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AI-ASSISTED SUBTITLING IN TRANSLATOR TRAINING: EFFICIENCY, QUALITY, AND STUDENT PERCEPTIONS IN AN EXPERIMENTAL STUDY

Digitalization continues to reshape translation practices across domains, with audiovisual translation (AVT) being one of the fields most affected by automation and artificial intelligence (AI). This study investigates the pedagogical implications of AI-assisted subtitling in the context of translator education. Twelve undergraduate students from the Faculty of Philology at Akhmet Yasawi University (Turkistan, Kazakhstan) participated online in a pre–post experimental design. In the pre-test, students manually subtitled a one-minute English promotional clip; in the post-test, they used AI-generated subtitles which they post-edited for accuracy, style, and cultural appropriateness. Data were collected through task completion times, rubric-based quality scores, error analysis, and student reflections.

The results indicate substantial improvements in both efficiency and quality. Mean task completion time decreased from 745 seconds in the manual condition to 451 seconds in the AI-assisted condition, representing a 40% reduction ($t(11) = 17.79$, $p < .001$, Cohen's $d = 5.13$). Quality scores improved significantly from 5.08/8 to 7.08/8 ($t(11) = -8.12$, $p < .001$, $d = 2.35$). Error analysis revealed a clear shift: manual subtitling produced numerous technical and segmentation errors, while AI subtitling largely eliminated these but required human correction of semantic and cultural nuances. Thematic analysis of reflections confirmed these trends: students valued the speed and technical precision of AI, but emphasized their indispensable role in ensuring idiomatic and culturally sensitive translations.

This study contributes to the growing body of literature on the hybrid ecology of AVT, where human and non-human actors collaborate within translation workflows. It suggests that AI-assisted subtitling can be fruitfully integrated into translator training as both a productivity aid and a pedagogical resource for critical reflection. At the same time, the findings highlight the limitations of automation and the continued necessity of human agency in audiovisual translation.

Keywords: audiovisual translation, AI-assisted subtitling, translator training, quality, student perceptions.

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Аудармашыларды даярлауда жасанды интеллекттің көмегімен субтитр жасау: тиімділік, сапа және эксперименттік зерттеудегі студенттердің қабылдауы

Цифрландыру әртүрлі салалардағы аударма тәжірибелерін қайта қалыптастыруды жалғастырып келеді, ал аудиовизуалды аударма (АВА) автоматтандыру мен жасанды интеллекттің (ЖИ) ең көп әсер еткен бағыттарының бірі болып отыр. Бұл зерттеу аудармашыларды даярлау контекстінде ЖИ-дің көмегімен субтитрлеудің педагогикалық салдарын қарастырады. Түркістандағы Ахмет Ясауи университетінің Филология факультетінің он екі бакалавриат студенті онлайн режимінде алдын-ала және кейінгі тестке негізделген эксперименттік зерттеу дизайнына қатысты. Алдын-ала тестте студенттер бір минуттық ағылшын тіліндегі жарнамалық бейнероликке субтитрді қолмен құрастырды; кейінгі тестте олар ЖИ жасаған субтитрлерді қолданып, дәлдік, стиль және мәдени сәйкестік тұрғысынан пост-редакция жасады. Деректер тапсырманы орындау уақыты, рубрика негізіндегі сапа көрсеткіштері, қателерді талдау және студенттік рефлексиялар арқылы жиналды.

Нәтижелер тиімділік пен сапаның айтарлықтай артқанын көрсетті. Қолмен субтитрлеу кезінде орташа орындау уақыты 745 секундты құраса, ЖИ көмегімен субтитрлеу кезінде 451 секундқа дейін қысқарып, 40% төмендеу байқалды ($t(11) = 17.79$, $p < .001$, Cohen's $d = 5.13$). Сапа көрсеткіштері де елеулі түрде жақсарды: 5.08/8-ден 7.08/8-ге дейін өсті ($t(11) = -8.12$, $p < .001$, $d = 2.35$). Қателерді талдау нақты өзгерісті айқындады: қолмен субтитрлеу кезінде техникалық және сегментация қателері көп болған, ал ЖИ негізіндегі субтитрлеу бұл қателерді

азайтқанымен, семантикалық және мәдени реңктерді түзету үшін адам тарапынан өңдеуді қажет етті. Тақырыптық талдау нәтижелері осы үрдісті растады: студенттер ЖИ-дің жылдамдығы мен техникалық дәлдігін жоғары бағаласа да, идиоматикалық және мәдени тұрғыдан сезімтал аудармаларды қамтамасыз етуде адам рөлінің алмастырылмайтынын атап өтті.

Зерттеу АВА-ның гибридті экологиясы жөніндегі әдебиетке үлес қосады, мұнда адам және адам емес акторлар аударма жұмыс ағындары шеңберінде бірлесе әрекет етеді. Зерттеу ЖИ көмегімен субтитрлеуді аудармашыларды даярлау үдерісіне тиімділік құрал ретінде ғана емес, сонымен бірге сыни рефлексияны дамытуға арналған педагогикалық ресурс ретінде де кіріктіруге болатынын ұсынады. Сонымен бірге, нәтижелер автоматтандырудың шектеулерін және аудиовизуалды аудармада адам агенттігінің сақталуының қажеттілігін айқын көрсетеді.

Түйін сөздер: аудиовизуалды аударма, ЖИ көмегімен субтитрлеу, аудармашыларды даярлау, сапа, студенттердің қабылдауы.

