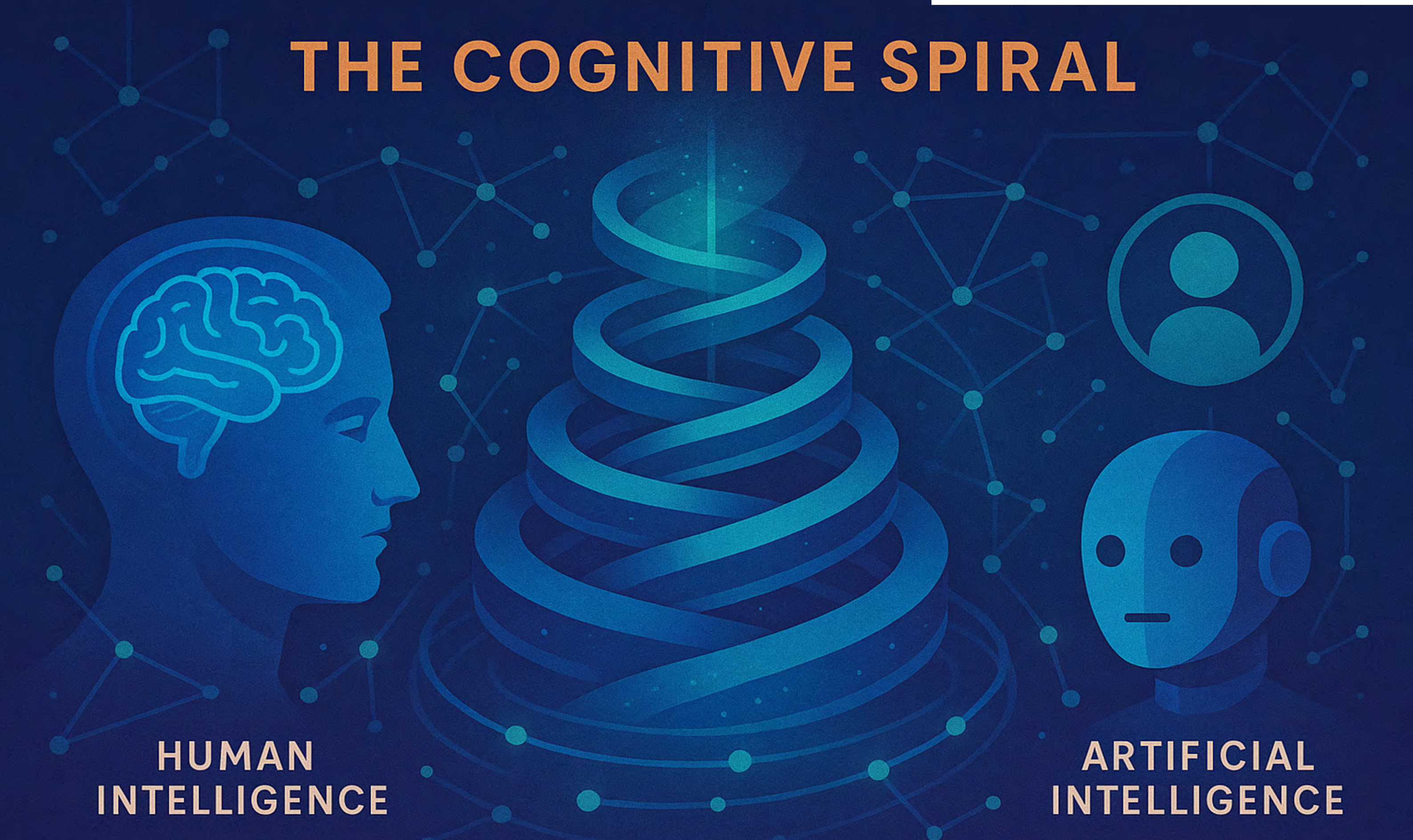
SAMUEL
Neaman Institute
FOR NATIONAL POLICY RESEARCH

International Round Table for Advancing Skills in STEM Education

Phase II

Dr. Eli Eisenberg
Prof. Arnon Bentur
Prof. Yehudit Judy Dori
Dr. Marwa Maklada
Dr. Avigdor Zonnenshain
Tamar Dayan

Education | 03/25



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March 2025

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1. Introduction / Background

Phase I of the International Round Table on Advancing STEM Skills focused on identifying key 21st-century competencies, including self-directed learning and lifelong learning; teamwork, collaboration and interpersonal communication; complex problem-solving and critical thinking.

The necessity for Phase II emerged from the recognition that educators (teachers in secondary schools and lecturers in universities) must be equipped to serve as mentors in fostering 21st-century STEM skills. This requires the development of practical teaching and learning materials and assessment frameworks to facilitate skills' acquisition.

To prepare students as autonomous learners, it is crucial to enhance educators' ability to demonstrate self-directed learning and learning methodologies (SRL).

Another key objective is to explore how AI tools can support the development of these for three competencies in the education system and how EduAI can contribute to their effective implementation.

Leading Team of phase II in the framework of Samuel Neaman Institute is:

- Dr. Eli Eisenberg (lead)
- Prof. Arnon Bentur
- Dr. Avigdor Zonnenshain
- Prof. Yehudit Judy Dori
- Dr. Marwa Maklada
- Tamar Dayan

Objectives of phase II

1. Exploring Generative AI for Teaching & Assessment: Investigating how AI-driven innovations can enhance STEM teaching and learning methodologies and assessment tools.
2. Developing a Practical Guide for Educators: Creating a structured framework to support high school teachers and university lecturers in integrating STEM skills' development into their curricula.

2.Methodology

The round table methodology was developed based on the following principles:

- Structured Zoom Meetings: Six sessions, each lasting two hours, conducted at six to eight-week intervals over a 10-month period.
- Comprehensive Documentation: Background professional documents and meeting summaries were prepared to support discussions and insights.
- Leadership & Coordination: The Samuel Neaman Institute coordinated the organizational and professional aspects of the initiative.
- Open Collaboration: Partner organizations openly shared materials and methodologies developed throughout the process.
- Data Management Platform: A dedicated platform was established to store and manage all collected data.
- Accessibility & Transparency: All outcomes and materials were made freely available to policymakers and the public.

