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Assessment of students' metacognitive skills in the context of education 4.0

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Introduction: This article measures the meta-comprehension of reading practices among schoolchildren and students.

Methods: The Metacognitive Awareness of Reading Strategies Inventory (MARSI) and Metacognitive Awareness of Reading Strategies Scale (MAI) was used to do this.

Results: The research results showed that MARSI students overall outperformed MARSI high school students, and the differences were tested using Student's *t*-test. The problem-solving subscale recorded high levels for students and moderate levels for high school students. Supported reading strategies and Global reading strategies were in the medium range for each age group.

Discussion: The obtained results are primarily important for students and teachers. By being aware of their cognitive processes, students take the first step towards meaningful and thoughtful reading, which is the goal of many modern developments and approaches. As students become more aware of their cognitive processes, their role in the learning process expands to the point where they dominate it, rather than the teacher.

KEYWORDS

21st-century skills, education 4.0, metacognition, Metacognitive Awareness of Reading Strategies Inventory (MARSI), Metacognitive Awareness Inventory (MAI)

1. Introduction

The current phase of society's development is widely referred to as the Fourth Industrial Revolution (Philbeck and Davis, 2018; Xu et al., 2018; Kayembe and Nel, 2019). The solution to this phase's major problem - insufficient skills and digital competence - is assigned to a new paradigm in education - Education 4.0 (Hariharasudan and Kot, 2018; Hussin, 2018; Keser and Semerci, 2019). Education 4.0 includes nine new features: independent distance learning; personalized learning; the student's freedom to choose teaching methods; students' role in curriculum development; reallocation of responsibilities between instructors and students; students' engagement in short-term projects; emphasis on practical training and field experience; data interpretation; statistical analysis; prediction and modeling using machine learning; more flexible student assessment systems (Hussin, 2018).

Learning metacognition and metacognitive skills is one of the main goals of today's major initiatives. School students must develop solid content knowledge by responding to various audience demands, tasks, goals, and disciplines, by critically synthesizing various resources and evaluating credible evidence (Craig et al., 2020). However, without a metacognitive assessment that can provide relevant data and instructional guidance, educational initiatives seem to unreliably take students' metacognitive development or adequacy for granted (Ozturk, 2017).

Preparing students for learning in the overhauled education system of the 21st century is a challenge. Globalization, technology, migration, international competition, changing markets, and cross-border environmental and political challenges give new relevance to the development of skills and knowledge necessary for learners to succeed in the 21st century. Educational actors, stakeholders, the Ministry of Education, and researchers refer to such skills through various terms, including '21st-century skills', 'higher-order thinking skills, 'deeper learning outcomes' and 'critical thinking and communication skills' (Saavedra and Opfer, 2012; Cabrera et al., 2021; Holt, 2021). According to the World Economic Forum report on Social and Emotional Learning, such skills include Critical Thinking, Communication Skills, Information Literacy, Logical Thinking, Flexibility, Leadership, Initiative, and Analytical Thinking (Figure 1).

The new generation of students is more engaged in learning than previous generations because of technology. They welcome interactive learning environments and teamwork, can study anywhere and are not restricted in their access to information, prefer digital assessment tools, contribute to online forums, and proactively use social media, particularly for educational purposes (O'Keefe et al., 2020; Chiu, 2022; Mpungose and Khoza, 2022; Omirzak et al., 2022). 21st century - skills (Figure 1) are expected to enable students to develop social and cultural awareness, leadership skills and adaptability, perseverance and proactivity, and competencies in critical thinking, creativity, and social interaction (Hussin, 2018). This is a challenge not only for students but also for instructors, who must fully meet the demands of their students and will be able to teach what they have gone through themselves (Anggraeni, 2018). Educational competence (professional knowledge, skills, and abilities) and social competence (the ability to use the techniques of professional communication and coordinated interaction with students and colleagues) are still important in the 21st century, but they are materialized from the digital tools' perspective (Hussin, 2018; Romero-Hall and Jaramillo Cherrez, 2022).

Following global trends, the following goals were set for instructors in Kazakhstan: improve teaching skills amid the challenges of contemporary education; overhaul existing approaches to assessment; and wide use of innovative technology in professional activities.