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Субтитрование с использованием искусственного интеллекта в подготовке переводчиков: эффективность, качество и восприятие студентов в экспериментальном исследовании

Цифровизация продолжает трансформировать переводческие практики в различных сферах, и аудиовизуальный перевод (АВП) является одной из областей, наиболее подверженных воздействию автоматизации и искусственного интеллекта (ИИ). Данное исследование рассматривает педагогические аспекты использования субтитрования с поддержкой ИИ в процессе подготовки переводчиков. В экспериментальном дизайне с предварительным и последующим тестированием приняли участие двенадцать студентов бакалавриата факультета филологии Университета Ахмета Ясауи (Туркестан, Казахстан) в онлайн-режиме. На этапе предтеста студенты вручную создавали субтитры к одной минуте англоязычного проморолика; на этапе посттеста они использовали субтитры, сгенерированные ИИ, которые затем редактировали с точки зрения точности, стиля и культурной уместности. Данные собирались на основе времени выполнения задания, оценок качества по рубрике, анализа ошибок и рефлексивных отзывов студентов.

Результаты демонстрируют значительные улучшения как в эффективности, так и в качестве. Среднее время выполнения задания сократилось с 745 секунд в ручном режиме до 451 секунды при использовании ИИ, что составляет снижение на 40% ($t(11) = 17.79$, $p < .001$, d Cohen = 5.13). Показатели качества также существенно выросли: с 5.08/8 до 7.08/8 ($t(11) = -8.12$, $p < .001$, $d = 2.35$). Анализ ошибок выявил выраженный сдвиг: при ручном субтитрировании наблюдалось большое количество технических и сегментационных ошибок, тогда как субтитры, созданные ИИ, практически устранили эти проблемы, но потребовали человеческой корректировки семантических и культурных нюансов. Тематический анализ рефлексий подтвердил эту тенденцию: студенты высоко оценили скорость и техническую точность ИИ, но подчеркнули незаменимую роль человека в обеспечении идиоматичности и культурной чуткости перевода.

Исследование вносит вклад в растущий корпус работ о гибридной экологии АВП, где человеческие и нечеловеческие акторы взаимодействуют в рамках переводческих рабочих процессов. Оно показывает, что субтитрирование с поддержкой ИИ может быть эффективно интегрировано в подготовку переводчиков как инструмент повышения производительности и как педагогический ресурс для развития критической рефлексии. В то же время результаты подчеркивают ограничения автоматизации и неизменную необходимость человеческого участия в аудиовизуальном переводе.

Ключевые слова: аудиовизуальный перевод, субтитрирование с поддержкой ИИ, подготовка переводчиков, качество, восприятие студентов.

Introduction

The rapid digitalization of translation practices has significantly transformed both professional workflows and pedagogical approaches in translator education. Audiovisual translation (AVT), particularly subtitling, represents one of the domains most directly influenced by digital innovations due to its inherent multimodality and technical constraints (Díaz-Cintas, 2020: 6). Subtitling requires the transfer of meaning under strict spatial and temporal limitations, a process that has traditionally demanded both linguistic proficiency and technical competence (Cintas & Remael, 2020: 10). In recent years, the emergence of artificial intelligence (AI) has further reshaped this landscape, offering semi-

automated solutions that accelerate subtitling while raising new questions about accuracy, creativity, and translator agency (Abdelaal & Al Sawi, 2024: 3).

Translation technologies are not entirely new in the educational context. Computer-assisted translation (CAT) tools and machine translation (MT) have long been integrated into translator training to familiarize students with the realities of professional practice (Bowker & Fisher, 2010: p.60; Doherty, 2016: 6). However, AI-based subtitling tools represent a novel pedagogical challenge because they not only automate transcription and initial translation but also intervene in segmenting and synchronizing subtitles – tasks that were once solely entrusted to the translator (Abdelaal, Noureldin & Al Sawi, 2025: 188). Translator trainees must learn to critically evaluate, correct, and adapt AI outputs, thereby developing new layers of competence that combine technological literacy with linguistic and intercultural skills (O'Hagan, 2022: 428).

From a pedagogical perspective, AI-assisted subtitling holds considerable potential. It can reduce the mechanical burden of transcription and timing, allowing students to concentrate more on meaning, cultural transfer, and audience-oriented strategies (O'Hagan, 2022**:** 428). At the same time, it exposes students to the limitations of automation, such as semantic inaccuracies, poor handling of idiomatic expressions, or culturally inappropriate renderings. This dual experience – benefiting from efficiency while recognizing technological shortcomings can foster reflective learning and critical awareness, which are central to translator education (Risku, 2018**:** 13).

Despite its increasing relevance, empirical research on the pedagogical applications of AI-assisted subtitling remains scarce, especially in the context of experimental designs involving translation students. Previous studies have often focused either on professional subtitlers' adoption of technology (Kwok and et al ., 2025) or on students' general use of CAT/MT tools (Lounds, 2021). Few attempts have systematically compared manual subtitling with AI-supported subtitling within a controlled training environment. Therefore, the present study aims to fill this gap by exploring how students engage with subtitling tasks both with and without AI assistance, and by analyzing their perceptions of the benefits and challenges associated with these tools.

The aim of the primary study is to investigate the role of AI-assisted subtitling as a pedagogical tool in audiovisual translation training. More specifically, it examines how the integration of AI tools influences subtitling performance, error types, and student perceptions, thereby contributing to discussions on the balance between human agency and technological support in translator education. In line with this aim, the research questions will be considered:

RQ1. How does AI-assisted subtitling affect the efficiency and technical quality of students' work compared with manual subtitling?

RQ2. In what ways do error types and frequencies differ between manual and AI-assisted subtitling?

RQ3. How do students perceive and evaluate the benefits and limitations of AI-assisted subtitling in their training experience?

In this study, these questions serve as the central guide for the research design and analysis. The experimental and reflective data collected from students will be examined with the aim of providing clear answers to these questions. By doing so, the study seeks to generate both quantitative evidence of performance differences and qualitative insights into learner perceptions, ultimately offering a holistic understanding of how AI-assisted subtitling can be integrated into translator training.

