Boosting Youth Inclusion in the Labor Market

Advancing STEM Excellence Skills in TVET

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1. Introduction

A significant body of research, which includes numerous documents, articles and programs, has examined the necessity for reform in the education and training systems, with a focus on developing skills and competencies. The proposed approaches to reform, which have been well-established in theory since the 1970s, have been widely studied. The importance of 21st century skills in the study of various subjects, the labor market and everyday life cannot be overstated and has been a consistent theme in research, papers, reports and surveys (Eisenberg and Selivansky, 2009).

Despite the abundance of publications on the subject, the actual implementation in practice has been limited and slow. The main factors contributing to this state of affairs include:

- The existence of numerous theoretical and often impractical definitions that are difficult to apply in real-world settings.
- The lack of accessible and effective teaching, learning and experiential methodologies for various teaching levels.
- The absence of well-developed and universally agreed upon assessment and measurement methods and tools that can be applied in the field.

There is a persistent gap between theory and practice in TVET, and it is high time to bridge this divide between what we policy and decision makers, experts, principals, teachers and trainers' students and parents know must be done and what is actually being implemented on a wider scale.

2. Inescapable skills and competencies for the employer and employee

The following competencies have been prioritized based on numerous research papers and surveys among employers and employees across various industries in different countries.

- Self-study, self-directed learning, life-long learning;
- Teamwork, collaboration and cooperation, interpersonal communication and prompts;
- Complex problem solving in uncertain environments and critical thinking;
- Entrepreneurship/innovation/creativity;
- Emotional and cognitive flexibility/adaptability/emotional resilience;

- Intercultural awareness, global competency and inclusion of the other;
- Taking responsibility and making decisions based on ethical and moral considerations/values.

The first three competencies were selected to define the components of each one, along with the effective teaching, learning and experiential methodologies naturally suited to develop the competency, and the assessment and measurement methods and tools that can be applied to the specific competency.

3. Self-study, self-directed study (SDL) and lifelong learning (LLL) competencies: definitions, teaching/learning/experience methodologies and assessment and measuring tools.

3.1 Components and Definitions

Self-study and Lifelong Learning (LLL) competencies are derivatives of (specific and broad) knowledge combined with skills, such as the ability to search and acquire relevant content and apply new learning strategies. It includes fostering the development of self-study competencies, the building of motivation to acquire relevant knowledge on one's own initiative, as well as instilling self-resilience to meet challenges and complexities that will all become an integral part of the future world of work. In addition, the 21st Century worker will need to think flexibly, take initiative and adapt to a changing and dynamic environment.

According to the OECD (Drake et al. 2018), self-study, self-directed learning and LLL are meta-learning skills that can be described as "the process by which learners become aware of and increasingly in control of habits of perception, inquiry, learning and growth, which implies the need for "being aware and taking control of one's own learning". It includes developing dispositions that support motivation, self-regulation, perseverance, adaptability and resilience. It also calls for a growth mindset – a belief in one's ability to learn – combined with the use of strategies for planning, reflecting on and monitoring progress towards one's goals and reviewing potential next steps, strategies and results.

According to the Israeli Ministry of Education, self-study involves the ability to make appropriate decisions, identify required actions, set personal targets for personal

development and learning as well as to take action to achieve them independently. It is not dependent only on the acquisition of the skills but also on their implementation. Taking responsibility for the process of self-development, which involves active partnership in the design of the learning process, will also significantly enhance the motivation and commitment, which in turn will assist in achieving the educational goals (the profile of the adult independent self-learner).

Based on the survey, the literature and the discussion in the roundtable, several components emerged as important considerations:

No.	Components
1	Ability to search and locate relevant information
2	Development of motivation to self-acquire knowledge
3	Self-management of the learning process
4	Continual development of self-learning habits
5	Self-growth attitude and self-efficacy
6	Effective planning and management of time and information
7	Setting achievable goals and striving to attain them

3.2 Methodologies for learning, teaching and experiencing

Self-learning implies the active student's engagement in their own education and in their understanding of their own learning. Active learning differs from the passive acquisition of learning as a receptacle of information.

It is essential that students have the opportunity to exercise this skill or capability, but it should not lead to untutored direction. it is important to find a balance between allowing autonomy and providing guidance. This is a discourse issue rather than a question of whether a student prepared a presentation or not, but rather what happens around that. The task should have features that allow the student autonomy for inquiry and a possibility of dialogue, with teachers enabling and supporting the process via the feedback and by framing the task in supportive ways.

