



CHEMISTRY TEACHERS' UNDERSTANDING OF LITERACY AND LEARNING SKILLS AS PART OF 21ST CENTURY SKILLS: A QUANTITATIVE DESCRIPTIVE ANALYSIS

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Abstract. Teachers play a crucial role in equipping students with 21st-century skills. Chemistry teachers' understanding of these competencies, particularly literacy and learning skills, is essential in shaping how they integrate them into classroom practice. This study explores the level of understanding chemistry teachers have regarding literacy and learning skills as core components of 21st-century skills. This study used a quantitative descriptive approach, using a questionnaire as its instrument. The questionnaire consisted of 44 questions covering aspects of literacy skills and learning skills. Data were obtained from 52 alumni of the Chemistry Education Study Program at UIN Syarif Hidayatullah Jakarta who currently work as chemistry teachers. Data analysis was conducted using descriptive statistics to assess the teachers' level of understanding in each domain and sub-aspect. Findings indicate that chemistry teachers' understanding of literacy and learning skills falls within the good category (74.1%) based on the average score across all measured aspects. In learning skills, the highest level of understanding was observed in communication and collaboration (72.4%), while critical thinking scored the lowest (69.4%). Regarding literacy skills, understanding was highest in information literacy (79.2%) and lowest in media literacy (75.2%). These results indicate that chemistry teachers have a good understanding of 21st-century skills, although critical thinking and media literacy skills still need improvement. Therefore, it is hoped that there will be a targeted development program for chemistry teachers to strengthen these weak skills.

Keywords: 21st century skills, perception, teacher understanding

INTRODUCTION

The advancement of the times demands that every student be well-prepared to face future competition. In the 21st century, academic achievement alone is insufficient to ensure individual success. Therefore, students must have various supporting skills to meet these challenges. There are three 21st-century skills that students are expected to master: learning skills, literacy skills, and life skills (Herlina et al., 2023). According to the Partnership for 21st-Century Skills, learning skills include creativity and innovation, critical thinking and problem-solving, and communication and collaboration. Literacy skills encompass information, media, and technology literacy, while life skills include productivity and accountability, leadership and responsibility, empathy and adaptability, and social and cross-cultural competence (Kaya et al., 2023).

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The role of educators is crucial in achieving student success and mastering their future skills. Education in Indonesia has implemented a Kurikulum Merdeka to meet the demands of the changing paradigm of 21st-century learning (Maulidia et al., 2023). This curriculum expects educators to guide students to master 21st-century skills, such as being productive, creative, innovative, and practical, by strengthening integrated attitudes (knowing why), skills (learning how), and knowledge (knowing what) (Redhana, 2019). The application of 21st-century skills in chemistry learning is crucial for preparing students for careers and future competition. Therefore, teachers' understanding as educators and mentors is crucial for mastering and applying 21st-century skills to learning, particularly in chemistry.

In addition to learning skills, 21st-century skills that require attention are media and digital literacy (Weninger, 2017). It is crucial for maximizing technology and information to develop students' potential in chemistry learning. Effective use of technology can improve teaching and learning quality and enhance thinking and other 21st-century skills (O'Neal et al., 2017). However, chemistry teachers still consider mastering 21st-century learning skills and literacy difficult and unimportant. It is because teachers often consider memorization paramount (Li, 2016), and many teachers struggle to incorporate the latest technology, leading to the continued use of outdated learning models (O'Neal et al., 2017).

Based on this explanation, teachers' understanding of teachers will undoubtedly influence how they guide students in developing their literacy and learning skills in the 21st century, particularly in chemistry education. Therefore, it is important to examine chemistry teachers' understanding of these two skills to determine their readiness to apply them in classroom practice.

METHOD

This study employed a quantitative descriptive approach, collecting data through a survey method. The sampling technique used was purposive sampling, targeting graduates of the Chemistry Education Study Program at UIN Syarif Hidayatullah Jakarta who work as chemistry teachers. This criterion was established to focus on the level of understanding of chemistry teachers who have received formal education in chemistry education from the same institution. Of the total population of graduates who met the criteria, 78 respondents agreed to participate, and 52 were considered representative. The identity and confidentiality of all questionnaire respondents were guaranteed.