Materials and methods

This chapter outlines the methodological framework adopted in the present study. It explains the research design, participants, instruments, and procedures that were employed to ensure a systematic and reliable investigation of the research questions. The following subsections provide detailed accounts of each methodological component, highlighting how the chosen methods align with the overall aims of the study.

Research Design. This study employed a within-subjects, quasi-experimental pre-post design to examine the pedagogical impact of AI-assisted subtitling in audiovisual translation (AVT) training. The pre-test required participants to complete a manual subtitling task (no AI support), while the post-test required AI-assisted subtitling (automatic draft plus post-editing). A mixed-methods strategy was adopted: (a) quantitative outcomes (task time, error counts, holistic quality score) were used to assess efficiency and technical / linguistic quality; (b) qualitative reflections captured perceptions, benefits, and challenges (Cresswell, 2017: 39). Two short English promotional clips of comparable difficulty (Clip A and Clip B) were used to minimize content effects.

Participants and Setting. Twelve undergraduate students (n = 12) participated voluntarily enrolled. Junior students have been studying in a Translation and Interpreting programme at the Akhmet Yasawi University in Turkestan, Kazakhstan. All had completed introductory courses in translation/AVT and reported limited or no prior experience with AI-based subtitling. The study was conducted online, reflecting current remote learning and cloud-based professional workflows. Students used their own laptops and stable internet connections.

Data Collection and Instruments. The study employed a range of materials and instruments to support the data collection process. As input, two English language videos were selected, each designed with a comparable speech rate and lexical density to ensure consistency across tasks. For the pre-test stage, participants used a freely available subtitling editor with the AI function disabled, thereby requiring them to create subtitles manually. In the post-test stage, however, students were introduced to two AI-based subtitling platforms, namely Veed AI and Maestra, which generated automatic subtitle drafts for subsequent post-editing. To track performance, task duration was measured by recording start and finish times in seconds. Subtitle quality was assessed using an adapted audiovisual translation (AVT) rubric, which rated performance on a scale of 0-2 per category and yielded a cumulative score ranging from 0 to 8, where higher scores indicated better quality. Finally, student perceptions were collected through short Likert-scale questionnaires administered after each task, complemented by a final reflection form approved by the instructor, which allowed participants to provide open-ended feedback on their experiences.

Before presenting the results, it is essential to clarify the technical standards applied in the subtitling tasks. These standards ensured comparability and controlled for readability, timing, and synchronization issues. Table 1 summarizes the key parameters – such as characters per second, subtitle line limits, and segmentation rules – that guided both the manual and AI-assisted subtitling processes.

Table 1 – Technical Standards in Subtitling (Applied in Both Tasks).

Standard	Definition	Example	Purpose
Characters per second (CPS ≤ 17)	Recommended reading speed threshold	A 34-character subtitle should remain ≥ 2 s on screen	Ensures readability (Cintas & Remael, 2020, p.107)
Maximum 2 lines	No more than 2 subtitle lines displayed	Subtitle should not exceed 2 lines of text	Preserves visual space (BBC, 2019)
Minimum 1 second / Maximum 6–7 seconds	Shortest and longest subtitle durations	Subtitle must stay ≥ 1 s and ≤ 6–7 s	Avoids “flashing” or overly long titles (Netflix, 2021)
Segmentation at syntactic breaks	Line breaks should follow natural pauses	Break after clause or conjunction	Improves coherence
Shot-change awareness	Subtitles should not cross hard cuts	New subtitle starts with shot change	Maintains visual synchrony (Cintas & Remael, 2020, p.50)

As shown in Table 1, the criteria emphasized a balance between linguistic clarity and technical feasibility. For instance, the restriction of a maximum of two lines preserved visual space, while the minimum/maximum duration requirement avoided overly short or excessively long subtitles. Together, these standards created a uniform baseline for assessing both manual and AI-generated outputs. Standards adapted from Cintas & Remael (2020), Netflix (2021), and BBC (2019).

To evaluate the quality of the subtitles, an adapted rubric was used. This rubric considered semantic accuracy, technical synchronization, segmentation and layout, as well as style and readability. Table 2 outlines the scoring criteria, which ranged from 0 (inadequate) to 2 (adequate) in each category, with a total score of 0-8.

Table 2 – Subtitling Assessment Rubric (0-8 total).

Criterion	0 = Inadequate	1 = Partial	2 = Adequate
Semantic accuracy	Major mistranslations, meaning lost; idioms/cultural items omitted or distorted	Some mistranslations or awkward renderings; partial transfer of meaning	Accurate meaning transfer; idioms/cultural items adapted appropriately
Technical synchronization	In/out times far from speech; subtitles overlap/cross shot changes	Minor mistiming; occasional overlap with shot changes	Well-synchronized; entry/exit times aligned with speech and shots
Segmentation & layout	Poor line breaks; > 2 lines; CPS/CPL consistently violated	Some segmentation errors; occasional CPS/CPL issues	Proper segmentation; 1-2 lines; CPS/CPL respected
Style & readability	Frequent punctuation/grammar errors; long/unnatural lines	Occasional errors; uneven style	Clear, concise, grammatically correct; easy to read

As indicated in Table 2, the rubric allowed for a nuanced assessment of student performance. While semantic accuracy focused on meaning transfer, technical synchronization addressed timing and alignment with audiovisual cues. Similarly, segmentation and style categories highlighted the importance of both structural coherence and readability. The scoring system thus provided a reliable basis for comparing the manual and AI-assisted subtitling tasks.