International Round Table Partners

The initiative involved key organizations with expertise in STEM education, including:

- Samuel Neaman Institute (Lead Organization)
- Israeli Ministry of Education
- National Authority for Measurement and Evaluation in Education (RAMA), Israel
- National Institute for Testing and Evaluation (NITE), Israel
- Bet Berl Academic College, Israel
- Technion - Israel Institute of Technology
- Afeka Engineering Academic College, Israel
- STEM Program of the Cleveland Society
- JOINT Israel
- IDF Behavioral Sciences Department
- TIES (Teaching Institute for Excellence in STEM), USA
- OECD, Deakin University
- ETF (European Training Foundation)
- Social Finance Israel (SFI)
- MindCET of CET, Israel

- PEAR Center at Harvard Medical School, USA
- Henrietta Szold Institute, Israel
- Ignite Ed, USA

(Full list of participants provided in Appendix 1)

Round Table Meetings

Six structured meetings were held, each focusing on a specific theme:

Table 1: Round Table Meetings

Meeting No.	Date	Content	Accompanying Documents
1	09.04.2024	Objectives, operational framework, participant insights	1. EduAI framework for nurturing skills 2. Teachers' skills guidebook framework
2	02.07.2024	EduAI and Guidebook for Self-Directed Learning Skill	Background materials, Review questionnaire
3	20.08.2024	EduAI and Guidebook for Teamwork/Collaboration Skill	Background materials, Review questionnaire
4	01.10.2024	EduAI and Guidebook for Complex Problem-Solving and Critical Thinking Skills	Background materials, Review questionnaire

Meeting No.	Date	Content	Accompanying Documents
5	12.11.2024	Participants' relevant presentations[1]	▪ Time to upgrade "science" in science education in the age of artificial intelligence ▪ Critical thinking for decision making and action in science ▪ Creating New Learning: Innovation in teaching and learning to foster critical thinking, problem solving and teamwork ▪ Evaluation of Teamwork in the IDF
6	14.01.2025	Participants' relevant presentations[2]	▪ IPRO MODEL- Skills for changing employment ▪ Teaching and learning to drive a radical shift in education from time-based to competency-based learning ▪ Measurement and Evaluation of the STEM Project ▪ Afterschool & STEM Research: ISRY's Tools

Before each meeting, an agenda and supporting documents were provided to participants. Simultaneous translation was available at each of the meetings to ensure accessibility and inclusivity. All meetings were recorded, and summaries were distributed post-session for review and feedback.

[1] Please note that 2 presentations were shared by participants of the International Skills' Round Table Phase II. The summaries of the following presentations appear in Appendix 8-9

[2] Please note that 4 presentations were shared by participants of the International Skills' Round Table Phase II. The summaries of the following presentations appear in Appendix 10-13

3.Practical Guide for Self-Directed Learning, Teamwork, and Complex Problem Solving with Critical Thinking Skills in STEM Education

Prof. Yehudit Judy Dori and PhD Candidate Or Shav Artza, Technion and Neaman Institute

3.1 Introduction

The need for students to develop advanced competencies in self-directed learning, teamwork, and problem-solving with critical thinking skills has never been more meaningful and essential, especially in the context of STEM education. These skills are integral for success in academic settings, professional environments, and for personal development. The aim of this literature review is to synthesize current research on these three essential competencies, exploring their role in enhancing learning outcomes, fostering collaborative problem-solving, and preparing students for complex, real-world challenges.

3.2 Self-Directed Learning

Self-directed learning (SDL) refers to a process where learners take the initiative to diagnose their learning needs, formulate goals, identify resources, and evaluate their progress (Bransford et al., 2000). This competency is increasingly valued in STEM education, where the capacity for lifelong learning is necessary due to the fast-paced evolution of knowledge and technology.

Figure 1 captures the essential elements of SDL, such as metacognitive skills, STEM relevance, technological tools, and students' skill development.

Figure 1: Representing the concept of Self-Directed Learning (SDL) in STEM education.

According to Arvatz and Dori (2024), high school students' perceptions of self-regulated learning (SRL) in science and mathematics highlight the importance of metacognitive skills. Students who are aware of their cognitive processes and can adjust strategies effectively are more likely to succeed in STEM disciplines. This is further corroborated by Hadas, Herscovitz, and Dori (2023), who emphasize that SRL, as part of SDL, enhances students' ability to work autonomously, manage time, and set achievable goals, all of which are critical for success in STEM fields.

In university settings, SRL is particularly important for chemistry students, where it supports the development of skills such as chemical understanding and graphing abilities (Avargil, 2019). The authors of this report would like to note that the SRL are probably imported to all STEM competencies. Furthermore, the shift towards more interactive and inquiry-based learning environments, such as project-based learning (PBL), requires students to take greater ownership of their educational experiences, thereby reinforcing the principles of SDL (Barron & Darling-Hammond, 2008).

The role of technology in fostering SRL is also noteworthy. Online learning environments and digital tools enable students to pursue learning independently, allowing them to explore diverse resources and engage in self-paced learning (Dori et al., 2017). Moreover, technologies such as educational escape rooms have been found to promote SDL by presenting students with challenges that require independent problem-solving and critical thinking (Veldkamp et al., 2020). A rubric and a typical SRL assignment are presented in the following Table 1 and Figure 2. (See below, based on Hadas et al., 2023).

Table 2 : Rubric for analysis of an online assignment: knowledge types, and SRL criteria with an example of "It's raining moles" assignment via a google-form (participant 2010122)

Knowledge type & Criterion	Score	Description or Excerpt	Reasoning
Pedagogical Content Knowledge (PCK) Higher order thinking levels	2/3	The assignment features different visual modes and multiple-choice questions, requiring no explanations.	While a variety of representational methods are present, the framework lacks comprehensive coverage of advanced cognitive processes, with several higher-order thinking levels entirely absent.
PCK Catering to student levels	3/3	The assignment includes watching the clip "Africa" concerning rain, constructing an online jigsaw puzzle to discover the next assignment, using the structural formula to choose the right functional group in the Geosmin molecule.	The activity includes a range of task types, ensuring students across all proficiency levels feel encouraged to participate and engage with the material.
Technological Knowledge (TK) Assignment design	3/3	 The assignment was prepared on a colorfully designed Google-form with linear progression, where one part leads to the next.	The layout features an appealing aesthetic design that enhances visual engagement
SRL Reflection	1/3	*"How did I feel during the online assessment?"* *"Where the directions clear?"* *"Was the assignment too long?"*	At the conclusion of the exercise, students engage in a fundamental reflective component that primarily focuses on descriptive observations rather than deeper analysis.
Assessment knowledge (AK) Self-assessment	2/3	*"Once you solve the riddle, it takes up to 3 minutes to find the answer online.* *Feedback: The answer is one word: the name of a substance."*	The assessment includes designated checkpoints where students submit responses and receive immediate automated feedback. However, this feedback mechanism is limited in its effectiveness, failing to promote substantive understanding or deeper learning outcomes.