The Education 4.0 approach, which incorporates the wide use of digital tools by instructors and students, is designed to provide society with proactive experienced professionals who can think critically and analytically, collaborate cohesively, be creative, flexible, and show leadership skills (Anggraeni, 2018; Hussin, 2018; Halili, 2019; Keser and Semerci, 2019). Digital tools do not replace reading but can transform it. The act of reading encompasses more than a mere passive reception of information. It also deals with thinking, evaluating, judging, analyzing, imagining, reasoning, and solving problems (Liao and Tian, 2022). The modern reader has unlimited access to information and can get an answer to almost any question in a matter of minutes, whereas before it took days to search through encyclopedias, archives, and libraries. Besides hard copies, school and university students around the world get information from phones, tablets, laptops, and interactive boards. Kazakhstani students, including our respondents, also widely use digital sources to meet their daily reading needs in academic and non-academic settings.

The paper explores metacognition and high school and undergraduate students' reading strategies in their academic reading practices. To achieve this goal, a number of tasks need to be solved: assessment of middle school students' metacognitive comprehension and use of reading strategies when reading school-recommended resources; assessment of university students' metacognitive comprehension and use of reading strategies when reading academic resources; assessment of the outcomes of the two groups for statistically significant differences; measurement of the metacognitive skills of school and university students.

1.1. Literature review

A chronological analysis of these studies suggested that recent assessments of metacognitive skills tended to use tasks related to a specific real-world context. To understand how metacognitive theory

FIGURE 1
Basic 21st-century skills.

and previous research on metacognition affect current assessment practices, these studies will be reviewed to define metacognition, assessment measures and procedures, and their limitations, if any. Furthermore, selected studies will be presented in chronological order to determine whether there is a new pattern in the assessment of metacognition as relevant literature continues to expand.

Addressing developmental differences among 5-8th grade students in monitoring comprehension and intended use of reading strategies, Kolić-Vehovec and Bajšanski (2006) used error correction and text sensitivity tasks from the meta-comprehension test. Self-reported data on the applied reading strategies were also adopted. Whereas the findings revealed significant differences in text comprehension scores and Cloze task performance, there were no statistically significant differences in error detection and text sensitivity between scores. Furthermore, comprehension monitoring was found to correlate significantly with reading comprehension. However, reading comprehension strategies were attributed to reading comprehension only for eighth-grade students.

Desoete (2008) assessed the metacognitive skills of third-grade students. To this end, four skills were examined: prediction, planning, monitoring, as well as assessment and calibration using the Prospective Assessment of Children (PAC), Retrospective Assessment of Children (RAC), and instructor assessments as autonomous assessments and a think-aloud protocol. On top of that, the EPA 2000 was used as a combined (prospective and retrospective) form of assessment. The instructor confirmed the outcomes: predictive skills scores correlated positively with the combined assessment measure but not with the children's questionnaire. Instructors' scores on assessment skills also correlated with concurrent and combined assessment methods. In addition, instructors' overall scores correlated with the performance of the intended child. The results of the children's perspective and retrospective questionnaires, which were not significantly affected by actual student performance, did not differ and showcased some evidence of convergent validity. The assessment skill was found to be relatively independent in the intended children's assessments and thinking aloud. On the other hand, the think-aloud protocols have presented some evidence of the interplay of monitoring, planning, and prediction skills. Although skills tend to be interrelated, the author recommended assessing skills separately.

To investigate the metacognition of Turkish high school students and its relationship to achievement goals, Sungur and Senler (2009) investigated students' metacognition by its preliminary components. For this purpose, the study resorted to the Metacognitive Awareness Inventory (MAI), the Achievement Goal Questionnaire (AGQ), the Expected Competence Scale, and the Challenges and Threats Interpretations. By conducting a confirmatory factor analysis, the authors drew attention to respondents' strong awareness of learning strategies. It was also claimed that all types of centering around goals as well as knowledge and cognitive control positively correlate at each level.