Literature review

Digitalization has radically altered the landscape of translation practice, and audiovisual translation (AVT) is one of the most affected sub fields because of its inherently multimodal nature. Subtitling, in particular, combines verbal, visual, and auditory channels, making it especially sensitive to technological developments. As Cintas and Remael (2020) argue, subtitling is no longer a purely linguistic task but a technologically mediated practice that requires balancing meaning transfer with technical parameters such as character-per-second (CPS), characters-per-line (CPL), reading speed, line breaks, and screen exposure time (2020: 106). These constraints are increasingly monitored not only by human reviewers but also by automated quality control systems embedded in professional subtitling platforms (Papi and et.al., 2023: 3).

The ecology of AVT has shifted from local, project-based workflows to globalized, cloud-based ecosystems. Cintas (2013) emphasizes that technological innovation has facilitated large-scale subtitling production for streaming services, often through cloud platforms that integrate automatic checks for segmentation, spotting, and synchronization (2013: 275). This shift reflects what Risku et al. (2016), translators function within networks of both human and non-human actors – where not only persons, institutions, and clients matter, but also technology, tools, documents, and other non-human elements shape translation practices (2016: 2). In this ecology, digital technologies act as powerful intermediaries that shape professional routines, collaboration patterns, and even quality standards.

Pedagogically, this ecological transformation highlights the importance of training students to operate effectively within digitally mediated environments. As Oziemblewska & Szarkowska (2022) notes, subtitling is now inseparable from technical literacy; learners must be able to navigate interfaces, interpret automated warnings, and adapt to platform-specific constraints (2022: 434). The ecology also underscores the growing role of digital infrastructures in shaping subtitling norms: while earlier studies framed subtitling as a craft, current research positions it as a hybrid activity where human creativity intersects with technological automation.

The broader implication is that AVT education must not only teach translation strategies but also prepare students to critically engage with the digital environments that now structure their work. In this sense, digitization constitutes not just a background condition but a determinant ecological factor that defines how subtitling is produced, evaluated, and taught.

From CAT and MT to AI-Assisted Subtitling. The integration of technology into translation practice has historically been dominated by computer-assisted translation (CAT) tools and, later, machine translation (MT) systems. CAT tools such as translation memory software, terminology databases, and alignment programs were designed to enhance consistency and efficiency in written translation. Their gradual incorporation into translator training aimed

to familiarize students with the realities of professional workflows and to cultivate digital literacy alongside linguistic competence (O'Brien, 2012: 115). With the emergence of neural machine translation (NMT), the landscape shifted even further: translation students increasingly engaged in post-editing activities, a practice that has been extensively studied in terms of its impact on quality, speed, and cognitive effort (Gaspari et al., 2015: 334).

However, subtitling presents challenges that extend beyond the textual domain. While CAT and MT tools primarily operate on linear written texts, subtitling requires negotiation between linguistic transfer and multimodal constraints, such as timing, segmentation, and synchronization. In this respect, AI-assisted subtitling represents a qualitative leap from previous technologies. AI systems now combine automatic speech recognition (ASR), machine translation, and auto-segmentation to generate draft subtitles in near real-time. These tools not only suggest translations but also decide where subtitles begin and end, how they are segmented, and how they are aligned with the audiovisual rhythm of the source text (Karakanta, 2022: 90). As a result, the translator's task is increasingly reframed from authoring subtitles from scratch to editing and refining AI-generated drafts.

This shift has pedagogical implications. As Abdelaal and Al Sawi (2024) points out, subtitling is at the crossroads of translation studies and media technology, and AI tools make this intersection even more complex. For students, exposure to AI-assisted subtitling creates opportunities to reduce the mechanical burden of transcription and timing, thereby enabling a stronger focus on cultural adaptation, audience design, and pragmatic choices. At the same time, it introduces risks of overreliance, since students may be tempted to accept AI output uncritically without sufficient reflection on accuracy, style, or cultural resonance (2024: 6).

Recent studies confirm this tension. Experimental research on automatic subtitling shows that AI outputs often achieve acceptable synchronization and segmentation but remain error-prone in terms of idiomatic expressions, humour, and culturally embedded references (Karakanta, 2022: 10). These finding suggest that while AI-assisted subtitling can accelerate workflows and enhance technical precision, human intervention remains indispensable for meaning negotiation and intercultural sensitivity.

In summary, the transition from CAT and MT to AI-assisted subtitling represents more than a technological upgrade; it signifies a paradigm shift in both professional and pedagogical contexts. It requires training translators not only to use technology effectively but also to cultivate critical digital agency, enabling them to assess, revise, and strategically adapt AI-generated outputs. This aligns with the broader pedagogical shift from tool use as a mechanical skill to technology literacy as an integral component of translator competence.

Technological Change and Industrial Practices. The professional subtitling industry has been reshaped by rapid technological innovation and the expansion of global streaming platforms. One of the most striking changes is the rise of semi-automated workflows, where translators rarely produce subtitles entirely from scratch but instead work with pre-prepared drafts. These drafts may take the form of templates – pre-segmented subtitle files with timings already established – or machine-generated subtitle output. As Georgakopoulou (2019) notes, such workflows have become "the Holy Grail" of large-scale subtitling, ensuring consistency across languages and reducing turnaround time (2019: 138).

However, the reliance on pre-prepared drafts introduces a new set of professional skills. Subtitlers are increasingly expected to act as editors and quality controllers, diagnosing segmentation problems, correcting machine errors, and ensuring compliance with technical metrics such as characters per line (CPL), characters per second (CPS), and shot-change synchronization (Karakanta, 2022: 13). Automated quality control systems embedded in cloud-based platforms further reinforce these expectations by flagging violations of style guides or timing standards. As Banos etal. (2023) observes, the industrial trend is clear: subtitlers are now positioned within socio-technical networks where both human expertise and machine-generated output shape the translation product.

These industrial transformations are directly relevant for translator education. AI-assisted subtitling in training environments mirrors the industry practice of working with pre-generated drafts. Students are no longer only creators but also post-editors of AI output, which closely resembles how professionals handle templates or machine-generated captions (Orrego-Carmona, 2022: 335). In this sense, AI-assisted subtitling tasks reproduce the very conditions under which students will later work: evaluating draft quality, repairing errors, and adapting subtitles to cultural and audience-specific needs.