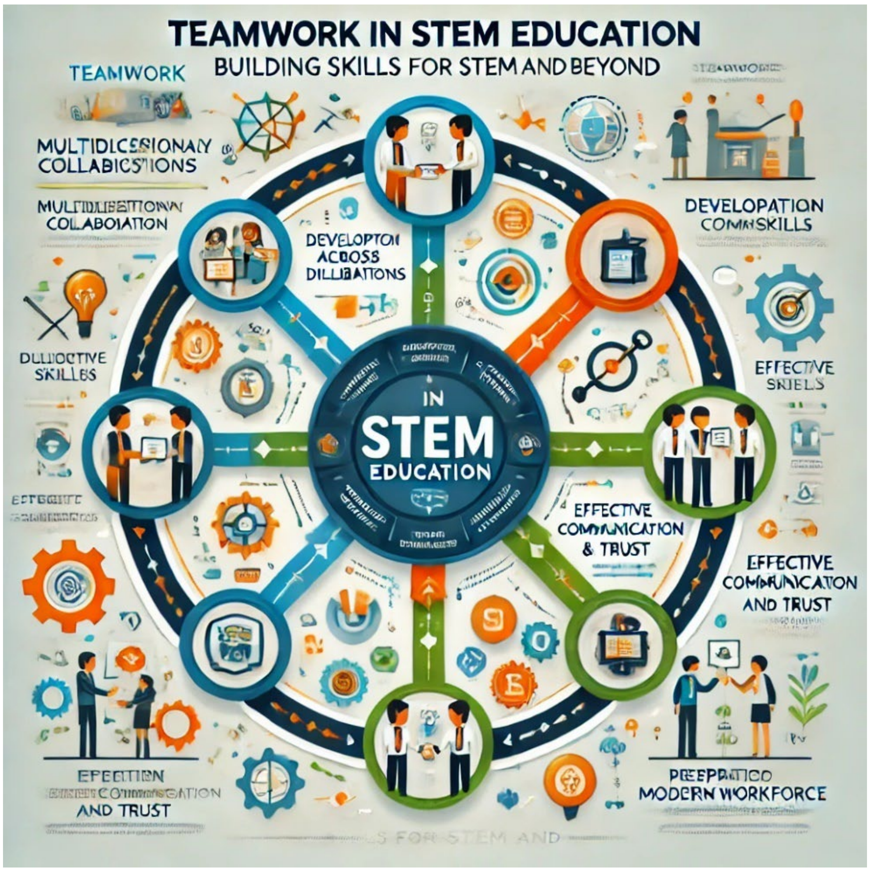
3.3 Teamwork

Teamwork, another critical competency in STEM education, involves collaborative efforts among individuals to achieve shared goals. Research has shown that effective teamwork not only improves academic performance but also fosters the development of interpersonal skills, which are essential for success in the modern workforce (Salas, Sims, & Burke, 2005).

The ability to work effectively in teams is particularly emphasized in STEM contexts, where complex tasks often require collaboration across disciplines. In a study by Johnson (2021), pre-service elementary school teachers reported that team teaching experiences in PBL environments enhanced their understanding of cooperative learning strategies and their ability to work in multidisciplinary teams. This collaborative approach to learning aligns with Bloom and Canty's (2022) exploration of technology education students, where teamwork helped in developing a deeper understanding of design pedagogy.

Figure 3 visually highlights key elements of teamwork in STEM education such as collaboration, interpersonal skill development, communication, and workforce preparation, aligned with research-based insights.

Figure 2 : The importance of teamwork in STEM education.



Effective teamwork also requires high levels of communication, coordination, and trust. As noted by Salas et al. (2005), successful teams exhibit shared mental models, clear communication channels, and mutual respect, all of which are key to overcoming challenges and achieving goals.

These factors are also critical in engineering and other STEM fields, where teamwork is essential for solving complex technical problems.

Moreover, teamwork in STEM education helps prepare students for the collaborative nature of modern professional environments, where interdisciplinary teams are often tasked with solving multifaceted problems (Phang et al., 2018). The importance of fostering teamwork is reflected in the findings of Tsybulsky (2019), who showed that pre-service science teachers, when engaged in PBL, demonstrated improved teamwork skills, which were directly linked to their effectiveness in real-world teaching situations.

A study on a chemistry-themed escape room found that participants improved their communication skills, cooperation, and higher-order thinking abilities. Students enjoyed the activity and felt motivated to learn, demonstrating the advantage of game-based learning environments in developing teamwork and other skills (Avargil, 2019, 2022; Veldkamp, Daemen, & Joosten-ten Brinke, 2020).

Figure 3 : Two chemistry students collaborating as a pair on solving a solution problem in an escape room (Based on Avargil 2022).

Figure 4 : A team of four students expand their chemistry knowledge by matching Dalton's historical symbols to periodic table elements (Based on Avargil 2022).

The images depict university students working collaboratively to solve puzzles in a chemistry-themed escape room. This educational activity, documented in Avargil's 2022 study "Knowledge and Skills of University Students in Chemistry-Related Departments as Expressed in a Specially Designed Escape-Room," features 19 distinct puzzles of varying complexity. Teams of 4-6 students typically require approximately 75 minutes to complete all the challenges.

3.4 Complex Problem-Solving and Critical Thinking Skills

Complex problem-solving and critical thinking are intertwined competencies that are critical for success in STEM education. These skills involve the ability to analyze problems, evaluate solutions, and make informed decisions based on evidence and reasoning (Facione, 2011). Table 3 presents an example of a question used in a problem-based test (Klegeris et al., 2013).

Table 3 : An example of a question used in a problem-based test (Klegeris et al., 2013)

Jane bought a new cabinet-type freezer. The manual gave the following instructions:

- Connect the appliance to the power and switch the appliance on.
- You will hear the motor running now.
- A red warning light (LED) on the display will light up.
- Turn the temperature control to the desired position. Position 2 is normal.
- The red warning light will stay on until the freezer temperature is low enough. This will take 1–3 h, depending on the temperature you set.
- Load the freezer with food after 4 h.

Position	Temperature (°C)
1	– 15
2	-18
3	-21
4	-25
5	-32

Jane followed these instructions, but she set the temperature control to position 4. After 4 h, she loaded the freezer with food. After 8 h, the red warning light was still on, although the motor was running and it felt cold in the freezer.

Question 1: Jane read the manual again to see if she had done something wrong. She found the following six warnings:

1. Do not connect the appliance to an unearthed power point.
2. Do not set the freezer temperatures lower than necessary (–18°C is normal).
3. The ventilation grills should not be obstructed. This could decrease the freezing capability of the appliance.
4. Do not freeze lettuce, radishes, grapes, whole apples and pears, or fatty meat.
5. Do not salt or season fresh food before freezing.
6. Do not open the freezer door too often.

Ignoring which of these six warnings could have caused the delay in the warning light going out?

Answer “Yes” or “No” for each of the six warnings.

Another example may require a modification of the question in Table 3 by including a request for an explanation of the "Yes" or "No" response for each of the six warnings. Additionally, ask for an explanation to justify these responses, transforming the question from being solely problem-based to one that also emphasizes critical thinking skills. Critical thinking is not only central to academic success but is also vital in addressing the complex challenges that professionals face in the workplace (Ennis, 2018).