Turan et al. (2009) argued that metacognitive awareness and self-regulated learning skills are especially important in the medical field because of the rapid change in knowledge. Conducting their study at four different medical schools with different curricula, the authors used the Self-Regulated Learning Perception Scale (SRLPS) and the Metacognitive Awareness Inventory (MAI) to collect data from 862 students. They found a statistically significant difference between medical school curriculum designs. MAI and SRLSP scores were higher for students in problem-based learning (PBL) curricula than in the case of discipline-and systems-based curricula designs.

Recognizing the importance of reading in a second language, Zhang (2009) suggested that non-native readers can apply their native language reading knowledge and strategies in the context of a second and/or foreign language. For effective strategy instruction, the paper also assessed students' metacognitive awareness and use of reading strategies and examined whether there were any differences in strategy choice between various levels of language proficiency. The author used SORS for this purpose. Analysis showcased that respondents use reading strategies with high frequency, with moderate to high use of problem-solving strategies as the primary choice, followed by global and support strategies (Sheikh et al., 2019).

Onovughe and Hannah (2011) also studied middle school students' awareness and use of metacognitive strategies to understand the course content and learning resources. Whereas students' awareness of reading skills and strategies was assessed on a 2-point scale, a set of 5 questions was used to measure students' reading goals. The authors argued that middle school learners were largely aware of metacognitive strategies, as there were over 60% confirmations for each aspect of metacognitive strategies. Furthermore, such respondents were heavily employing metacognitive strategies in reading and comprehension. The authors also emphasized the correlation between metacognitive awareness and the use of metacognitive strategies.

Studying the relationship between cognitive regulation and everyday problem-solving, Lee et al. (2009) selected 254 fifth-grade students and asked them to solve an everyday decision-making problem: how to choose a bicycle. To understand children's decision-making process, the authors adapted the MAI for a problem-solving scenario. The findings made it clear that regulation and awareness of cognitive skills accounted for 30.6% of the variance. Therefore, the authors argued that the students who made the worst decisions in the context of this task could not distinguish between the components of metacognition.

Akyol and Garrison (2011) investigated how online learners demonstrate their metacognitive knowledge and skills. By classifying the responses of 16 undergraduates on knowledge of cognition, monitoring, and cognitive regulation, the authors chose 3 weeks (Week 1, Week 5, and Week 9) of online discussions to assess students' metacognition. Observing possible changes in metacognition over time, the authors claimed that while knowledge of cognition decreases over time, the monitoring and regulation of cognition increases over time.

Saraç and Karakelle (2012) examined the relationship between various online and offline parameters for assessing metacognition. Working with 47 fifth-grade elementary school students, the authors used a teacher assessment scale, a self-reported data questionnaire (Jr. MAI), think-aloud protocols, and judgment of learning score (JOL). The findings provided limited evidence of a correlation between the two offline parameters (positive) and the online parameters (negative). However, there was no significant correlation between offline and online scores.

There is a certain correlation between metacognitive level and academic achievement. Students who develop metacognitive skills usually achieve better results in learning, as they can more effectively use their cognitive potential and manage their learning (Abdelrahman, 2020). For example, students who can plan and organize their work usually perform

better on homework and exams. Additionally, students who can identify their strengths and weaknesses can more effectively work on problem areas and achieve better learning outcomes (Hayat et al., 2020).

Arguing that metacognitive skills directly shape learning behavior and therefore affect learning outcomes, Veenman (2005) assesses metacognitive skills. Because they argued that metacognitive skills could be assessed using online tools, log files of students' online assignments were used as data sources. However, because such log files do not reflect the metacognitive aspects of specific regulations, the analysis of the log files was tested against other online methods. 52 students completed a computer-assisted inductive learning task and then were asked to perform post-tests of performance. The findings suggested strong convergent validity between the logfile scores and assessments of student performance.

Such analysis of ten recent studies confirmed that knowledge of cognition and cognitive regulation were assessed simultaneously in most cases as represented by the metacognitive theory (Ozturk, 2016). Babikova et al. (2018) assessed university students' metacognitive awareness using the Metacognitive Awareness Inventory. The application of metacognitive strategies is considered a basic student skill at any educational level. Ondé et al. (2022) evaluated a short version of the Metacognitive Awareness of Reading Strategies Inventory (MARSI-R) in Spanish. This is a tool for self-reporting designed to measure students' metacognitive awareness and perceptions of the strategies they use when reading school-recommended learning resources. MARSI-R is shaped by three subscales: (a) global reading strategies (GRS), (b) problem-solving strategies, and (c) reading support strategies.