Thus, understanding technological change in industrial practices provides a strong rationale for

introducing AI tools in translator training. By engaging with AI-assisted subtitling, students not only acquire technical literacy but also develop the critical ability to negotiate between automation and human creativity. As Falempin and Ranadireksa (2024) point out, subtitling today must be seen as a hybrid activity where human translators collaborate with digital tools to achieve communicative effectiveness. Incorporating this reality into pedagogy ensures that students are better prepared for the evolving demands of the profession (2024: 528). Collectively, integrating AI into translator education allows students to balance efficiency with interpretive skill, fostering both technical competence and creative judgment in their professional development.

Pedagogical Integration: Benefits and Tensions. The integration of artificial intelligence (AI) into audiovisual translation (AVT) pedagogy has created both opportunities and challenges. On the one hand, AI-assisted subtitling reduces the mechanical workload of transcription and initial segmentation, allowing students to focus more on higher-order translation decisions such as cultural transfer, audience design, and pragmatic nuance (Lounds, 2021). This echoes findings in translator education more broadly: when repetitive or time-consuming tasks are automated, learners can redirect their attention towards strategic and creative aspects of translation (O'Hagan; McDonough Dolmaya, 2023: 10). By working with AI-generated drafts, students gain first-hand exposure to industry-relevant workflows while simultaneously developing critical digital literacy.

Several studies highlight the pedagogical benefits of integrating AI tools into subtitling courses. For example, Abdelaal and Al Sawi (2024) found that AI subtitles enhanced timing accuracy and reduced task completion time, which students perceived as a motivational factor (2024: 5). Similarly, Kwok et al. (2025) demonstrated that generative AI support improved fluency and syntactic complexity in learner translations. In training contexts, these findings suggest that AI can foster efficiency, technical competence, and learner engagement, making the classroom experience more closely aligned with professional practice (2025: 2).

At the same time, researchers caution against tensions and risks. A common concern is the potential for overreliance: students may accept AI output uncritically, overlooking semantic inaccuracies, cultural mismatches, or stylistic weaknesses. This risk highlights the importance of embedding reflective tasks into pedagogy, where students must not only correct AI errors but also explain and justify their revisions. Kiraly's (2014) social constructivist model of translator education stresses precisely this dimension of agency: learners should be empowered to make informed decisions rather than passively adopt machine suggestions (2014: 249).

Another tension arises from the balance between efficiency and creativity. While AI accelerates workflows, it may inadvertently limit opportunities for students to practice transcription, segmentation, and creative problem-solving from scratch. This could weaken their confidence in situations where automation is unavailable or inappropriate (Orrelano et.al., 2024: 989). Therefore, educators must carefully design tasks that combine manual and AI-assisted subtitling so that students experience both the challenges of full authorship and the benefits of semi-automation.

In sum, the pedagogical integration of AI-assisted subtitling is best understood as a double-edged process. It can significantly enrich translator training by simulating real-world workflows and enhancing efficiency, but it also requires careful scaffolding to preserve human agency, creativity, and critical judgment. The present study contributes to this pedagogical debate by empirically examining how students engage with both manual and AI-assisted subtitling tasks, what benefits they perceive, and what limitations they identify.

Results and discussion

In this part, the procedures applied during the experiment are explained in detail. The section presents the sequence of activities conducted with the participants, beginning with the pre-test phase, continuing with the treatment, and concluding with the post-test and data collection. The aim is to provide a transparent account of how the study was carried out so that it can be replicated in future research.

The procedure consisted of three main stages. In the pre-test phase, participants were asked to subtitle one of the selected video clips entirely from scratch using a free subtitling editor with the AI function disabled. They were instructed to adhere to the established technical standards, after which they exported their subtitle files and recorded their completion times. Immediately following the task, students completed a brief questionnaire designed to capture their perceptions of difficulty, usability, and confidence.

In the post-test phase, participants worked with the second video clip, but this time an AI-generated subtitle draft was provided through modern subtitling platforms (Veed AI and Maestra). Students were required to post-edit the draft for semantic accuracy, segmentation, style, and synchronization. Completion times were again logged, the final files were collected, and the same short questionnaire was administered. Notably, the pilot use of these platforms showed that technical timing and segmentation issues were minimal, while semantic and stylistic corrections were still frequently required.

Finally, in the reflection stage, participants completed an open-ended reflection form in which they compared the manual and AI-assisted workflows. This allowed them to articulate the perceived benefits and limitations of each approach, as well as to reflect on the implications for their professional readiness in audiovisual translation contexts.

Data Analysis. Data analysis combined both quantitative and qualitative approaches in order to capture the effectiveness of manual and AI-assisted subtitling. On the quantitative side, within-subjects comparisons were carried out to examine pre–post differences. Specifically, paired-samples t-tests were conducted to compare participants' task completion times (measured in seconds) as well as their total quality scores on the 0-8 rubric scale. To ensure reliability, inter-rater agreement was also calculated, with effect sizes reported through Cohen's d for each quality category.

In addition, qualitative data derived from the open-ended reflection forms were analyzed thematically. Following Braun and Clarke's (2006) framework for thematic analysis, an inductive coding procedure was used to identify recurring patterns in the students' responses. Prominent themes included perceptions of efficiency and time-saving, evaluations of technical accuracy, concerns about semantic limitations, and reflections on human agency and creativity (2006: 6). These qualitative insights were subsequently triangulated with the quantitative results, allowing for a richer interpretation of the findings. In this way, the study combined numerical evidence with participants' subjective perspectives, providing a more comprehensive account of how AI-assisted subtitling compared with manual subtitling in both measurable outcomes and learner perceptions.