Figure 5 : Complex problem-solving and critical thinking in STEM education

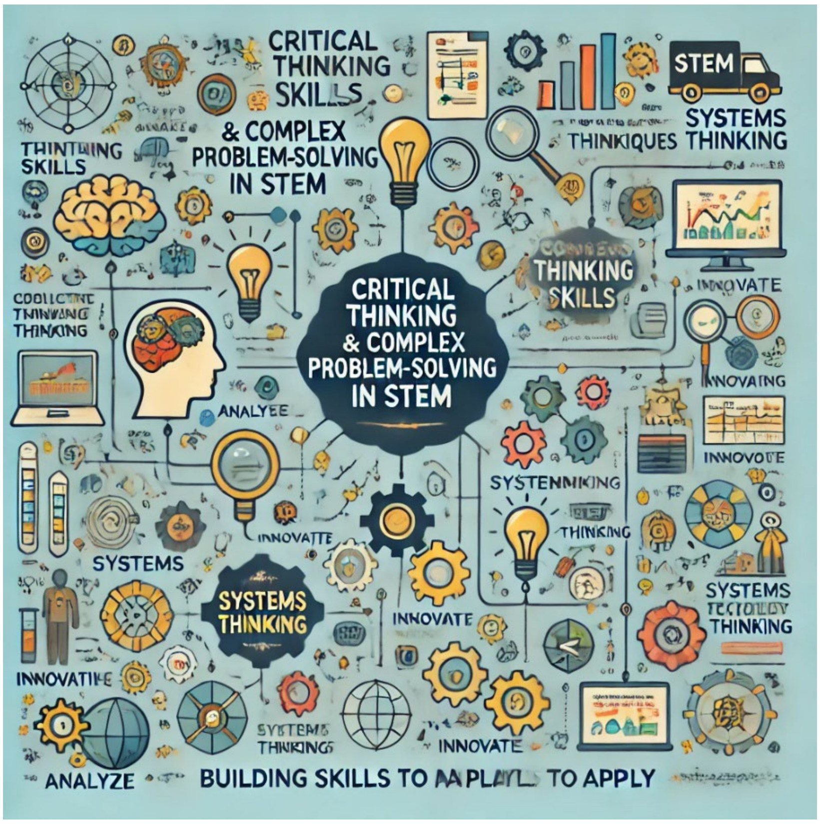


Figure 5 illustrates complex problem-solving and critical thinking and highlights key components such as critical thinking skills, problem-solving techniques, systems thinking, and real-world applications. Ahern et al. (2019) discuss the role of critical thinking in engineering education, arguing that engineering students must develop the ability to think analytically, evaluate competing solutions, and apply theoretical knowledge to practical problems. This is particularly relevant in problem-based learning (PBL) settings, where students are presented with real-world problems that require them to apply critical thinking and problem-solving techniques to find innovative solutions (Hmelo-Silver, 2004). Jonassen (2011) emphasizes that problem-solving in STEM is not just about applying predefined solutions but involves the generation of new ideas and approaches. This form of creative problem-solving is necessary for tackling the novel challenges faced by STEM professionals, where established knowledge is often insufficient to address emerging issues.

Moreover, complex problem-solving often requires systems thinking, an approach that emphasizes the interdependence of components within a whole system (Mioduser, 1998). Dori et al. (2020) highlights the importance of systems thinking in engineering education, particularly in project-based courses, where students must consider various perspectives and variables in solving problems. Similarly, Lavi et al. (2021) examine how students in technological fields use systems thinking to address challenges in designing technological systems, which is a key skill for professional success in STEM industries.

The integration of critical thinking into problem-solving processes is essential for students to navigate the increasingly complex nature of problems they encounter in the STEM fields (Klapwijk, 2018). Facione (2011) asserts that critical thinking involves not only the ability to reason effectively but also the disposition to engage in reflective thinking, a characteristic that is essential for both academic and professional success.

3.5 Conclusions

The development of self-directed learning, teamwork, and complex problem-solving with critical thinking skills is essential for preparing students for the challenges they will face in STEM disciplines and beyond. As the literature indicates, these skills are not only important for academic success but are also critical for lifelong learning and professional development. Educational strategies such as project-based learning, inquiry-based learning, and the use of technology have been shown to effectively promote these competencies, making them central to modern STEM education.

Self-directed learning allows students to take ownership of their education, fostering independence and lifelong learning habits. Teamwork enhances collaboration and communication skills, which are crucial for success in the interdisciplinary and collaborative nature of STEM fields. Finally, complex problem-solving and critical thinking are essential for students to navigate the challenges of modern society and contribute to the advancement of knowledge and technology. Together, these competencies form the foundation of a robust STEM education, equipping students with the skills they need to succeed in both academic and professional environments.

Please note that three presentations were shared by participants of the International Skills' Round Table Phase II, of integrating EduAI in STEM education, enhancing skills' acquisition and assessment.

The summaries of the following presentations appear in Appendix 2-4:

- Appendix 2 - Practices for Cultivating Teamwork Skills by Dr. Noa Ragonis
- Appendix 3 - Problem Solving Skills – Identification and Pedagogical Dilemma by Dr. Osnat Dagan
- Appendix 4 - Critical thinking for decision making and action in science by Prof. Russell Tytler

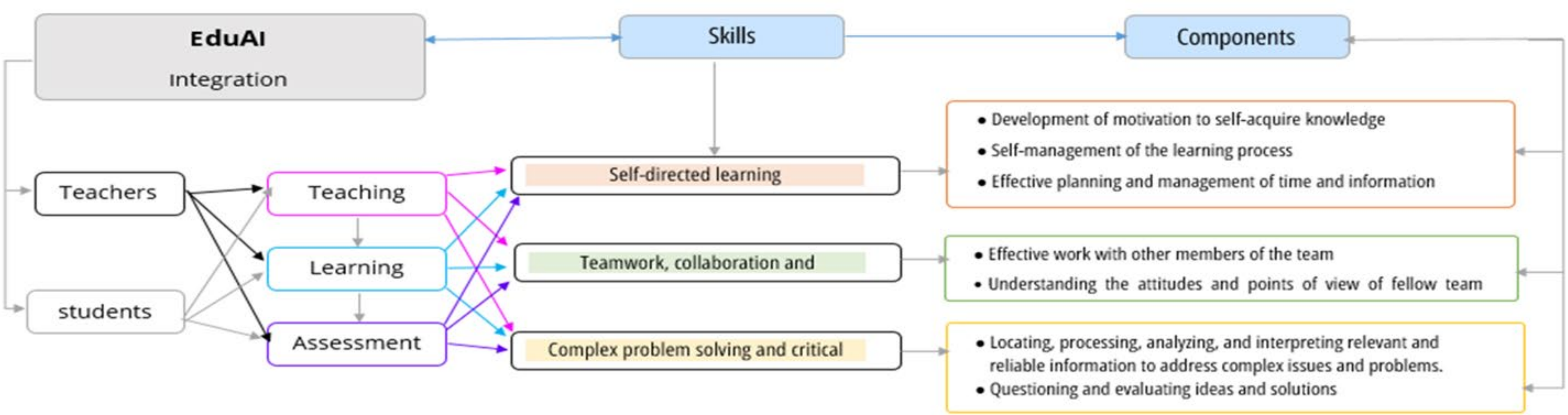
4.Leveraging Education Artificial Intelligence (EduAI) to Enhance Self-Directed Learning, Teamwork, Complex Problem-Solving and Critical Thinking Skills: A Systematic Literature Review and Enhancing Delphi Consensus

Dr. Marwa Maklada, Ministry of Education

4.1 Practical Use of EduAI

Figure 6 presents a framework for understanding the impact of EduAI integration on key skills in teaching, learning, and assessment. Focusing on self-study and lifelong learning, teamwork and collaboration, complex problem-solving and critical thinking skills. The study analyzes each skill into its components and discusses their impact on the fundamental pillars of education: teaching, learning, and assessment. Furthermore, it identifies and examines the challenges inherent in the integration process. The subsequent chapter delves deeper into the identified components, formally defining them as individual "Key Skills" within the broader framework of teaching, learning, and assessment. This analysis of the literature review will be applied to all three skill sets explored in Figure 6.