Three main learning, teaching and experiencing methodologies were highly agreed upon as follows:

No.	Components
1	Project/inquiry-based learning
2	Experiment laboratory
3	Flipped classroom – practicing information and knowledge acquired at home in the classroom

The successful implementation of these methodologies requires well-trained and qualified teachers/instructors, which necessitates the development of appropriate training programs for current teachers within the context outlined below. The first step is to ensure that teachers have a solid understanding of what Self-Directed Learning (SDL) is and what its key components are. SDL is a six-step process, as described by Robinson and Perski (2020):

- Developing goals for study.
- Outlining assessment with respect to how the learner will know when they have achieved those goals.
- Identifying the structure and sequence of activities.
- Laying out a timeline to complete activities.
- Identifying resources to achieve each goal.
- Locating a mentor/faculty member to provide feedback on the plan.

It is further suggested that developing self-directed learners requires a scaffolded approach in which more self-paced- or teacher-directed activities are introduced early on, during didactic instruction, to help students become more self-regulated in their "self-directedness." Over time, as the student moves from the classroom to the experiential setting, control of the learning environment can be shifted from the instructor to the student. This scaffolding transition may include starting with more self-paced activities and providing guidance to the learner on how to be more self-regulated.

3.3 Assessment and measurement tools for self-study and lifelong learning

Self-Directed Learning (SDL) evaluation often requires more qualitative methods, since the focus is on building meaning and self-developing skills that are often emotional in nature and based on experience.

Four evaluation and measurement tools to assess self-study acquisition in the framework of education are proposed:

No.	Components
1	Self-feedback questionnaires
2	Observation indicators
3	Interviews
4	Peer-feedback questionnaire

Some of the approaches may be subjective in nature and they include:

- Reflections
- Interviews
- Observations of behaviors
- Feedback from students
- Self-reporting questionnaires

Additional considerations in implementing these modes of evaluation:

- Skill assessment should be continuous and cannot be assessed with a single tool. It is an ongoing process that needs to be measured at several different points in time. If the focus is on the explicit acquisition of skills, assessment can be conducted during the learning/acquisition process itself (self-report).
- There are high stakes in the evaluation process, namely, do these tests hinder the development of these skills? Assessment may influence one's behavior and this raises the question of whether assessment could hinder the development of these skills.

4. Teamwork, collaboration and cooperation Competencies: Definitions, Methodologies & Evaluation

4.1 Components and Definitions

Eisenberg and Raveh (2020) define teamwork, collaboration and cooperation as the ability of the individual to collaborate and cooperate as part of a team to meet the

challenges of complex tasks and the ability to continue the teamwork when difficulties arise. Effective teamwork requires social as well as cognitive abilities, including project management and task focusing. The website of the Ministry of Education of Ontario, Canada, defines collaboration as involving the interplay of the cognitive (thinking and reasoning), interpersonal and intrapersonal competencies needed to work with others effectively and ethically. These skills are improved as they are applied and practiced with increasing versatility to co-construct knowledge, meaning and content with others in diverse situations, both physical and virtual, that involve a variety of roles, groups and perspectives.

Eight components are prioritized:

No.	components
1	Acting resiliently as a team despite difficulties and challenges
2	A team's quality of project management (assignment of tasks, time management, etc.)
3	Maximum utilization of the team members' knowledge and cognitive resources
4	Ability to make decisions collaboratively
5	Effective work with other members of the team
6	Flexibility and adaptability as a team member
7	Collaborative responsibility of the team
8	Understanding the attitudes and points of view of fellow team members

4.2 Methodologies for learning, teaching and experiencing

In the research conducted by the "International Round Table for Advancing Skills in STEM Education," seven methodologies were identified as most important:

No.	components
1	Team-based learning
2	Problem-/project-/product-based learning
3	Group discussion

4	Collaborative inquiry learning
5	Detailed planning of the team members' roles, work methods, behavioral rules, etc.
6	Teamwork in a variety of environments: nature, jobs, communities
7	Creating a heterogeneous team of team members with different abilities and strengths.

4.3 Evaluation and measurement tools for teamwork, cooperation and collaboration and interpersonal communication

Evaluating teamwork means assessing the quality of the team as a whole working together, while assessing the quality and contribution of each individual member of the team.

When faced with a collaborative task, the most important question is how to assign credit to each member of the group, as well as how to account for differences across groups that may bias a given member's performance. This issue arises whether members are asked to work in pre-assigned complementary roles or whether they are also being assessed on their skills in inventing ways to collaborate in an undefined situation. Questions on assigning individual performance as well as group ratings become even more salient for international assessments where cultural boundaries are crossed (Kechagias 2011).