Ethical Considerations. The research was conducted in full compliance with institutional ethical standards. All participants were informed about the purpose and scope of the study, and their participation was entirely voluntary. Written informed consent was obtained, and students were assured that they could withdraw at any stage without facing academic disadvantages. To protect confidentiality, no identifying information was collected, and responses were coded with neutral labels such as "Student 1" and "Student 2." The reflection forms were reviewed and approved by the course instructor to guarantee pedagogical appropriateness and to avoid any risk of discomfort. Furthermore, all collected data, including subtitle files and questionnaires, were stored securely with restricted access, available only to the researcher. These measures ensured that the rights, dignity, and privacy of participants were respected throughout the research process.

This chapter presents the results of the study in accordance with the three procedural stages: Stage 1 (manual subtitling), Stage 2 (AI-assisted subtitling), and Stage 3 (student reflections). The findings are organized to provide both descriptive and inferential insights. First, descriptive statistics are reported to illustrate general patterns in task completion times and quality scores across conditions. This is followed by inferential statistics derived from paired-samples t-tests, which allow for a direct comparison of participants' performance between the manual and AI-assisted subtitling tasks. Such tests enable the identification of statistically significant differences within the same group under two conditions, thereby ensuring a reliable interpretation of the observed outcomes.

In addition to the quantitative results, the qualitative data obtained from the reflection forms are presented to capture students' subjective perceptions of both workflows. These reflections highlight recurring themes such as efficiency, accuracy, semantic and stylistic challenges, and the perceived role of human creativity alongside AI tools. Presenting both sets of results in tandem makes it possible to map the findings back to the guiding research questions and to provide a holistic picture of how AI-assisted subtitling compared to manual subtitling in terms of both measurable outcomes and learner experiences.

Stage 1 vs Stage 2: Descriptive statistics of the analysis

To compare students' performance across the two conditions, descriptive statistics were first calculated for task completion times and quality scores. Table 3 presents the mean values, standard deviations, and standard errors for both manual and AI-assisted subtitling tasks. These figures provide an initial overview of the differences in efficiency and quality between the two approaches.

Table 3 – Descriptive Statistics of The Analysis

Pair	Variable	Mean	N	SD	SE Mean
Pair 1 (Time)	timepre (manual)	745.00 s	12	53.94	15.57
	timepost (AI)	451.25 s	12	30.01	8.66
Pair 2 (Quality)	scorepre (manual)	5.0833	12	0.6686	0.1930
	scorepost (AI)	7.0833	12	0.6686	0.1930

As shown in Table 3, students completed the AI-assisted subtitling task considerably faster than the manual task, with an average time reduction of nearly five minutes (451 s = 7:31 min vs. 745 s = 12:25 min). In addition to greater efficiency, the quality of subtitles also improved when using AI tools. The mean quality score increased by approximately two points on the 0-8 rubric scale (from 5.08 to 7.08). These results suggest that AI assistance not only reduced the cognitive and temporal load on students but also supported more accurate and readable subtitle production.

In addition to descriptive comparisons, correlation analyses were conducted to examine whether students' pre-test and post-test measures were related. This step helps to determine whether performance in the manual condition predicts performance in the AI-assisted condition, or whether the latter represents a qualitatively different mode of task execution. Table 4 displays the paired samples correlations generated by SPSS.

As shown in Table 4, correlations between pre- and post-test measures were weak and statistically non-significant for both time ($r = .166$, $p = .607$) and quality scores ($r = .186$, $p = .562$). This suggests that students who performed relatively faster or with higher quality in the manual condition did not necessarily perform similarly in the AI-assisted condition. In other words, the AI tools appear to have introduced a substantial shift in performance dynamics, reducing the extent to which individual ability in manual subtitling predicted outcomes in the assisted workflow. This finding aligns with the interpretation that AI support functions as a condition that materially alters the subtitling process, creating more equalized outcomes across participants regardless of their initial skill level.

Table 4 – Paired Samples Correlations (SPSS)

Pair	N	Correlation (r)	Sig.
timepre & timepost	12	0.166	.607
scorepre & scorepost	12	0.186	.562

Stage 1 vs Stage 2: Inferential Tests

To determine whether the differences observed in descriptive statistics were statistically meaningful, paired-samples *t*-tests were applied. This inferential test makes it possible to evaluate whether students' performance in the AI-assisted condition differed significantly from their performance in the manual condition. Both completion times and quality scores were analyzed, and the results are presented in Table 5.

Table 5 – Paired Samples t-Tests (SPSS)

Pair (Difference)	Mean Difference	Standard Deviation Difference	Standard Error Difference	t	Sig. (2-tailed)
timepre – timepost	293.75 s	57.21	16.52	17.786	.001
scorepre – scorepost	–2.00	0.853	0.246	–8.124	.001

As presented in Table 5, the paired-samples *t*-tests revealed highly significant results in both measures. For task completion time, students working with AI were on average almost five minutes faster than when subtitling manually, and this reduction was statistically significant ($t = 17.786$, $p = .001$). Similarly, the mean subtitle quality score increased by two points on the 0–8 scale, a difference that was also statistically significant ($t = –8.124$, $p = .001$). These findings confirm that AI assistance not only enhanced efficiency but also improved subtitle quality. Taken together, the results provide strong evidence that AI-based tools produced a consistent and measurable impact on participants' subtitling performance beyond what could be attributed to chance variation.

Effect Sizes (Cohen's d)

In addition to statistical significance, it is important to consider the magnitude of the differences between manual and AI-assisted subtitling. Cohen's *d* provides such a measure by showing how large the observed effects are. According to Cohen's widely used guidelines, values around 0.20 are considered small, 0.50 medium, 0.80 large, and anything above 1.20 extremely large (Becker, 2000, p.2).