Data collection was conducted using a questionnaire distributed through Google Forms. Each respondent completed the questionnaire independently. The questionnaire items were structured using a Likert scale, allowing researchers to measure respondents' understanding of 21st-century learning and literacy skills. Before use, the questionnaire underwent a content validity test by chemistry education experts to ensure the indicators aligned with the measured constructs. Empirical validity testing was conducted using item-total correlation analysis. The instrument's reliability was tested using Cronbach's Alpha coefficient, with a 0.922 result indicating high reliability. Validity and reliability tests revealed 44 valid and reliable statements.

The data analysis process consisted of five main stages. First, editing was performed to ensure completeness and consistency of the collected responses. Second, scoring was conducted by assigning values from 1 to 4 according to the Likert scale. Third, tabulating involved organizing responses into tables and diagrams to facilitate data processing. The percentages obtained were categorized into five interpretation levels: excellent, good, enough, less, and very less (Hadeli, 2006). The tabulating

process is carried out by calculating the results of the teacher's perception research questionnaire using the percentage formula:

$$P = \frac{F}{N} \times 100\%$$

Remarks:

P = Percentage

F = Respondent's answer effect

N = Number of cases

The questionnaire results were analyzed using the Likert scale (Riduwan, 2007), which is then grouped according to Table 1.

Table 1. Clarification of percentage interpretation

Percentage (%)	Interpretation
81-100	Excellent
61-80	Good
41-60	Enough
21-40	Less
0-20	Very less

The fourth stage, data display, involved presenting the processed data in narrative form. Finally, the fifth stage was conclusion drawing and verification, in which the results were interpreted and compared with existing theoretical frameworks (Hadeli, 2006).

RESULTS AND DISCUSSION

Based on the results of a study of 52 chemistry teacher respondents, it was shown that the understanding of learning skills and literacy in supporting 21st-century skills was included in the "good" category, with an average score of 74.1%, while the perception of chemistry teachers towards skills and literacy can be explained as follows:

Chemistry Teachers' Understanding of Learning Skills.

Based on the results of the study, it can be seen that the communication and collaboration aspects are the aspects that have the highest percentage of assessment, followed by the percentage of creative thinking and innovation and the aspects of critical thinking and problem-solving (Tables 2, 3, and 4). The discussion of teachers' understanding of each aspect of learning skills is explained as follows.

a. Creative Thinking and Innovation

Respondents were given six indicators with seven statements to assess their perception of creative thinking and innovation. The results showed that respondents had a good perception of each indicator, except for the concept of innovation, which was included in the enough category.

Table 2. Results of creative thinking and innovation perception

Indicator	Percentage	Criteria
Understanding the concept of creative thinking	77.9% ± 0.58	Good
Realize the importance of creative thinking	73.8% ± 0.56	Good
Apply creative thinking skills	68.3% ± 0.53	Good
Understanding the concept of innovation	57.7% ± 0.70	Enough
Recognizing the importance of innovation	77.4% ± 0.63	Good

Indicator	Percentage	Criteria
Applying innovation capabilities	73.6% $\pm$ 0.61	Good
Average	71.8% $\pm$ 0.65	Good

Respondents' understanding of the concept of innovation is quite good, although some data still indicate misconceptions. Many respondents still view innovation as something that can occur spontaneously, rather than as a process that requires planning, creativity, and directed development. It indicates that, despite its perceived importance, the conceptual depth of the need to direct innovation in students remains unclear. According to Redhana (2019), innovation in education is most effective when built upon a foundation of students' creative ideas, highlighting the importance of cultivating creativity as a precursor to meaningful innovation. Despite these challenges, the results related to creative thinking and innovation skills were categorized as good overall. Many respondents had previously participated in professional development activities or workshops on 21st-century skills. These learning opportunities have positively influenced their understanding and appreciation of the role of creative thinking and innovation in effective teaching. The importance of integrating these skills into the chemistry learning process is well-documented, as they help prepare students to meet the complex demands of the 21st century.

These findings are consistent with previous research by Sinay et al. (2018), which reported that teachers who participated in targeted workshops on 21st-century skills demonstrated a significantly stronger perception and readiness to implement such competencies in the classroom compared to those who had not received similar training. This underscores the value of continuous professional development in enhancing teachers' conceptual understanding and practical application of innovation and creativity in education. Teachers who have participated in the workshop will better understand that creativity and innovation are important to be applied in all subjects, especially chemistry (Sinay et al., 2018). A good teacher's perception will help students master the aspects of creative thinking and innovation because creativity and innovation are skills needed to be ready to face the 21st century, which requires many new solutions and creativity (Kasirer & Shnitzer-Meirovich, 2021).

b. Critical Thinking and Problem Solving

The perception of critical thinking and problem-solving was measured using 12 statement items, organized into six key indicators. The findings revealed that respondents demonstrated a consistently good level of perception across all indicators, suggesting a positive overall understanding of these essential 21st-century skills (Table 3).