Whereas studies resorted to a variety of measures and procedures to assess metacognition, a total of eight studies in this review relied on various autonomous measures, such as the MAI, MARSI, Jr.MAI, and SORS, to assess knowledge of cognition. Only one study used an online tool to measure knowledge about cognition. This study managed to capture metacognitive behavior, and the researchers concluded the respondents' knowledge of cognition. All studies addressed the regulation of cognitive functions. In addition to the aforementioned measures, various self-reporting, and online tools were used to assess cognitive regulation. However, only five studies assessed cognitive regulation using online tools, such as error correction and text sensitivity, thinking aloud, observing metacognitive behavior, and analyzing online task logs. Furthermore, although not mentioned in the literature, two studies used instructor assessments to test students' metacognition.

Several studies have cited limitations arising from their choice of measurements. Although previous studies and pioneers in the field have explicitly identified the limitations of existing measurement approaches, most researchers in this review were concerned about sample size, the parameters of the respondents, and/or the contexts from which they collected their data, if limitations were ever mentioned. Caution and vigilance are also necessary when considering potential measurement deficiencies, keeping in mind the generalizability of the findings and the need for replicating similar studies.

Recent studies included specific tasks to assess metacognition, rather than assessing it as a rigid framework. Earlier studies tended to use domain-wide autonomous measures to assess metacognition. In contrast, recent studies have included more specific tasks from real-world contexts that require respondents to use various cognitive skills to solve them. While respondents were busy completing tasks, their metacognition was assessed using online tools. Rather than generalizing a person's metacognitive skills, such assessment procedures shed light on metacognitive processes and skills at a specific time.

Metacognition can be defined as knowing and controlling one's cognitive activities. Such metacognitive competence constitutes the foundation of 'learning to learn' and understanding. The development of the learner's metacognitive skills will contribute to the development of his or her self-regulated learning. Flavell (1979), the inventor of the term, defined metacognition as self-knowledge regarding one's cognitive processes and products or anything related thereto. Later he added motivational and affective components to the definition.

The concept of metacognition includes three types of knowledge: (a) declaratory (referring to strategies used for learning), (b) procedural (steps in the use of selected strategies), and (c) conditional (when, where, and why selected strategies are used instead of others), as well as its content - self-regulation through planning, choosing strategies, and evaluating learning or monitoring. These types of metacognitive knowledge and strategies are being studied in many areas of the education sector (Popandopulo et al., 2021). Reading and comprehension are among the major learning tools (Lukitasari et al., 2022; Stakić and Janković, 2022). To become a competent reader, cognitive and self-regulatory skills are needed. These very skills enable awareness and control of comprehension. Successful reading is marked by proficiency in strategies for monitoring and revising approaches to working with texts, a specific degree of awareness of reading methods and task requirements, and the use of context - that is, the meta-comprehension of reading.

2. Materials and methods

2.1. Research design

This study is based on a survey design with a quantitative approach. A purposive sampling method was used to collect data. Such a sample included only eighth and ninth-grade students of secondary schools No. 5, No. 9, No. 16 of Pavlodar and first and second-year students of Pavlodar Pedagogical University (Kazakhstan). The study sample included 218 respondents. Respondents were divided into a group of school students ($n=111$) and a group of university students ($n=107$). The survey was conducted in educational institutions using cell phones or tablets (in Google Forms) after the end of core classes. The instructor was the same person.

Two methods were used in this study: Metacognitive Awareness of Reading Strategies Inventory (MARSI) and Metacognitive Awareness Inventory (MAI). These tools are autonomous measures because they can be applied effectively to large groups and are easy to evaluate. MARSI was designed to assess metacognitive skills specific to a particular subject area. The approach developed by Mokhtari and Reichard (2002) was used to measure: metacognitive awareness among adolescent and adult readers and perceived use of reading strategies; global reading strategies, problem-solving strategies, and hands-on support strategies.