Figure 6 : EduAI assisted Skills, categorized according to their components



4.2 Self-directed learning Components

Table 4: EduAI assisted promoting self-directed learning

	EduAI assisted promoting self-directed learning		
components	**Teaching**	**Learning**	**Assessment**
Development of motivation to self-acquire knowledge	• Fostering motivation • Mentoring for individual support • solidifying the acquired knowledge • Equipping students with essential digital skills	• Tailoring to each individual's needs, strengths, and learning styles • Deepens understanding of needs and interests throughout life	• Promoting self-monitoring and self-assessment for continuous improvement. • Leveraging EduAI offers opportunity to expose students to a wider variety of assessment methods • Creating a storyboard for a process-related assessment or producing a podcast on a core topic • Fostering active engagement and self-evaluation • Enhancing teachers' ethical assessment practices
Self-management of the learning process	• Promoting self-regulated learning • Fostering an understanding of their learning needs by Technology-enhanced environments • Appling ethical and responsible AI	• Providing personalized support, simplifying tasks, and promoting metacognitive reflection • Providing personalized learning content and plans. • Fostering a more engaging and effective learning experience	• Promoting self-regulated learning by technology-enhanced environments • Enhancing writing skills • Metacognitive abilities, and self-confidence
Effective planning and management of time and information	• Freeing teachers for deeper dives • Balancing AI with traditional teaching to equip students for the future • Enhancing educational efficiency • Providing learners with relevant administrative and logistical information • Fostering diverse outcomes through mentoring students	• Enhancing students' writing skills • Detecting inconsistencies and inaccuracies • Leveraging AI without being misled by its "hallucinations" • Providing tailored guidance and relevant resources	• Creating a storyboard for a process-related assessment or producing a podcast on a core topic by AI-generated feedback. • Analyzing interaction data to identify patterns • Providing insights for enhancing learning effectiveness
Challenges	Teaching diverse styles	• Learning discomfort with AI assistants • Underperforming students	• Personalizing actionable feedback

4.3 Teamwork, collaboration and cooperation skills

Table 5 : EduAI-assisted promotion of Teamwork, collaboration and cooperation

	EduAI-assisted promotion of Teamwork, collaboration and cooperation		
Components	Teaching	Learning	Assessment
Effective work with other team members	• Considering AI as a team member due to limitations in technical cognition • Facilitating the creation of well-balanced teams • Identifying individual strengths and weaknesses • Fostering personalized learning through the provision of targeted • Monitoring team interactions and provide feedback on communication and conflict resolution • Developing self-awareness and refine their teamwork skills	• Incorporating durable skills like communication and teamwork into online learning • Facilitate meaningful communication among classmates, promoting collaboration and peer-to-peer learning. • Considering EduAI a true team member due to technical cognition limitations	• Offering the potential to provide granular insights into individual and group performance
Understanding the attitudes and points of view of fellow team members	• Preparing students for success in a world increasingly characterized by collaboration and the integration of EduAI technologies. • Creating universal access to global classrooms, fostering cross-cultural understanding and collaboration	• Developing online learning environments of essential skills like empathy and cultural competence. • Effecting communication fostered through a strong factual foundation and opportunities for collaboration	• Transcending the limitations of traditional, homogenous assessment methods
Challenges	• Training educators to use these tools effectively to foster teamwork skills • Training and evaluation methods for EduAI in teamwork context	• Understanding and responding to human emotions, which are crucial for effective teamwork. • Effecting use EduAI tools to promote teamwork in online learning environments.	• Defining clear criteria, maintaining transparency, ensuring human oversight, adhering to ethics, and adapting to changing team dynamics

4.4 Complex problem solving and critical thinking skills

Table 6 : EduAI assisted promoting Complex problem solving and critical thinking

	EduAI assisted promoting Complex problem solving and critical thinking		
Components	**Teaching**	**Learning**	**Assessment**
Identifying, processing, analyzing, and interpreting relevant and reliable information to address complex issues and problems	• Cultivating language awareness through effective prompting and assessment	• Identifying areas for improvement and providing personalized recommendations • Reasoning techniques, accurate inference, and drawing logical conclusions from information • Using AI responsibly only with a solid knowledge base can students and scholars leverage AI without being misled by its "hallucinations". • Keeping traditional learning and knowledge for effective use by AI-perceptive consumers of information	• Capturing students' learning and analyzing their problem-solving strategies by Computer-aided interactive environments • This section explores four assessment systems of problem-solving skills • Offering client interaction environment, behavior recorder, behavior analyzer, system feedback generator, student model, and diagnostic assessment generator • Identifying patterns and extracting meaningful information about the students' approach to problem solving.
Questioning and assessing ideas and solutions	• Experimenting with work styles refines their future working methods. Discovering what works best for them. This self-discovery strengthens time. management skills and prepares them for complex future challenges.	• Asking questions and finding answers	• Capturing student-learning processes and analyzing their problem-solving strategies
Challenges	• Eroding the line between factual information and AI-generated "hallucinations" • Equipping students with a strong foundation of basic skills; ability to collaborate effectively with machine	• Hindering students' development of critical thinking skills. Promoting critical thinking, AI feedback should provide analytical explanations of examples rather than simply offering prescriptive suggestions.	• Lacking reasoning and justification, hindered effective learning and its potential as a valuable educational tool.

Please note that three presentations were shared by participants of the International Skills' Round Table Phase II, involving the integration of EduAI in STEM education, enhancing skills' acquisition and assessment.

The summaries of the following presentations appear in Appendix 5-7:

Appendix 5 - Time to upgrade "science" in science education in the age of artificial intelligence by Prof. Sibel Arduran

Appendix 6 - Integrating AI in STEM Education, Science division, Ministry of Education by Dr. Gilmor Keshet-Maor & Iris Pelled

Appendix 7 - The HI-AI-CI Framework by Guy Levi

5.Key Insights and Conclusions

5.1 Practical Implementation for Educators

1. Adapting Teaching Methods & Self-Directed Learning
   - Integration of technological, pedagogical, and content knowledge (TPACK)
   - Encouraging critical thinking through case studies and Socratic questioning
2. Enhancing Teamwork & Collaboration
   - Differentiation between cooperative and collaborative learning models
   - Application of structured group activities and real-time feedback mechanisms
3. Advancing Problem-Solving & Critical Thinking
   - Transition from linear to iterative problem-solving frameworks
   - Use of technology-driven planning and experiential learning techniques
   - Use Project Based Learning (PBL) approach
4. Implications for Education Policy & Implementation
   - Development of a comprehensive teaching guide incorporating research-backed methodologies.
   - Integration of STEM skills' development into schools' and universities' curricula.
   - Leveraging AI-driven educational tools while maintaining a balanced role for educators.