Computed as **Mean Difference ÷ SD of Difference** (paired design):

Time: $d = 293.75 / 57.21 =$ **5.13** – **extremely large** effect.

Quality: $d = 2.00 / 0.853 =$ **2.35** – **very large** effect.

The effect sizes in this study were striking. For completion time, the effect size was $d = 5.13$, which is far above the threshold for an extremely large effect. This means that the difference in how quickly students completed the subtitling task with AI compared to manually was dramatic. For quality, the effect size was $d = 2.35$, also well above the threshold for a very large effect. In other words, AI assistance not only made the work significantly faster but also led to a clear and meaningful improvement in the quality of subtitles.

Stage 1 – Manual Subtitling (Profile)

In Stage 1 (manual subtitling), students had to create subtitles from scratch without technological support. The results revealed that this condition generated a higher number of technical and segmentation issues. For instance, many subtitles showed early or late entry and exit times, as well as line breaks that did not align with natural syntactic pauses. Exceeding the recommended characters per second (CPS) or characters per line (CPL) limits was also common. Although the semantic transfer of meaning was generally adequate, stylistic weaknesses were frequent. These included overly long lines, punctuation mistakes, and less fluid phrasing, which at times reduced the overall readability of the subtitles. Taken together, the manual subtitling profile illustrates the cognitive and technical demands placed on students when they must manage both timing and linguistic accuracy simultaneously.

Stage 2 – AI-Assisted Subtitling (Profile)

By contrast, Stage 2 (AI-assisted subtitling) presented a very different performance profile. Since students began with automatically generated drafts, the technical aspects of subtitling – such as timing and segmentation – were already handled with near-perfect accuracy. As a result, their effort shifted primarily toward refining semantic transfer and improving stylistic quality. Edits often focused on idiomatic expressions, culture-bound references, and the naturalness of phrasing. Students essentially acted as post-editors, polishing the meaning and tone of the subtitles rather than constructing them from scratch. This demonstrates that AI support substantially reduced the technical burden of the task, enabling learners to concentrate on higher-order linguistic and stylistic considerations.

To provide a clearer picture of the types of challenges students faced, error profiles were analyzed by category. Using the study's assessment rubric, errors were grouped into four main dimensions: technical synchronization, segmentation/layout, semantic accuracy, and style/readability. Table 6 presents the average number of errors per student before (manual subtitling) and after AI support, along with the percentage of change.

As shown in Table 6, AI assistance almost completely eliminated technical and segmentation-related issues. Errors in synchronization decreased by 95%, while segmentation and layout problems fell by 85%. This confirms that modern AI subtitling platforms are highly effective in handling timing and structural constraints automatically. However, the results also show that semantic and stylistic aspects still required considerable human intervention. Semantic accuracy improved by 33%, but this gain came from students' active post-editing of idioms, culture-specific references, and nuanced meanings. Style and readability errors decreased by only 37%, indicating that punctuation, line breaks, and natural phrasing continue to pose challenges that AI cannot fully resolve.

Table 6 – Error Profile by Category (per-student averages; study rubric)

Category	Pre (Manual)	Post (AI)	Change
Technical synchronization	5.8	0.3	↓ 95%
Segmentation/layout	4.3	0.6	↓ 85%
Semantic accuracy	2.1	2.8	↑ 33%
Style/readability	3.0	1.9	↓ 37%

Taken together, these findings demonstrate a complementary division of labor: AI efficiently addresses the mechanical and technical dimensions of subtitling, while human translators remain indispensable for meaning-making, cultural adaptation, and stylistic refinement. This pattern reflects exactly the workflow anticipated for AI-assisted subtitling, where machines handle structural precision and humans safeguard communicative quality.

Stage 3 – Reflections (Perceptions)

Beyond the statistical outcomes, students' qualitative reflections were analyzed to gain deeper insights into their experiences with manual and AI-assisted subtitling. The open-ended responses were coded thematically, which allowed for the identification of recurring patterns in how participants perceived efficiency, technical accuracy, semantic challenges, and the role of human agency. Table 7 presents a thematic summary of these reflections, including the number of students who endorsed each theme and illustrative comments that exemplify their views.

As reflected in Table 7, the most salient theme was efficiency and time-saving, endorsed by ten students. Their comments clearly show that AI tools reduced the cognitive burden of subtitling by automatically handling technical aspects. For example, one student noted, "AI saved me at least five minutes; I could spend my energy on translation choices," while another emphasized feeling "less stressed about deadlines." These remarks illustrate that AI assistance shifted the focus from time management to linguistic decision-making, allowing students to allocate more attention to meaning.

Table 7 – Thematic Summary with Expanded Illustrative Comments (n = 12)

Theme	Students endorsing	Illustrative comments
Efficiency & time-saving	10	– "I finished much faster and could focus on meaning instead of timing." – "AI saved me at least five minutes; I could spend my energy on translation choices." – "Compared with manual subtitling, I felt less stressed about deadlines."
Technical accuracy	9	– "Segmentation was already correct – little timing work was needed." – "Unlike manual subtitling, the AI respected shot changes automatically."
Semantic limitations	8	– "Idioms were literal; I had to rephrase them in natural Kazakh." – "Cultural jokes were mistranslated, and without editing they made no sense." – "The draft sometimes used formal words that sounded strange in context."
Human agency & creativity	7	– "AI helps, but the final quality depends on my edits." – "I realized that technology cannot replace human creativity – it only gives a starting point." – "AI is good for speed, but the translator's cultural knowledge is still essential."

Technical accuracy was also strongly recognized, with nine students praising the system's ability to provide well-synchronized and correctly segmented drafts. As one student stated, "Segmentation was already correct – little timing work was needed," showing that AI reduced mechanical workload. Another highlighted how "the AI respected shot changes automatically," a technical detail that is often challenging for beginners. These responses suggest that students valued the reliability of AI in areas where human error was common during manual subtitling.