MARSI is notable among the many instruments created to assess reading metacognition due to its user-friendliness, as noted by Mokhtari and Reichard (2002). The methodology proposes

three subscale-based assessments of the subject area: global reading strategies (GLOB Subscale, centering around global text analysis); problem-solving strategies (PROB Subscale, used in situations where parts of the text seem difficult to read); and assistive reading strategies (SUP Subscale, support strategies such as using reference materials or taking notes) (Figure 2). These strategies are activated when a text presents a certain degree of comprehension difficulty for the learner.

Mokhtari and Reichard (2002) developed a survey questionnaire comprising 30 items that were divided into three subscales: GLOB Subscale (items 1–13), PROB Subscale (items 14–21), and SUP Subscale (items 22–30). The reliability of MARSI has been endorsed by many previous studies. The instructor explained the purpose of the survey, after which students had to read each of the 30 statements and report using the strategy described in that statement on a 5-point Likert scale, where 1 stand for 'never' and 5 stands for 'always'. The instructor emphasized that students' answers should only be about reading school-recommended resources.

Scores were calculated for each respondent on 3 subscales, and the overall average score for each subscale was determined. The findings were ranked as follows: strong (more than 3.5 points), medium (2.5–3.4 points), and poor (2.4 and below). Using the MARSI methodology (Mokhtari and Reichard, 2002), the study focuses on reading (both paper and digital sources). Differences between the two age categories (undergraduate students and school students) were assessed using Student's *t*-test. The null and alternative hypotheses of the study were put forward. H0: no statistically significant difference between MARSI in the two age groups. H1: there are statistically significant differences between MARSI in the two age groups.

The MAI developed by Schraw and Dennison (1994) is used to measure general adult metacognitive knowledge and cognitive regulation. These tools are autonomous measures because they can be applied effectively to large groups and are easy to evaluate. This study measured the knowledge of cognition and cognitive regulation. According to the methodology adopted by Vancouver Island University (Canada), possible answers included 'rather agree' (1 point) or 'rather disagree' (0 points). The findings were ranked as follows: strong (more than 114 points), medium (85–114 points), poor (50–84 and below), and very low (less than 50).

The questionnaires were validated using Cronbach's alpha version. The interpretation of Cronbach's alpha values is as follows: >0.9 is excellent; >0.8 is good; 0.7 is acceptable; 0.6 is doubtful; and > 0.5 is poor. The overall Cronbach's alpha value for the questionnaire was 0.92 for MARSI and 0.88 for MAI. Conclusion - the questionnaire is reliable and can be used for surveying.

2.2. Ethical issues

Participation in the study was voluntary. All underage respondents received written parental (guardian) consent to participate. No personal information was collected.

2.3. Research limitations

This study is subject to specific limitations. There is a chance that students were aware of reading strategies, but did not have the opportunity to practice them within the educational institutions, as the entire focus was on the specific task at hand, rather than an awareness of the importance of reading strategy. It is also important to mention that students might not have recognized the importance of using reading strategies even though they were aware of them. Merely knowing the strategies of reading is not enough. It is important to apply them successfully and to focus on controlling this application.

In addition, evaluating metacognitive skills involves taking into account different factors that may impact metacognitive engagement and can be mistaken for student competency. For example, when a person is evaluated for one's own accomplishments, achievement motivation can interfere with interpretation. On the other hand, such a person may not be interested in the given task and, therefore, may not be motivated to perform the task. Without recognition of the features and potential consequences of tasks and recognition of individuals' volitional control, interpretations of metacognitive assessment may be biased or incomplete (Liu and Read, 2021). Therefore, future research on metacognitive assessment needs to consider motivators or barriers for learners to engage in metacognitive processes and actions.

