many AI-powered ed-tech apps have appeared in schools in wealthier countries. Yet, despite its purported capabilities, AI-driven educational software may not be palatable as a sweeping solution for a country's educational woes and its implementation needs to be handled carefully. AI-based software brings new challenges that are morally problematic. Detailed policies should be drawn up to tackle likely issues with the implementation of AI-based education.

The use of Artificial Intelligence (AI) in education has become an important topic in the 21st century. For Central Asia, the effective use of AI in science and math education holds great promise in promoting quality education. However, along with its positive potential, ethical and legal risks are also increasing across all areas of AI application while it is being integrated into the educational ecosystem. This paper describes ethical and legal aspects of AI in education while focusing on science and math education in Central Asia. The current AI application in education and ethical and legal issues are outlined. Then, relevant national law and historical experiences of the world are described to rigorously prevent possible harm from AI while it is being widely implemented in education. The possible future directions of the application of AI in education along with ethical and legal matters are discussed. It is expected that this paper could shed light on the bright and dark sides of the current AI application in education while applying lessons learned from the history. The emergence of AI-driven educational technologies has undoubtedly transformed the educational landscape worldwide. The participation of AI as a co-teacher has benefited education in various ways such as the personalized learning journey of students, advanced educational systems, the availability of learning materials, and so on. However, in Central Asia, the heavy and rampant adoption of AI in education has raised concerns over increasing ethical and legal challenges. It is well recognized that the benefits of AI in education heavily depend on the conduct of AI applications [43]. The rigorous considerations of ethical and legal issues with AI applications could reduce inequities associated with AI-powered education. The constructive solutions resulting from the present challenges of AI in education could not only benefit the future AI implementation in education but also serve as a comprehensive guideline to any AI adoption in society in anticipation of prevention of its potential pitfalls in developmental phases [46].

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