Nevertheless, semantic limitations were reported by eight students, who pointed out that the AI struggled with idioms, humor, and culture-specific content. Comments such as "Cultural jokes were

mistranslated, and without editing they made no sense" and "The draft sometimes used formal words that sounded strange in context" reveal that meaning transfer remained an area requiring human intervention. This indicates that while AI managed structure with precision, it still lacked sensitivity to cultural and pragmatic nuances.

Finally, seven students stressed the continuing importance of human agency and creativity. One participant explained, "AI helps, but the final quality depends on my edits," while another reflected, "Technology cannot replace human creativity – it only gives a starting point." These statements underline that students perceived themselves as indispensable co-creators, ensuring that subtitles were not only technically sound but also culturally appropriate and stylistically effective.

Overall, the reflections confirm that AI greatly reduced technical workload and increased efficiency, but students recognized that true quality in subtitling still required their own cultural knowledge, stylistic awareness, and creative decision-making.

The findings of this study demonstrated that AI-assisted subtitling significantly enhanced both efficiency and quality compared to manual subtitling. Students completed the AI-supported task approximately 40% faster, with technical and segmentation errors reduced to near zero. At the same time, overall quality scores increased by an average of two points. These results confirm that digital tools, when integrated effectively, can provide substantial pedagogical benefits in audiovisual translation (AVT) training. This outcome aligns with recent scholarship that has documented the increasing reliability of AI-based tools in subtitling workflows. As Cintas and Remael (2020) note, automation can handle many repetitive or technical aspects of subtitling, such as timing and segmentation, allowing human translators to focus more on semantic accuracy and stylistic nuance (2020: 35). Our results also resonate with O'Hagan & McDonough (2023), who observed that the role of the translator in AI-assisted contexts increasingly shifts from "creator" to post-editor, emphasizing human oversight rather than mechanical labour. Interestingly, while technical errors decreased dramatically in the AI-assisted stage, semantic and cultural issues remained, sometimes even increasing (2023: 4). This finding echoes Cintas & Massidda (2019), who argues that cultural adaptation and pragmatic meaning remain non-automatable aspects of AVT (2019: 263). The reflections of our students reinforce this point: most valued the time-saving and technical precision of AI, but they also insisted that human agency was essential for capturing idiomatic and culturally sensitive expressions. In this sense, the study illustrates the "hybrid ecology" of subtitling described by Gambier (2023), where machine efficiency and human creativity coexist in the same workflow (2023: 2).

From a pedagogical perspective, these findings support integrating AI subtitling platforms into translator education, not as replacements for human work but as tools for enhancing critical awareness and editing skills. Similar arguments have been made by Orrego-Carmona (2022), who advocates for task designs where students critically evaluate machine output rather than simply rely on it (p.330). Our participants' reflections demonstrate that such exercises foster not only technical proficiency but also metacognitive awareness of their professional role in a digitalized translation landscape.

Conclusion

This study examined the impact of AI-assisted subtitling on efficiency, quality, and student perceptions within translator training. The findings demonstrated that AI tools significantly reduced task completion time and enhanced subtitle quality. Whereas manual subtitling was often accompanied by technical and segmentation errors, AI assistance largely eliminated these issues, allowing students to concentrate on meaning, style, and cultural adaptation. The study emphasizes that AI functions best as a complement to human expertise rather than a replacement. By automating repetitive aspects of subtitling, AI enables students to engage more deeply with the creative and interpretive dimensions of translation. This hybrid approach not only reflects current professional practices but also equips students with critical post-editing skills and a reflective awareness of their future roles as translators.

Regarding the research questions, the study yielded the following insights: AI-assisted subtitling improved efficiency and technical quality, as evidenced by faster completion times and fewer errors. The error analysis revealed a shift in error types: manual subtitling exhibited more segmentation and synchronization mistakes, while AI-assisted subtitling reduced these errors but required greater attention to semantic and stylistic refinement. Student reflections highlighted the benefits of AI in reducing workload and facilitating focus on meaning, alongside concerns about potential over-reliance and diminished engagement with creative decision-making.

In conclusion, AI-assisted subtitling represents a valuable pedagogical tool in translator education. It delivers efficiency and technical precision while preserving the centrality of human creativity, cultural sensitivity, and critical decision-making. Integrating AI tools into curricula can prepare students for the realities of a digitalized professional environment, fostering a collaborative network in which human and technological actors work together effectively.

Pedagogical Implications

This study provides strong evidence that AI-assisted subtitling can be fruitfully incorporated into translator training. First, AI tools reduce mechanical workload and task completion time, creating more classroom space for discussions of semantics, pragmatics, and cultural transfer. Second, by asking students to post-edit machine output, instructors can develop learners' ability to identify weaknesses, evaluate multiple solutions, and justify their choices – key components of professional competence (Moorkens etal., 2018: 17). Third, the hybrid workflow mirrors real-world industry practice, preparing students for professional contexts where human-machine collaboration is becoming the norm.

Limitations and Future Research

Several limitations must be acknowledged. First, the sample size was small (n = 12), which restricts the generalizability of the findings. Replication with larger cohorts would strengthen the evidence base. Second, the study used only two short clips of similar difficulty; longer or more complex materials might yield different results. Third, the study did not employ a control group, which would have allowed for a stronger experimental design. Finally, while reflections highlighted valuable perceptions, more in-depth interviews could provide richer insights into how students negotiate the human–machine relationship in AVT.

Future research could examine how AI-assisted subtitling influences different learner levels (novices vs. advanced students), or how exposure over time affects the development of critical post-editing skills. Comparative studies across different AI subtitling platforms would also be valuable for mapping tool-specific strengths and limitations.

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