3. Results and discussions

3.1. MARSI

Table 1 provides the survey outcomes for the MARSI questionnaire. The first column provides the question number on the MARSI questionnaire. The second column shows the subdivision of this question in the subscale (Glob, Prob, Sup). The third column provides the average score given by respondents from the 'undergraduate students' sample. The fourth column gives the standard deviation of the 'undergraduate students' sample. The average score of the "school students" sample is provided in the fifth

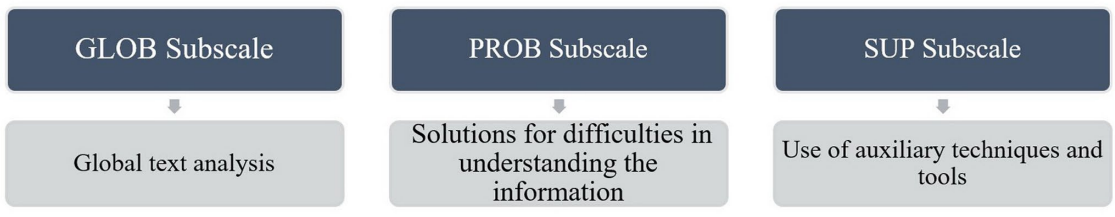

FIGURE 2
MARSI subscales.

TABLE 1 MARSI survey outcome.

Question number in the questionnaire	Question number in the subscale	undergraduate students		School students	
		M	SD	*M*	SD
1	Glob1	2.70	0.96	2.53	1.12
2	Glob2	2.43	0.94	2.96	1.24
3	Glob3	2.96	1.01	2.47	1.06
4	Glob4	3.14	1.06	3.06	0.96
5	Glob5	2.51	1.04	2.79	1.05
6	Glob6	2.20	1.08	2.34	1.13
7	Glob7	3.04	1.12	2.89	1.09
8	Glob8	2.96	0.97	3.16	0.99
9	Glob9	8	1.05	3.24	1.04
10	Glob10	3.11	0.97	2.46	1.13
11	Glob11	2.72	1.99	2.68	0.98
12	Glob12	2.64	1.12	2.74	1.02
13	Glob13	3.19	1.09	2.59	1.09
Average Glob		2.80	1.11	2.76	1.07
14	Prob1	3.41	0.94	2.53	1.24
15	Prob2	3.26	1.15	2.64	1.06
16	Prob3	3.15	1.02	2.89	1.12
17	Prob4	3.69	1.06	2.96	1.13
18	Prob5	3.80	0.99	2.54	1.07
19	Prob6	3.74	0.98	2.74	1.04
20	Prob7	3.55	1.14	3.05	1.01
21	Prob8	3.91	1.06	2.49	1.08
Average Prob		3.56	1.04	2.73	1.09
22	Sup1	3.16	0.92	3.02	0.98
23	Sup2	2.87	1.06	2.66	0.94
24	Sup3	3.04	0.99	2.89	0.82
25	Sup4	3.32	0.95	3.15	1.04
26	Sup5	3.40	1.04	2.68	0.93
27	Sup6	3.19	1.07	2.64	0.81
28	Sup7	2.95	1.17	2.85	1.01
29	Sup8	3.14	0.96	3.08	0.95
30	Sup9	3.08	0.93	3.13	0.92
Average Sup		3.13	1.01	2.90	0.93

Mokhtari and Reichard (2002)

column. The sixth column contains the standard deviation of the 'school students' sample.

Therefore, MARSI undergraduate students generally outperformed school students on all three subscales: 2.80 for 'undergraduate students versus 2.76 for 'school students' on the Glob subscale; 3.56 for 'undergraduate students versus 2.73 for 'school students' on the Prob subscale; 3.13 for 'undergraduate students' versus 2.90 for 'school students' on the Sup subscale. Undergraduate students reported a strong use of the Prob strategy, whereas the Glob and Sup strategies were used at an intermediate level. School students report average use of all three strategies. Table 2 shows the

TABLE 2 The results of the Student's *t*-test between two samples.

	Glob	Prob	Sup
t-statistic	0.40	6.08	2.77
p-value	0.70	0.00	0.02
tcr	2.18	2.36	2.31

results of the *t*-test for the three subscales (Glob, Prob, Sup) at $p < 0.05$. A Student's *t*-test between the two samples showed statistically significant differences between MARSI's 'undergraduate students' and 'school students' on the two subscales - Prob and Sup, whereas, on the Glob subscale, the outcomes for the two age groups are not statistically significantly different.