5.2 EduAI

The round table discussions underscored the need for a fundamental shift in STEM education, incorporating advanced AI-driven methodologies to enhance teaching, learning, and assessment. The primary insights include:

- Personalized Learning: AI tools enable tailored learning experiences based on student performance analytics, fostering improved engagement and understanding.
- Enhanced Engagement: Interactive simulations, gamification, and real-time feedback encourage motivation and deeper learning.
- Promoting Self-Learning: AI-driven platforms support students in self-regulating their learning, time management, and motivation.

- Evolving Role of Teachers: AI integration redefines educators as facilitators, emphasizing critical thinking and complex problem-solving over direct knowledge transmission.
- Strengthening Collaboration: AI improves communication, real-time feedback, and knowledge sharing, fostering teamwork and interdisciplinary learning.
- Innovative Assessment Tools: AI enables the development of dynamic, adaptive assessments that provide immediate, data-driven feedback.
- Mitigating Bias in Evaluation: AI-driven assessments reduce subjective biases, ensuring fair and data-backed grading processes.

Challenges & Considerations

Despite the opportunities AI presents, several challenges must be addressed:

- Content Accuracy: Ensuring AI-generated educational materials are reliable and high-quality.
- Ethical Considerations: Incorporating ethical AI usage and critical awareness in STEM education.
- Avoiding Over-Reliance on Technology: Encouraging independent thinking to prevent excessive dependency on AI tools.
- Digital Literacy: Training students and educators to effectively use AI-driven tools.
- Adapting Educational Systems: Updating curricula and evaluation methods to integrate AI seamlessly.
- Hallucinations - A robust knowledge foundation is essential for students to effectively utilize AI and mitigate the risk of encountering and being misled by its "hallucinations"
- Digital gap between the haves and the have-nots: social economical and geographical peripheries.

Final Note

This initiative represents a transformative step toward redefining STEM education in alignment with the needs of the modern workforce. By leveraging AI and collaborative methodologies, we can equip future generations with essential skills for lifelong learning success.

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Appendices

Appendix 1 - List of Participants

Table 7 : List of Participants

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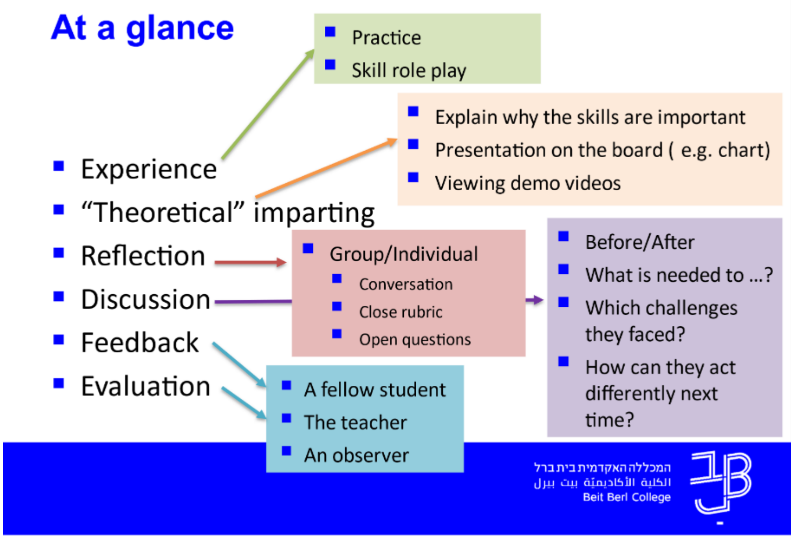
Appendix 2 – Dr. Noa Ragonis – Practices for Cultivating Teamwork Skills

Main ideas:

- Cultivating Teamwork Skills: The presentation focuses on methods for developing teamwork skills within STEM education, emphasizing the importance of direct practice, guidance and explicit instruction. It distinguishes between collaborative and cooperative learning, highlighting their unique benefits and structures.
- Pedagogical Models and Approaches: The presentation introduces the pedagogical circle model, which includes experience, theoretical imparting, reflection, discussion, feedback/evaluation and assessment. It also discusses various pedagogical approaches and stages of learning, such as spiral and incremental methods.
- Assessment and Feedback: The presentation outlines the purposes of formative, self, and summative assessments, emphasizing the use of rubrics for objective feedback. It highlights the importance of assessments for learning and skill cultivation rather than judgmental evaluations.
- Practical Activities and Tools: The presentation provides examples of group activities and tools for developing teamwork skills, such as sticky notes, construction activities, and demo videos. It includes detailed instructions and visual depictions of these activities. Crucial aspects to be considered: Roles in the Group, Feedback and Assessment, Group Size and Participants.

How can it be done?



Appendix 3 - Dr. Osnat Dagan - Problem Solving Skills – Identification and Pedagogical Dilemma

Main ideas

1. Problem-Solving Definition: A problem exists when there is a gap or conflict between the desired situation and the current situation. Problem-solving is a cognitive process that involves eliminating or reducing this gap.
2. Problem-Solving Skills: These are high-level thinking skills that include analysis, synthesis, creativity and evaluation.
3. Methods for Solving Problems:
   - Algorithmic Approach: This involves logically defining routes to possible solutions, similar to mathematical and technological processes.
   - Heuristic Approach: This involves improvising solutions and generating ideas based on a given state, goal state and operators.
4. Problem Solving in Technology Education: This includes practical tasks that require more than just theoretical solutions. It involves procedural knowledge, conceptual knowledge, declarative knowledge, metacognition and motivation.
5. Design Process: The technological and engineering design processes involve higher-order thinking skills and include a making phase. The process starts with defining the problem, finding a solution, and ends with a working solution.
6. Critique on Linear Methodology: The linear design process was critiqued for not considering alternative mental models of students and for not being flexible enough to accommodate different processes, problems and situations.
7. Iterative Models: These models are more flexible and involve continuous improvement and adaptation.
8. Pedagogical Method: This involves experiencing problem-solving in teams, reflecting on the process, theoretical overview, discussion, solving new problems in teams and assessment.
9. Assessment: Various methods for assessing problem-solving skills, including rubrics, holistic assessment and adaptive comparative judgment.

Appendix 4 - Prof. Russell Tytler - Critical thinking for decision making and action in science

Integrating critical thinking and decision-making skills into science education to address 21st-century challenges. Key points include:

- PISA 2024 Strategic Vision and Direction for Science
- A Vision for What Young People Should Know About Science and be Able to Do with Science in the Future

Critical Thinking and Science Education

Prof. Russell Tytler emphasizes the need for science education to evolve, incorporating critical analysis, decision-making, and action to prepare students for socio-ecological challenges. Creative systems thinking and respect for diverse perspectives are central to this approach.