Table 3. Results of critical thinking and problem-solving perception

Indicator	Percentage	Criteria
Understand the concept of critical thinking	70.7% $\pm$ 0.58	Good
Supports critical thinking skills	68.0% $\pm$ 0.63	Good
Directs critical thinking skills	67.5% $\pm$ 0.60	Good
Understand the concept of problem-solving	69.5% $\pm$ 0.61	Good
Recognize the importance of problem-solving skills	72.1% $\pm$ 0.54	Good
Direct problem-solving capabilities	68.8% $\pm$ 0.55	Good
Average	69.4% $\pm$ 0.65	Good

The respondents understand critical thinking and problem-solving well, which can be attributed to their previous participation in 21st-century skills training. All respondents were chemistry graduates who had certainly learned how to apply critical thinking skills in their learning. This aligns with the findings of Tuzlukova et al., (2018), which indicate that teachers who undergo relevant training tend to develop a strong grasp of critical thinking and problem-solving competencies.

This result is meaningful because chemistry teachers with a strong understanding of these skills tend to integrate them effectively into their teaching practice, especially in chemistry education. Educators who model and apply critical thinking and problem-solving in the classroom are better positioned to guide students in developing these essential skills. As supported by previous research by Toharudin (2017), the implementation of such skills by teachers significantly contributes to students' ability to analyze, evaluate, and synthesize information.

Furthermore, Panggabean et al., (2021) emphasize that students require critical thinking and problem-solving abilities to make sense of the vast information they encounter. These competencies enable learners to approach real-life challenges with a reflective and solution-oriented mindset, which is vital for navigating the complexities of 21st-century life, particularly through chemistry learning.

c. Communication and Collaboration

Regarding communication and collaboration, respondents' perceptions were assessed by filling in 10 statements grouped into six indicators. The results showed respondents had an excellent perception of indicators supporting the collaboration process, while the other five indicators were categorized as good.

Table 4. Results of communication and collaboration perception

Indicator	Percentage	Criteria
Understanding the concept of communication	78.8% $\pm$ 0.64	Good
Realize the importance of communication skills	71.2% $\pm$ 0.62	Good
Develop communication skills	76.4% $\pm$ 0.54	Good
Understanding the concept of collaboration	68.3% $\pm$ 0.75	Good
Support the collaborative process	81.7% $\pm$ 0.60	Excellent
Apply collaboration skills	64.4% $\pm$ 0.54	Good
Average	72.4% $\pm$ 0.74	Good

The results of this questionnaire show that respondents have understood the urgency and support the collaborative process in chemistry learning. Respondents supported the collaboration process by appreciating each student equally, without discriminating against their position when working in groups. This result is supported by the statement of Loes et al., (2018), where, when students collaborate, it is important for teachers to guide students to respect and appreciate each member regardless of their background.

Overall, respondents gained a good perception of communication and collaboration. This result was obtained because respondents had participated in training on communication and collaboration in 21st-century skills. This ability must be applied in chemistry learning to prepare students for the global era. These results align with Ngang et al., research, which stated that teachers who have participated in professional training perceive communication and collaboration skills as the two primary soft skills important to prepare for the future (Ngang et al., 2015).

Teachers who have a good perception of the aspects of communication and collaboration will apply the elements of communication and collaboration in

chemistry learning. Bahtiar et al. stated that the ability to communicate and collaborate is important for students in dealing with cultural and economic developments in the global era (Bahtiar et al., 2023). In addition, teachers who have a good perception of the aspects of communication and collaboration will direct students to be able to understand and use spoken language well, as well as be able to work in a team, have leadership qualities, and share responsibility (Thornhill-Miller et al., 2023).

Chemistry Teacher's Perception Regarding Literacy Skills

The study results show that information literacy has the highest percentage of perception, followed by the elements of technological literacy and media literacy. An explanation of perception in each component of literacy skills is explained as follows:

a. Information Literacy

In the aspect of information literacy, respondents' perceptions were assessed using six statements. The results showed that the respondents obtained a very good category in the indicator of understanding the concept of literacy and a good category in the other two indicators.