Four methodologies and tools for effective assessing teamwork and collaboration competencies are proposed:

No.	components
1	Peer assessment
2	Behavioral observation
3	Self-feedback questionnaire
4	Utilization of advanced technologies such as simulations and AI

5. Complex problem solving and critical thinking: Definitions, Methodologies & Evaluation

5.1 Components and Definitions

Critical thinking and problem solving involve locating, processing, analyzing and interpreting relevant and reliable information to address complex issues and problems, making informed judgements and decisions and taking effective action. With critical thinking skills comes an awareness that solving problems can have a positive impact on the world, and this contributes to achieving one's potential as a constructive and reflective citizen. Learning is deepened when it occurs in the context of authentic and meaningful real-world experiences.

Problem solving according to UNICEF MENA is a higher-order thinking process interrelated with other important life skills, such as critical thinking, analytical thinking, decision-making and creativity. More specifically, being able to solve problems implies a process of planning, i.e., the formulation of a method to attain the desired goal. Problem solving begins with recognizing that a problematic situation exists and establishing an understanding of the nature of the situation. It requires the solver to identify the specific problem(s) to be solved, plan and carry out a solution and monitor and evaluate progress throughout the activity.

According to the OECD (Drake et al., 2018) critical thinking can be defined as questioning and evaluating ideas and solutions. This definition of critical thinking skills embodies components of metacognition, social and emotional skills (reflection and evaluation within a cultural context), and even attitudes and values (moral judgment and integration with one's own goals and values), depending on the context.

Pearson (n.d.) has defined critical thinking as consisting of four core skills: 1. systems analysis: the ability to determine the relationship between variables in a system; 2. argument analysis: the ability to draw logical conclusions based on data or claims; 3. creation: the ability to construct a strategy, theory, method or argument based on a synthesis of evidence (the artifact that is created goes beyond the information at hand); 4. evaluation: the ability to judge the quality of procedures or solutions. Evaluation involves criticism of a work product using a set of standards or specific framework.

The following five definitions-components of complex problem solving and critical thinking were identified as most important:

No.	Components
1	Locating, processing, analyzing and interpreting relevant and reliable information to address complex issues and problems
2	Questioning and evaluating ideas and solutions
3	Understanding and resolving situations where a method or solution is not immediately obvious
4	Three types of thinking: reasoning, making judgements and problem solving
5	Learners learn that for every issue there are multiple perspectives that they can explore

Some interesting issues were raised in the written remarks and in the discussions at the meetings, including:

1. EntreComp and the DigComp, initiatives of the European Training Foundation, are relevant examples of the components of complex problem solving and critical thinking (presentation attached).
2. The components/definitions of the skills/competencies should be stated in terms of behavioral objectives – what the student needs to do to demonstrate their mastery of the skill.
3. There is an important and meaningful connection between STEM subject matter and the components/definition of complex problem solving and critical thinking skills/competencies. The content domain affects the use of skills and their development.

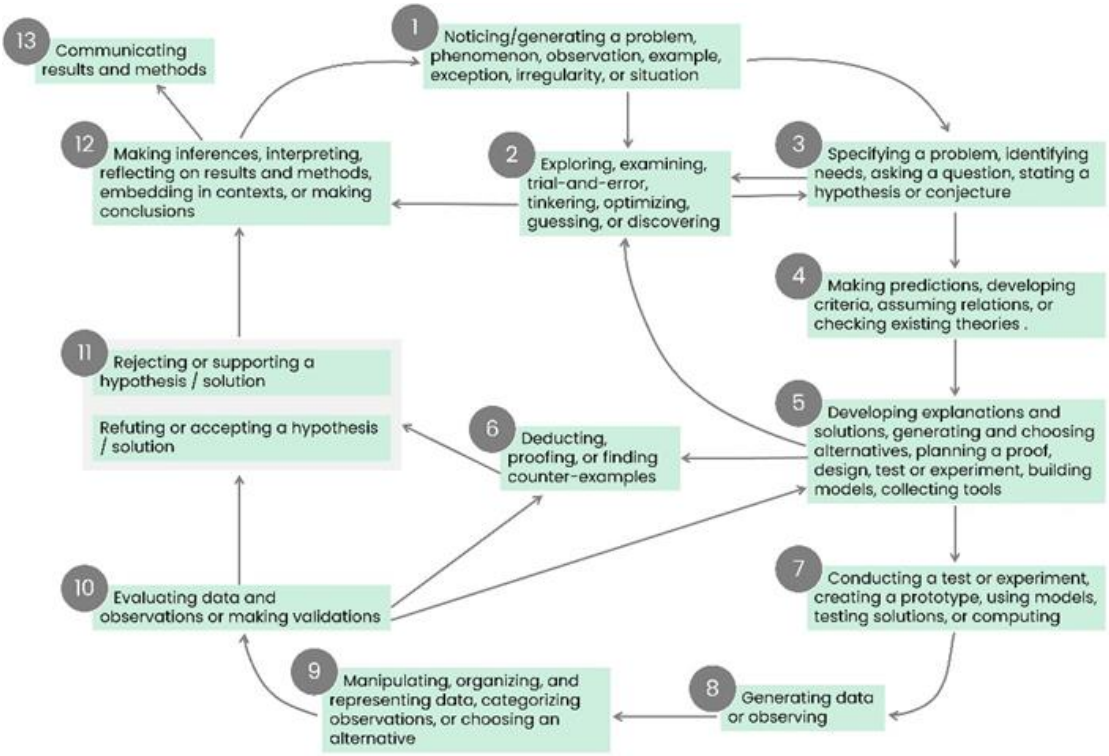
5.2 Methodologies for learning, teaching and experiencing