Agency and Student Engagement

The concept of agency is detailed through three interconnected elements: International, practical-evaluative, and projective, which represent different facets of student engagement.

The concept of agency in climate change education. It underscores empowering students by:

- Providing agency in their scientific ideas.
- Encouraging critical evaluation of stakeholder perspectives.
- Supporting projections of future outcomes.

PISA 2025 Framework

The PISA 2025 framework introduces:

- Competencies: Explaining scientific phenomena, designing and evaluating inquiries, and using scientific knowledge for decision-making.
- New Knowledge Areas: Socio-environmental systems, sustainability, informatics, and understanding the misuse of scientific knowledge.
- Scientific Identity: Includes science capital, critical science agency, inclusive science experiences, and ethics/values.

  These updates aim to prepare students for complex global and local challenges.

Assessment and Evaluation

PISA 2025 assessment framework, focusing on:

- Evaluating arguments based on scientific evidence.
- Identifying trustworthy sources.
- Understanding human-environment interactions. Visuals in the presentation outline a framework categorizing questions by knowledge type, competency, context, and cognitive demand.

Case Studies and Educational Approaches

Examples of integrating critical thinking include:

- A guided inquiry project where students designed systems to slow ice melting.
- A microbiological contamination investigation in schools, promoting collaborative problem-solving and stakeholder engagement.

Appendix 5 - Prof. Sibel Erduran – Time to upgrade "science" in science education in the age of artificial intelligence

Key points include:

Impact of AI on Science

- AI has revolutionized scientific research, such as protein-folding prediction and advancing mathematical conjectures.
- Examples include analyzing biological data, making high-quality predictions, and uncovering new scientific insights.

AI in Science Education

- AI's role in education spans applications like educational robots, machine learning, and intelligent tutoring systems.
- It prompts critical questions about teaching, assessment, and ethical implications.

Scientific Practices

- Using models, analyzing data, and constructing explanations align with international science curricula like NGSS (Next Generation Science Standards).
- AI tools can simulate professional scientific methods, aiding students' understanding of scientific practices.

Critical Thinking

- Defined as self-directed and disciplined thought aimed at improving thinking quality.
- Focus areas include data analysis, experimentation, and representation.

Positioning AI in Education

- As a methodological tool, AI enables students to engage critically with scientific tools.
- As a learning tool, it supports discussions on data ethics and societal implications.
- As a societal commodity, AI prepares students for professional and social integration in a digital world.

Applications in Teaching

- Role-playing scenarios and argumentation frameworks foster engagement with AI-related ethical and societal issues.

Appendix 6 - Dr. Gilmor Keshet-Maor & Iris Pelled – Integrating AI in STEM Education, Science division, Ministry of Education

The presentation is about integrating artificial intelligence in STEM education, specifically focusing on training teachers, implementing AI with students, and strengthening the professional resilience of teachers as leaders of innovation and progress. For elementary, middle, and high school levels, the focus varies at each stage of education.

The main idea

1. Purpose and Strategy:
    - Integrating AI skills into teaching, learning and assessment practices.
    - Strengthening the professional resilience of teachers as leaders of innovation.
2. Operations:
    - Training instructors and teachers in AI tools.
    - Establishing and training a leading team across various subjects and age levels.
    - Building a cooperative community of science and mathematics teachers for continuous learning and support.
3. Continuous Professional Development:
    - Offering training courses, webinars, workshops and teaching resources.
    - Providing continuous support through newsletters, conferences, seminars and a professional website.
4. Achievements:
    - Training 2,000 teachers and 100 instructors.
    - 30% of students are involved in the actual implementation of AI in classrooms.
    - High enthusiasm and participation, with a need for ongoing support.
5. Objectives for 2024-2025:
    - Forming a vision for AI use with students.
    - Expanding the number of teachers learning and applying AI in the classroom.
6. Development Plan:
    - Focusing on scientific literacy, creative thinking and critical thinking.
    - Implementing standardized assessments and inquiry learning in various subjects and school levels.

Appendix 7 - Guy Levi – The HI-AI-CI Framework

Enhancing Teamwork through Human, Artificial and Collective Intelligence

The HI-AI-CI Framework focuses on the integration of Human Intelligence (HI), Artificial Intelligence (AI), and Collective Intelligence (CI) to enhance teamwork and collaboration. This framework emphasizes the synergistic interaction between these components, leveraging their unique strengths to create a dynamic and adaptive learning system.

At the core of the framework is the idea of discourse and dialogue between human, artificial, and collective intelligence. This interaction facilitates a two-way flow of knowledge where AI enhances human cognitive abilities while simultaneously learning from human feedback and experience. The result is a collaborative system that strengthens team dynamics, problem-solving skills, and interdisciplinary knowledge sharing.

The framework demonstrates its effectiveness in STEAM (Science, Technology, Engineering, Arts, and Mathematics) projects. By integrating generative AI tools, teams experience:

- Enhanced Communication through real-time feedback, language translation, and conflict resolution.
- Knowledge-sharing by simplifying concepts, connecting disciplines, and customizing learning resources.
- Creativity and Innovation through AI-driven idea generation, reframing challenges, and risk-free experimentation.
- Reflective Practice by analyzing collaboration patterns, tracking progress, and prompting continuous improvement.
- Skills Development via simulations, role-playing exercises, and personalized learning paths.

An example of the framework in action is the UNICEF Moldova STEAM Project, where participants created a STEAM ecosystem and developed pedagogical narratives with GenAI tools. This two-day workshop fostered student-centered learning, environmental awareness, and interdisciplinary collaboration. Additionally, AI simulators – like the GPT-based Teamwork Facilitator – provide virtual scenarios that allow teams to practice collaboration, receive feedback, and bridge skill gaps.

Appendix 8 - Dr. Yair Noam – Evaluation of Teamwork in the IDF

The presentation focuses on evaluating teamwork in the IDF and examines the various components of team performance and metrics for assessing effective teamwork at different levels within the organization.

The Importance of Teamwork in the IDF

Teamwork is defined as an essential component for organizational success, present at all levels—from the individual soldier to entire units.

The presentation emphasizes the need for tailored and multidimensional assessment mechanisms to improve team performance in the IDF and achieve optimal results.

Metrics for Evaluating Teamwork

- Integration and Contribution to the Team: The level of active engagement and personal contribution of team members towards achieving group goals.
- Role Distribution: Understanding the roles of team members.
- Advanced Understanding of Team Principles: Demonstrating knowledge of fundamentals such as cooperation, attentiveness and balancing interests.

Metrics at Senior Levels

- Influence: The ability to motivate others and create change within the team.
- Mobilization: Engaging team members towards a common goal and increasing group commitment.
- Political Understanding: Identifying interpersonal dynamics and dealing with complex relationships.