Table 5. Results of information literacy perception

Indicator	Percentage	Criteria
Understanding Information Literacy	81.3% $\pm$ 0.68	Excellent
Realize the importance of information literacy	77.2% $\pm$ 0.54	Good
Directing Information Literacy	79.3% $\pm$ 0.68	Good
Average	79.2% $\pm$ 0.65	Good

Respondents appeared to have a good understanding of the urgency of information literacy in chemistry learning. That demonstrates a strong awareness among chemistry teachers of the importance of verifying the accuracy of information used in the learning process. Respondents recognized the importance of ensuring information validity to avoid misunderstandings or misinformation when presenting instructional content. This attitude aligns with Enikő (2023), who emphasized that one of the key characteristics of adequate information literacy is the ability to identify and disseminate information before applying it. Therefore, teachers are expected to be prepared to guide their students in using available information ethically.

The results of this study also indicate that respondents understood how to develop and cultivate sound information literacy skills. This understanding was acquired during their higher education. This aligns with the findings of Bury et al., (2017), who noted that graduates and final-year students generally demonstrate strong information literacy skills due to frequent exposure to and familiarity with their application during their academic studies. This experience equips them with the competencies to guide students in effectively using reliable and relevant information. Chemistry teachers' strong perceptions and understanding of information literacy are closely related to their ability to select appropriate and credible learning resources. It will undoubtedly improve the quality of chemistry teaching materials provided to students and support a more accurate and meaningful chemistry learning experience.

b. Media Literacy

Respondents' perceptions of media literacy were assessed through five statements broken down into three indicators. The results showed that respondents had a good understanding of the concept and application of media literacy and an excellent understanding of the importance of media literacy in the learning process. The respondents' background likely influences these positive results, as they are

education graduates. It is because during their higher education, respondents received lectures and training on the importance of using media in chemistry learning. This experience contributed to their awareness of the importance of integrating media literacy into chemistry learning.

These results align with those of Setyowati & Mawardi (2018), who found that teachers who received instruction and training on media use demonstrated good perception training and were better prepared to apply media literacy in their teaching practice. This certainly reinforces the idea that positive chemistry teacher perceptions will influence the implementation of targeted skills in chemistry learning. Furthermore, Maraver-López et al., (2017) also emphasized that those with a good perception of media literacy are better prepared to adapt to developments in educational media and design innovative learning strategies based on the latest technological advances. That suggests that chemistry teacher respondents will undoubtedly be able to adapt to various emerging media and apply them in chemistry learning.

Table 6. Results of media literacy perception

Indicator	Percentage	Criteria
Understanding the Concept of Media Literacy	69.7% ± 0.64	Good
Realizing the importance of media literacy	84.1% ± 0.59	Excellent
Implementing Media Literacy	68.3% ± 0.60	Good
Average	75.2% ± 0.70	Good

In 21st-century education, integrating media into the classroom has become a fundamental element of effective teaching. Therefore, modern educators, including chemistry teachers, are expected to be no longer unfamiliar with utilizing diverse learning media to enhance student engagement, skills, and understanding. In the learning process, teachers must be skilled at finding, selecting, and using media appropriate to the needs and abilities of their class (Asmawati, 2021).

c. Technology Literacy

The understanding of technological literacy was measured using four statement items distributed across three indicators. The findings revealed that respondents demonstrated a good level of perception across all indicators. This positive perception is likely the result of prior participation in professional training or workshops, which enabled chemistry teachers to recognize the importance of integrating technological literacy into their teaching practices.

Table 7. Results of technology literacy perception

Indicator	Percentage	Criteria
Understands Information and Communication Technology (ICT) concepts	78.4% ± 0.53	Good
Realizing the importance of ICT	80.0% ± 0.66	Good
Implementing the use of ICT	68.3% ± 0.63	Good
Average	76.7% ± 0.66	Good

These findings indicate that chemistry teacher respondents positively perceive the application of technological literacy to their students. It is likely because teachers who are education graduates have been taught to implement technological literacy in chemistry classrooms. This finding is supported by research by Nafisah et al., (2024), which states that teachers who have participated in technology-focused training are more likely to have a positive perception of technological literacy. This positive

understanding improves their chemistry teaching strategies and can positively contribute to students' enthusiasm for understanding and applying technology in chemistry learning contexts. Nowadays, teachers not only have to master subjects and pedagogical knowledge, but also need to know about technology in the learning process (Aini et al., 2022).