Integrated framework of problem solving (Burkhard et al., 2019)

The framework can support both practice and research by providing a common background that relates the means, steps, processes and activities to solving problems in the different domains to a single common reference. In doing so, it can support teachers in explaining the multiple ways in which scientific problems can be solved and in constructing problems that reflect these numerous ways. STEM and computer science educational research can use the framework to develop competencies of problem solving at a fine-grained level, to construct corresponding assessment tools and to investigate under what conditions learning progressions can be achieved.

Figure 1 shows the multiple processes consisting of 13 steps, through which problems can be solved.

Figure 1: Visual representation of an integrated framework of problem solving.



The framework is illustrated with arrows between the different steps, which are represented by boxes. Each step/box contains distinct but comparable activities that belong to the step, for example, specifying a problem, identifying needs, asking a question or stating a hypothesis or conjecture. These activities may be alternatives, or more than one activity can be relevant for solving a particular problem. The step involving the communication of results and methods is not necessarily a problem-solving step because it is a common practice to share the results derived from this process, and is a vital activity in education.

The advantage of using the framework is that it offers a variety of different activities to assist in problem-solving. However, the framework does not solve the specific problem for the students. Nonetheless, given that the students understand the steps, the framework can serve as a toolbox that offers options and helps them not to forget important processes.

The framework can be used for teaching purposes in a manner that is acutely linked to meaningful problems and is applied to content. In this way, the framework can help students gain a comprehensive view of problem-solving methods and techniques used in STEM domains.

The framework can help to reflect problem-solving processes after a problem is solved or after students have given up. All steps taken can be identified, retraced and made

visible in a representation such as Figure 1. This helps to focus on the scientific strategies of problem solving, putting the solution into a larger context, and to relate the solution to the students' prior knowledge, which is a prerequisite for achieving competencies in solving problems.

The Skill's International Round Table identified upon six highly ranked methodologies for learning/teaching/experiencing for complex problem-solving and critical thinking skills. There is broad agreement with regard to the use of simulations, especially computer simulations, to teach problem-solving skills.

No.	components
1	Instructional model
2	Explicit instruction
3	Case libraries
4	Worked examples
5	Concept maps
6	Simulations

5.3 Evaluation and measurement tools for complex problem solving and critical thinking.

The current prevailing concept in research is that critical thinking is not a general skill, but rather is context dependent. The general cognitive skills required for critical thinking are interpretation, analysis and evaluation of claims, drawing conclusions in view of the information and self-management (i.e., re-evaluation of previous concepts in view of new information and data). Yet, for each field of knowledge, the characteristic data, research methodologies and their suitability for evaluation of the basic assumptions (axioms and norms) are context specific (Leitmanovich 2021).

In order to assess all skills involved in critical thinking, educators should aggregate a mix of evidence from critical-thinking activities. Evidence can come from first-hand observations, work products from artifacts (e.g., writing samples, concept maps) or real-time performance data from simulations. Recent advances in technology can supplement observations by enabling real-time capturing and automated scoring of these aspects of writing and systems analysis. When possible, feedback around performance should be provided at both the skill level (e.g., argument analysis) as well as around the task (e.g., does the student make logical conclusions in the argument?).