Questions 1–13, relating to Global Reading Strategies, were generalized, intentional reading strategies. The outnumbering of senior students was not statistically significant in the category of global analysis of academic program texts. Each age group rated its own MARSI within the average level. Questions 14–21 of the Problem-Solving subscale focused on strategies for dealing with the difficulty of reading test comprehension. A statistically significant difference was found between undergraduate students and school students in their MARSI scores, with undergraduate students reporting higher levels of reading metacognition. This suggests that undergraduate students may have better skills for working with difficult-to-understand texts, which could be attributed to their stronger focus on problem-solving in higher education. Questions 22–30 (about Support Reading Strategies) regarding the use of external reference information, notes, and other hands-on support strategies also showcased an advantage in metacognition for the senior respondents, who, coping with academic programs of higher education, are proactively practicing functional and auxiliary strategies.

3.2. MAI

Table 3 shows the respondents' answers to the MAI questionnaire. The first column shows the age group. The second column provides the number of respondents. The third column contains the grade point average (on a 5-point scale adopted in Kazakhstan). The fourth column provides the average MAI score (expressed in points). The fifth column shows the average MAI (expressed as a percentage). Table 3 suggests that the 'undergraduate students group is slightly ahead of the 'school students group in terms of average MAI score while having a lower grade point average.

Table 4 shows the distribution of respondents by the level of metacognitive awareness. The first column shows the level according to the ranking adopted in the study. The second column provides the range of scores. The third column shows their values, expressed in percentage terms. The fourth column provides the number of students by MAI. The fifth column gives the percentage of students based on the MAI level. The sixth column presents the average MAI score for each level. The seventh column presents each level's average MAI score (expressed in percentage terms).

The distribution of respondents in both groups depending on metacognitive awareness (Table 4) showed that 4.1% of students have very low metacognitive awareness, 40.8% have poor metacognitive awareness, 46.8% have medium awareness, and 8.3% of students have

TABLE 3 The respondents' answers to the MAI questionnaire.

Age group	Number of students	Average grade point average	Average MAI	
			Scores	%
Undergraduate students	107	3.67	101.2	46.3
School students	111	4.10	96.9	44.5

TABLE 4 Distribution of respondents by metacognitive awareness.

Level	Range		Students		Average MAI	
	Scores	%	Quantity	%	Scores	%
Very low	Less than 50	0–25	9	4.1	21.3	9.8
Poor	84–50	26–50	89	40.8	74.4	34.1
Medium	114–85	51–75	102	46.8	103.6	47.5
Strong	More than 114	76–100	18	8.3	125.2	57.4

strong metacognitive awareness. This can be considered a very satisfactory outcome for Education 4.0. Analysis of variance showed no statistically significant differences between the different age groups of participants, so summarized outcomes are presented (Table 4).

Based on the data presented in Table 5, one can see the presence of a high level of correlation between metacognitive understanding, deployment of reading strategies among students, and academic success. Integrating cutting-edge technology into the learning process has become an integral task of teaching. Being no longer associated with print media, learning resources are distributed in visual, audio, and graphic form, which inevitably changes the idea of literacy (Boche and Henning, 2015).

Researchers who relied on the Metacognitive Awareness of Reading Strategies Inventory (MARSI) questionnaire, report undergraduate students' preference for problem-solving strategies over support strategies and global reading strategies (Kazi et al., 2020), which is consistent with the findings of this paper. Previous studies addressing online reading have also reported problem-solving and information comprehension strategies (similar to the Prob and Sup subscales considered in this study) as the ones which are most cited by respondents (Sain et al., 2019). However, it is appropriate to clarify that this study did not distinguish between online and offline reading, reading from paper or digital sources, but viewed reading as a holistic process, allowing for both paper and electronic modifications. Adaptation of the MARSI questionnaire for reading text using digital devices (e.g., iPads) started by identifying the need to specify iPad use strategies for academic reading purposes. An adapted version of i-MARSI was tested on a large sample ($n = 869$), with the resulting high i-MARSI reliability scores (Cardullo et al., 2018). The MARSI questionnaire was not originally intended by its creators to be a comprehensive measure of students' ability to control comprehension. Instead, it is intended to help students to improve metacognitive awareness and use of strategies while reading from paper sources (Mokhtari et al., 2018), which is quite sufficient for the purposes and objectives of this study.