Given the rapid advancement of educational technology, chemistry teachers' ability to effectively integrate technological tools is crucial in facilitating meaningful and future-ready learning experiences, especially in subjects like chemistry, where visualization, simulation, and interactivity can significantly enrich the delivery of chemistry content. Furthermore, in the process of integrating technology, teachers must already understand the significant role technology plays in the classroom. According to Almerich et al., (2024), teachers must be able to plan the implementation of technology in the school based on a structured approach, considering that the implementation of technology is not only a matter of mastery but also requires in-depth understanding and habituation.

CONCLUSION

Based on the research findings, chemistry teacher respondents demonstrated a good understanding of 21st-century learning and literacy skills, reflected in the overall average percentage score of 74.1%, which is categorized as good. This finding indicates that respondents generally have a good understanding of integrating key 21st-century competencies, such as critical thinking, collaboration, information literacy, and the use of technology into their teaching practices. Their positive perceptions reflect conceptual awareness and practical readiness to support students in developing essential skills for future academic and professional success. For further research, it is hoped that they can examine more deeply the extent to which teachers have applied the concepts of 21st-century skills that they have, especially in chemistry learning, because it is hoped that these 21st-century skills are not only theory but also advanced applications.

REFERENCES

- Aini, L. A. N., Wijarini, F., & Adhani, A. (2022). Analisis Kemampuan TPCK (Technological Pedagogical Content Knowledge) Pada Guru Biologi SMA/MA Selama Pembelajaran Daring. *Quantum: Jurnal Inovasi Pendidikan Sains*, 13(2), 215. <https://doi.org/10.20527/quantum.v13i2.13701>
- Almerich, G., Gargallo-Jaquotot, P., & Suárez-Rodríguez, J. (2024). ICT integration by teachers: A basic model of ICT use, pedagogical beliefs, and personal and contextual factors. *Teaching and Teacher Education*, 145(October 2023). <https://doi.org/10.1016/j.tate.2024.104617>
- Asmawati, A. (2021). Perbandingan Media Powerpoint dan Media Gambar Pada Pembelajaran Discovery Learning Terhadap Peningkatan Hasil Belajar IPA. *Quantum: Jurnal Inovasi Pendidikan Sains*, 12(2), 160–171. <https://dx.doi.org/10.20527/quantum.v12i2.11517>
- Bahtiar, Maimun, & Ibrahim. (2023). Analysis of Collaboration, Communication, Critical Thinking, and Creative Thinking Ability of Students in Solving Science Problems in Terms of Gender. *Jurnal Pendidikan Sains Indonesia*, 11(2), 379–400. <https://doi.org/10.24815/jpsi.v11i2.29065>
- Bury, S., Craig, D., Shujah, S., Craig, & Shujah. (2017). Celebrating undergraduate students' research at York University: Information literacy competencies of high- achieving students. *Journal of Information Literacy*, 11(2), 4–27. <https://doi.org/10.11645/11.2.2219>