Providing both these types of feedback can ensure that the student knows how they are progressing in critical-thinking instruction (Pearson).

The PISA assessment examines students' capacities to generate diverse and original ideas, and to evaluate and improve ideas across a range of contexts or "domains." The assessment includes four domains: written expression, visual expression, social problem-solving and scientific problem-solving. In each of these domains, students engage with open tasks that have no single correct response. They are asked either to provide multiple, distinct responses, or to generate a response that is not conventional. These responses can take the form of a solution to a problem, a creative text or a visual artifact.

Researchers share an overall common understanding on the key dimensions of creativity and critical thinking. However, applying the concepts in an educational setting requires further translation. This is where rubrics come in (Vincent-Lancrin et al., 2019). The OECD rubrics (Vincent-Lancrin et al., 2019) can serve the teachers as a methodology of teaching and learning as well as for evaluation.

Rubrics are a way to simplify, translate and construct a social representation of creativity and critical thinking in the teaching, learning and assessing process. They aim to create a shared understanding of what creativity means in the classroom, and share expectations among teachers and students. The function of rubrics is to simplify the big concepts of creativity and critical thinking so that they can become more relevant to teachers and learners in their actual educational activities. They also allow teachers to monitor and formatively assess whether their students develop those skills. Rubrics are a metacognitive tool that helps make learning visible and tangible and facilitate intentional teaching.

The table below shows two assessment and measurement tools that were highly ranked and mostly agreed upon by the participants of the Skill's Round Table for complex problem solving and critical thinking skills.

No.	Components
1	Indicators
2	Assessment Task Models (writing tasks, simulation tasks, concept map tasks)

Some issues to be considered:

1. A self-reflection questionnaire could serve as an effective tool for evaluation, asking the student to reflect on: How did you analyze the problem? How did you come up with different solutions? How did you decide which solution is best?

2. It is recommended to use rubrics – indicators to support the evaluation of the assessor.
3. We should investigate the use of Ed-Tech assessment tools and methodologies, such as the use of simulations in Israel's MSR Institute for Simulation, for cost-effective assessment and measurement tools, especially when large numbers of students are involved,.

6. Main Insights

- Skills and competencies should be taught and assessed in different contexts for three main reasons:
    - The teaching/learning/experiencing methodologies and the assessment and measurement tools need to be adapted to the discipline and domain of learning.
    - The retention rate and the implementation of skills and competencies are significantly higher.
    - There is little evidence of transferring and implementing skills from one context to the other.

- We are interested in the subject of the growth mindset but also grit. For example, self-learning and LLL involve cognitive aspects (metacognition, planning, breaking things down into information, etc.), practical strategies and skills (searching for information, screening information, using the information effectively). Additional factors are related to motivation (initiative, proactiveness, management) and factors related to the reflective aspect of the learning process, such as using feedback, assessment of knowledge, etc.
- The Ed-Tech community has provided excellent e-portfolios and digital portfolios. If learning is a journey across the education system, where does it capture how the student presents? Can the student (and not just the teacher) document the process? At what point does the culture change when the students pass through the various interface points as they shift from one part of the system to another, from k-12 to the IDF/civil service to higher education? How can these capabilities be demonstrated? What we've seen is that the Ed-Tech world not only provides simulations and some of the tools, but can gather them too.
- There are overlaps among the components/definitions of different skills and competencies which should be defined. However, there are basic, generic components which are inescapable in each of the skills and competencies, and we should start with them.

- The process of research-planning-implementation-evaluating 21st century skills and competencies should start now! (We are already at the end of the first quarter of the century). The effective connection between research conclusions and field implementation insights will significantly contribute to the relevance of the education of the graduates of the school system and of higher education.
- The development of the students' skills and competencies empower them to participate in and take responsibility for the learning process.
- The teaching of skills and competencies should be implemented gradually and adapted to the different age levels from early childhood, kindergarten, primary, middle and high school, higher education and lifelong learning.
- There are a variety of clearly defined definitions for these competencies, which can aid in the practical application of these competencies in real-life settings. These competencies can be effectively developed by using the methodologies presented in this paper. Furthermore, evaluation methodologies are discussed and presented. It is worth noting that advanced and digital technologies, such as VR, AR, AI, simulations and other tools (Ed-Tech) can be used for the development and the assessment of those competencies.
- As these competencies are also essential for the job market and the real-life ecosystem, it is recommended to develop and nurture skills and competencies as Lifelong Learning (LLL).

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