Those who read fluently in English were reported to be more likely to use global strategies, switch between reading tasks more easily, and

TABLE 5 Results of the correlation analysis of the studied factors.

	g-value	Significant values
MARSI	0.66	0.00
MAI	0.55	0.01

align their reading strategies more effectively with specific needs (Huang, 2012; Bedir and Dursun, 2022). This is an interesting conclusion, which the current study, in terms of its objectives, can neither refute nor confirm. Indeed, third and fourth-year university students in Kazakhstan often use international publications in English in their learning activities. However, their English skills usually do not allow them to read articles without an online translation tool. Hence, it is possible that the members of the "undergraduate students" sample scored higher on the GLOB subscale due to their fluency in English.

The research findings suggest that metacognition scores correlate with overall achievement in both the 'school students' and the 'undergraduate students' samples. Numerous studies (Avargil et al., 2018; Ward and Butler, 2019; Abdelrahman, 2020) support a similar conclusion. Some researchers suggest that self-regulation and self-efficacy are as closely related to academic achievements as metacognitive awareness (Ward and Butler, 2019). Indeed, these, as well as a number of other factors, can interact with metacognition and contribute to the final MAI score, as the concept of metacognition is multifaceted, and it is possible to limit it to a certain framework only purely theoretically.

Reflection can help students better understand their learning experience and find ways to improve it. This may involve analyzing what students have learned, how they have learned it, what they have understood, and what they need to improve. Reflection can be used to analyze not only academic experiences but also personal and professional development (Muhid et al., 2020).

A comprehensive analysis of the relationship between students' midterm and final grade point averages reported a significant correlation between MAI and student grade point averages (Young and Fry, 2008). However, attention is drawn to the fact that MAIs and midterm grades for personalized learning assignments do not often have a strong correlation. This study looked only at the relationship between MAI and student grade point average. The issues of the correlation of midterm assessments, such as homework, projects, exams, and MAIs of students of different ages, are left for future researchers to consider. This is a promising area, as it will clarify the focus of the curriculum and improve the learning effectiveness as part of Education 4.0 implementation.

4. Conclusion

The paper explored metacognition and high school and undergraduate students' reading strategies in their academic reading practices. Metacognitive comprehension and deployment of reading strategies among school and university students were assessed using the MARSI questionnaire, which included three assessment subscales. On the Global Reading Strategies subscale, undergraduate students and school students rated their ability at an average level. When it comes to the Problem-Solving subscale, undergraduate students reported strong metacognitive skills, while school students reported medium metacognitive skills. As for the Support Reading Strategies, each age group's scores are within the medium level. Although the

advantage demonstrated by university students for each of these scales was not statistically significant according to the Student's *t*-test, they still showed a slight priority. An assessment of school and university students' metacognitive skills based on the MAI questionnaire suggested that 48% of students have a medium level of metacognitive awareness, while only 4.1% of students have a very low level of metacognitive awareness. Students' metacognitive awareness correlates with their overall performance.

School and university educators interested in using effective strategies to develop metacognition can learn from the identified assessments of students' metacognitive skills, to properly incorporate metacognitive practices into the learning process. The results can be used to improve student achievements and more effective student learning, instruction planning, and classroom research. Knowing their metacognitive skills makes students aware of their reading strategies, allows them to compare themselves to other readers, and changes their attitudes toward text comprehension.

Future researchers have the opportunity to develop effective teaching methods that promote the development of metacognitive skills. Special courses could be created that teach students various strategies for controlling and regulating their cognitive processes. Additionally, tools and technologies could be developed to help students track their progress and evaluate their achievements.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Pavlodar Pedagogical University (Kazakhstan). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

AP, AK, and NF contributed to the conception and design of the study. MN organized the database. AK and NK performed the analysis. NF wrote the first draft of the manuscript. AP, AK, NK, and NF wrote sections of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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