- Enikö, S.-M. (2023). Assessment of Information Literacy Skills: A Case Study. *Educatia* 21, 25, 178–186. <https://doi.org/10.24193/ed21.2023.25.19>
- Hadeli. (2006). *Metode Penelitian Pendidikan*. PT. Ciputat Press.
- Herlina, E., Sundari, F. S., & Novita, L. (2023). Analysis of 21st Century Skills Through Thematic Learning in Elementary Schools. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, 6(1), 119–122. <https://doi.org/10.55215/jppguseda.v6i1.7526>
- Kasirer, A., & Shnitzer-Meirovich, S. (2021). The perception of creativity and creative abilities among general education and special education teachers. *Thinking Skills and Creativity*, 40(December 2020), 100820. <https://doi.org/10.1016/j.tsc.2021.100820>
- Kaya, E., Karatana, Ö., & Yıldırım, T. Ö. (2023). The relationship between the online learning process, 21st century skills and work readiness in senior nursing students. *Nurse Education in Practice*, 73, 103801. <https://doi.org/https://doi.org/10.1016/j.nepr.2023.103801>
- Li, L. (2016). Integrating thinking skills in foreign language learning: What can we learn from teachers' perspectives? *Thinking Skills and Creativity*, 22, 273–288. <https://doi.org/10.1016/j.tsc.2016.09.008>
- Loes, C. N., Culver, K. C., & Trolan, T. L. (2018). How Collaborative Learning Enhances Students' Openness to Diversity. *Journal of Higher Education*, 89(6), 935–960. <https://doi.org/10.1080/00221546.2018.1442638>
- Maraver-López, Pablo, Caldeiro-Pedreira, Mari-Carmen, & Pérez-Lis-boa, S. (2017). Perception of media literacy and training in teachers from Chile. *Universitas*, 15(27), 201–218. <https://doi.org/http://dx.doi.org/10.17163/uni.n27.2017.10>
- Maulidia, L., Nafaridah, T., Ahmad, Ratumbusang, Monry FN, & Sari, E. M. (2023). Analisis Keterampilan Abad Ke 21 melalui Implementasi Kurikulum Merdeka Belajar di SMA Negeri 2 Bajarsari. *Seminar Nasional (PROSPEK II), Prospek Ii*, 127–133.
- Nafisah, D., Permatasari, D., Dayu, K., Nurlaily, V. A., & Cindy, A. H. (2024). Pelatihan Kegiatan Literasi Digital Untuk Meningkatkan Kompetensi Guru Di Era Kurikulum Merdeka Belajar Training in Digital Literacy Activities To Improve Teacher Competencies in the Era of the Independent Learning Curriculum. *Jurnal Abdi Masya*, 5(1), 53–59. <https://doi.org/10.52561/abma.v5i1.373>
- Ngang, T. K., Hashim, N. H., & Yunus, H. M. (2015). Novice Teacher Perceptions of the Soft Skills Needed in Today's Workplace. *Procedia - Social and Behavioral Sciences*, 177(July 2014), 284–288. <https://doi.org/10.1016/j.sbspro.2015.02.338>
- O'Neal, L. T. J., Gibson, P., & Cotten, S. R. (2017). Elementary School Teachers' Beliefs about the Role of Technology in 21st-Century Teaching and Learning. *Computers in the Schools*, 34(3), 192–206. <https://doi.org/10.1080/07380569.2017.1347443>
- Panggabean, F. T. M., Puspa Olivia Pardede, Rizky Mauli Dini Sitorus, Yani Kartini Situmorang, Evan S Naibaho, & Juan Samuel Simanjuntak. (2021). Application of 21st Century Learning Skills Oriented Digital-Age Literacy to Improve Student Literacy HOTS in Science Learning in Class IX SMP. *Jurnal Mantik*, 5(3), 1992–1930. <https://iocscience.org/ejournal/index.php/mantik/article/view/1796>
- Redhana, I. W. (2019). Mengembangkan Keterampilan Abad Ke-21 Dalam Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, 13(1).

- Riduwan. (2007). *Skala Pengukuran Variabel-Variabel Penelitian*. Alfabeta.
- Setyowati, N., & Mawardi, M. (2018). Sinergi Project Based Learning dan Pembelajaran Bermakna untuk Meningkatkan Hasil Belajar Matematika. *Scholaria: Jurnal Pendidikan dan Kebudayaan*, 8(3), 253–263. <https://doi.org/10.24246/j.js.2018.v8.i3.p253-263>
- Sinay, E., Nahornick, A., & Graikinis, D. (2018). *Creativity and Innovation in Teaching and Learning: a Focus on Fostering Global Competencies and Deeper Learning With Digital Technologies and Learning: a Focus on Innovative* (Nomor January).
- Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, 11(3). <https://doi.org/10.3390/jintelligence11030054>
- Toharudin, U. (2017). Critical Thinking and Problem Solving Skills: How these Skills are needed in Educational Psychology? *International Journal of Science and Research (IJSR)*, 6(3), 2004–2007. <https://doi.org/DOI:10.21275/ART20171836>
- Tuzlukova, V., Al Busaidi, S., Burns, S., & Bugon, G. (2018). Exploring Teachers' Perceptions of 21st Century Skills in Teaching and Learning in English Language Classrooms in Oman's Higher Education Institutions. *Journal of Teaching English for Specific and Academic Purposes*, 6(1), 191. <https://doi.org/10.22190/jtesap1801191t>
- Weninger, C. (2017). The “vernacularization” of global education policy: media and digital literacy as twenty-first century skills in Singapore. *Asia Pacific Journal of Education*, 37(4), 500–516. <https://doi.org/10.1080/02188791.2017.1336429>