Challenges in Evaluating Teamwork

- Halo Effect: The influence of factors not directly related to teamwork, such as analytical ability or leadership skills, on evaluation.
- Distribution of abilities within the team: Does the disparity between high abilities and average levels reflect reality?
- Inclusion and representation of unique populations: How does the group structure in exercises and reality affect performance?

An example of an indicator: How can we identify "noise" that may hamper teamwork evaluation and how do we address these issues?

Appendix 9 - Dr. Jolien van Uden – Creating New Learning: Innovation in teaching and learning to foster critical thinking, problem solving and teamwork

Related to educational innovation, featuring research conducted by the European Training Foundation (ETF), an EU agency focused on improving human capital through education and employment system reforms.

Research Focus

- Exploring factors that facilitate or hinder the development, implementation, and sustainability of innovative teaching and learning practices.
- Identifying characteristics of such innovations that improve learning outcomes and experiences.

Methodology

- Iterative research processes involving desk research, exploratory sessions, case studies, validation, and cross-analysis.
- Includes 18 case studies across 9 countries.

Case Studies

- Biljana Face Cream Project: Encourages teamwork, entrepreneurial spirit, and understanding production processes.
- Escape Room: Aims to enhance motivation, self-assessment, and digital literacy in informatics.
- Teaching Pre-service English Teachers: Focuses on improving language skills and confidence through real-life projects.
- Export Consultants Program: Fosters innovation and builds networks for export advisory services.
- STEM Clubs in Georgia: Promotes professional development for STEM teachers and hands-on learning for students.

Goals of Innovations

- Enhancing motivation, critical thinking, and problem-solving skills.
- Encouraging collaboration, hands-on experiences, and interdisciplinary approaches.
- Strengthening educator competencies and fostering supportive management structures.

Appendix 10 – Sharon Fischer – The I Pro Model – Skills for Changing Employment

The presentation focuses on human capital development and skill-based employment interventions, especially for marginalized populations.

The presentation emphasizes large-scale changes in the labor market through innovation, measurement, and a focus on empowering marginalized groups.

Impact Goals

- Quality employment for marginalized populations (Arabs, Haredim, older adults).
- Inclusive productivity improvement.
- Enhancing wages and skill levels of low-skilled workers.

Intervention Strategies

- Integrating skills-based learning into vocational training.
- Career counselling focused on skill development.
- Dedicated modules and experiential workshops for skill-building by clusters.

Key Skills for the Workforce

- Time and task management.
- Teamwork and collaboration.
- Lifelong learning.
- Complex problem-solving.
- Basic and digital literacy skills.

Skill Measurement

- Skill mapping to identify employment gaps.
- Self-report questionnaires and digital literacy tests.
- Development of behavioral tests based on scenarios.

Results and Metrics

- Improvements in digital literacy across various programs.
- Comparative analysis before and after interventions.

Next Steps

- Integration of measurement tools in employment and education programs.
- Development of behavioral tests and AI-based training bots.

Appendix 11 – Danielle (Stein) Eisenberg- Teaching and Learning aimed at driving a radical shift in education, from time-based to competencies-based learning

The overall goal is to create a dynamic, evidence-based educational ecosystem that provides meaningful insights into students' skill development and aligns with workforce and academic expectations.

The proposed shift in the education system is to move from a time-based model to a competencies- and skills-based model. This transformation focuses on measuring and validating students' skills and competencies rather than the amount of time they spend in class. The goal is to better prepare students to thrive in today's complex and interconnected world by emphasizing skill acquisition and development.

- Shift from Time-Based to Competency and Skills-Based Education: The proposal aims to transform the education system to focus on competencies and skills rather than time spent in class.
- Multi-Source Evidence Collection: Capturing skill acquisition in real-time from various sources, including classroom work, assessments, and out-of-classroom experiences.
- Validated Skill Development: Creating reliable and valid measures of students' durable skills, such as critical thinking, collaboration, and communication.
- Meaningful Insights and Comprehensive Transcripts: Providing personalized feedback to students, educators, and families, and offering new ways for postsecondary institutions and employers to identify capable students and employees.
- Research Basis and Skills Progressions: Developing detailed progressions for each skill with input from experts, and focusing on skills like civic engagement, creativity, digital literacy, and leadership to predict outcomes like academic success, college readiness, and workforce success.

Appendix 12 – Orly Rauch – Measurement and Evaluation of the STEM Project

The presentation focuses on the measurement and evaluation of STEM projects from 2020 to 2024. Key points include:

1. Evaluation Framework: Emphasizes the use of diverse evaluation tools, regular integration, stakeholder dialogue, and field-based recommendations.
2. Respondents and Tools: Over 9,452 respondents and 101 evaluation tools were used, with response rates between 62% and 90%.
3. Support for Social-Emotional Learning (SEL): Various initiatives like virtual group meetings, workshops, and parent training were rated on a scale of 1-5, with high interest in emotional resilience and technological tools for active learning.
4. Preference for Direct Content: Students and teachers preferred direct content and tools to pedagogical discussions, with a focus on critical thinking and creativity.
5. Student Skills: Reports on group work and problem-solving skills showed progress in self-confidence, critical thinking, and independent learning.
6. Parental Involvement: Preferences for joint activities and lectures were highlighted, with significant interest in participating in community and school-based activities.
7. Student Engagement: Positive feedback on student engagement and learning in STEM activities, with high ratings for creativity, teamwork, and understanding of STEM concepts.
8. Critical Thinking Skills: Schools were evaluated on their implementation of critical thinking skills, with average ratings provided.
9. Next Steps for 2025: Plans include formulating work plans based on parental needs, improving English proficiency, early career preparation, training in SEL skills, increasing parental involvement, and developing students' emotional resilience.

Appendix 13 - Prof. Gil Noam – Afterschool & STEM Research: ISRY’s Tools

The presentation focuses on the research and tools developed by the Institute for the Study of Resilience in Youth (ISRY) at Harvard Medical School. Key topics include:

Main Components

1. Psychometrics and Training: Development of assessment tools for informal STEM educational settings.
2. Dashboarding and Continuous Improvement: Usage of dynamic dashboards to analyze educational outcomes and improve STEM programs.

Assessment Tools

- Dimensions of Success (DoS): Observation data used to evaluate program quality.
- Common Instrument Suite - Student (CIS-S) and Educator (CIS-E): Surveys that measure youth and educator perspectives on STEM engagement, relationships, critical thinking, perseverance, and SEL (social-emotional learning) constructs.

STEM and SEL/D Constructs

- Focus on how STEM interest, knowledge, identity, and SEL competencies intersect.

Research and Findings

- Analysis of large datasets from afterschool networks and informal STEM programs.
- Emphasis on higher program quality leading to better youth outcomes.

Key Framework

- Clover Model: ISRY's evidence-based framework for youth social-emotional development.

National and AI Initiatives

- Collaboration with Mott/STEM Next studies.
- Exploration of AI for qualitative analysis and cognitive skills evaluation.

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Education

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