Process indicators for inquiry based learning skills development

The ELITe project process indicators aim to provide information and context to facilitate interpretation of outcome indicators (http://www.learning-in-teaching.eu/images/docs/EN/IO2/IO2-table2.pdf). They aim to serve as an evaluation tool to indicate whether an IB skill and competence has been practiced by learners when performing IBL activities.

IB skill - competence	Activities of the weSPOT IB model		Process indicators (Indicating whether an IB skill /competence has been practiced by learners when performing IB activities)
Critical thinking (argumentation skills, comprehension skills, evaluation skills and inferring)	Problem/Topic Phase– Wonder moment	⇨	Providing a wonder moment
	Problem/Topic Phase– Concept map	⇨	Developing a concept map
	Problem/Topic Phase – Definition of concepts	⇨	Concept defining
	Problem/Topic Phase- Need to know	⇨	Describing what we still need to know
	Problem/Topic Phase – Phase 1 reflection	⇨	Understanding different kinds of scientific questions and examining and evaluating this aspect of the learning experience thinking (evaluation)
	Operationalisation- planning the method	⇨	Formulating hypothesis
	Operationalisation-Methodology	⇨	Set up inquiry procedure
	Operationalisation- phase 2 reflection	⇨	Discussing the phase in a critical manner (e.g. implications, limitations of approach, lessons for future studies) by providing arguments
	Data collection – phase 3 reflection	⇨	Reflecting on what knowledge was gained and what has not been collected yet, and examining and evaluating this aspect of the learning experience
	Data analysis – phase 4 reflection	⇨	Checking the analyses and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Interpretation – fit the findings with existing knowledge	⇨	Interpreting findings in light of previous knowledge
	Interpretation – counterevidence	⇨	Judging evidence and counterevidence
	Interpretation – phase 5 reflection	⇨	Checking the interpretation (process) and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Communication – implications, limitations, lessons learned	⇨	Discussing the findings in a critical manner (implications, limitations, lessons learned)
	Communication- phase 6 reflection	⇨	Checking the method of communication and coming up with alternative approaches, and examining and evaluating this aspect of the learning experience
Information literacy (existing knowledge and learning)	Problem/Topic phase- Existing knowledge	⇨	Describing what we already know
	Problem/Topic Phase – Definition of concepts	⇨	Concept defining
	Operationalisation- indicators for measuring	⇨	Coming up with resources and ways how to measure
	Operationalisation- prediction	⇨	Coming up with indicators for concepts that can be measured to develop and test ideas
	Operationalisation- Ethical concerns	⇨	Showing ethical concern with inquiry set up
	Interpretation – fit the findings with existing knowledge	⇨	Interpreting findings in light of previous knowledge

IB skill - competence	Activities of the weSPOT IB model		Process indicators (Indicating whether an IB skill /competence has been practiced by learners when performing IB activities)
Analytical skills (classification, quantitative & qualitative analysis and statistical skills)	Problem/Topic Phase- Need to know	⇨	Describing what we still need to know
	Operationalisation- planning the method	⇨	Formulating hypothesis
	Data analysis – procedure of clustering	⇨	Clustering data
	Interpretation – relevance of results to the problem	⇨	Making sure the results are relevant to the problem
Communication skills (presentation, language, writing skills)	Problem/Topic Phase – Definition of concepts	⇨	Concept defining
	Data analysis – visualization of data	⇨	Using various types of visualization
	Communication – conclusion	⇨	Presenting findings in clear written form
	Communication – technical tools	⇨	Using technical tools for communicating results
	Communication – feedback	⇨	Discussing the findings in a critical manner (implications, limitations, lessons learned
	Communication – implications, limitations, lessons learned	⇨	Providing feedback on findings of others
Digital skills	Data collection-description of data collection tool	⇨	Using appropriate tools to collect data
	Data collection – evidence	⇨	Collecting evidence
	Data collection – data privacy	⇨	Taking privacy of data into consideration
	Data collection – followed data collection methods	⇨	Careful record keeping of methods and findings
	Data analysis –analyzed data	⇨	Using data analysis tools

Note: For more information on how we came up with these indicators refer to O2: Context-based indicators for evaluating STEM teachers' competence development accessible here: http://www.learning-in-teaching.eu/images/docs/EN/IO2/O2_interim.pdf

IB skill - competence	Activities of the weSPOT IB model		Process indicators (Indicating whether an IB skill /competence has been practiced by learners when performing IB activities)
Metacognitive skills	Problem/Topic phase- Concept map	⇨	Developing a concept map
	Problem/Topic Phase – Phase 1 reflection	⇨	Understanding different kinds of scientific questions and examining and evaluating this aspect of the learning experience thinking (evaluation)
	Operationalisation – phase 2 reflection	⇨	Discussing the phase in a critical manner (e.g. implications, limitations of approach, lessons for future studies) by providing arguments
	Data collection – phase 3 reflection	⇨	Reflecting on what knowledge was gained and what has not been collected yet, and examining and evaluating this aspect of the learning experience
	Data analysis – phase 4 reflection	⇨	Checking the analyses and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Interpretation – phase 5 reflection	⇨	Checking the interpretation (process) and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Communication- phase 6 reflection	⇨	Checking the method of communication and coming up with alternative approaches, and examining and evaluating this aspect of the learning experience
(other) Research skills (experimentation, observation, organisation and planning skills)	Problem/Topic phase – Specify context	⇨	Conducting a search for resources/literature research
	Operationalisation-Methodology	⇨	Set up inquiry procedure
	Data collection – collect information	⇨	Collecting data to develop/test ideas
	Data collection –description of inquiry	⇨	Testing hypothesis/ideas
	Data collection – systematic data collection	⇨	Using authorities resources
	Communication –impact	⇨	Considering impact, content, routs and stakeholders

Theoretical background

The weSPOT IB model on which the ELITe's process indicators are based

The weSPOT model moves on from the simplistic cyclical models steps required for good research, steps described in scientific literature (Crawford & Stucki, 1990; Hunt & Colander, 2010) such as, data collection, data analysis, hypothesis forming, communication and dissemination of findings etc. and it is closely related to the inquiry model by Mulholland et al. (2012). It shares many of the phases that Mulholland et al. (2012) described in their model, such as create a question or a hypothesis, collect data, analyse data, share finding etc., but it is more elaborate regarding the sub-phases providing a detailed description of things that teachers and students should consider when doing inquiry.

The weSPOT inquiry-based learning model presented in figure 1, consists of six phases, placed within the context, that mirror the phases that researchers need to go through in order to conduct their research, since inquiry is an integral feature of science. Each phase also consists of a number of activities ranging from six to eleven. Activities in each phase are outlined here below:

Problem/Topic: Embedding; Existing knowledge; Mental representation; Language/definitions; Field of research; Ethics; Empirical meaning ; Discussion/Argumentaion; Question; Hypothesis; Reflection

Operationalisation (realisation of idea with the aim to measure): Indicators; Predictions; Resources; Methodology (of data collection and processing); Ethics (Ethical issues); Discussion/Argumentaion; Reflection

Data collection: Information foraging; Systematic observation; Experimentation; Tools; Simulation; Data storage; Data security; Documentation; Discussion/Argumentaion; Reflection

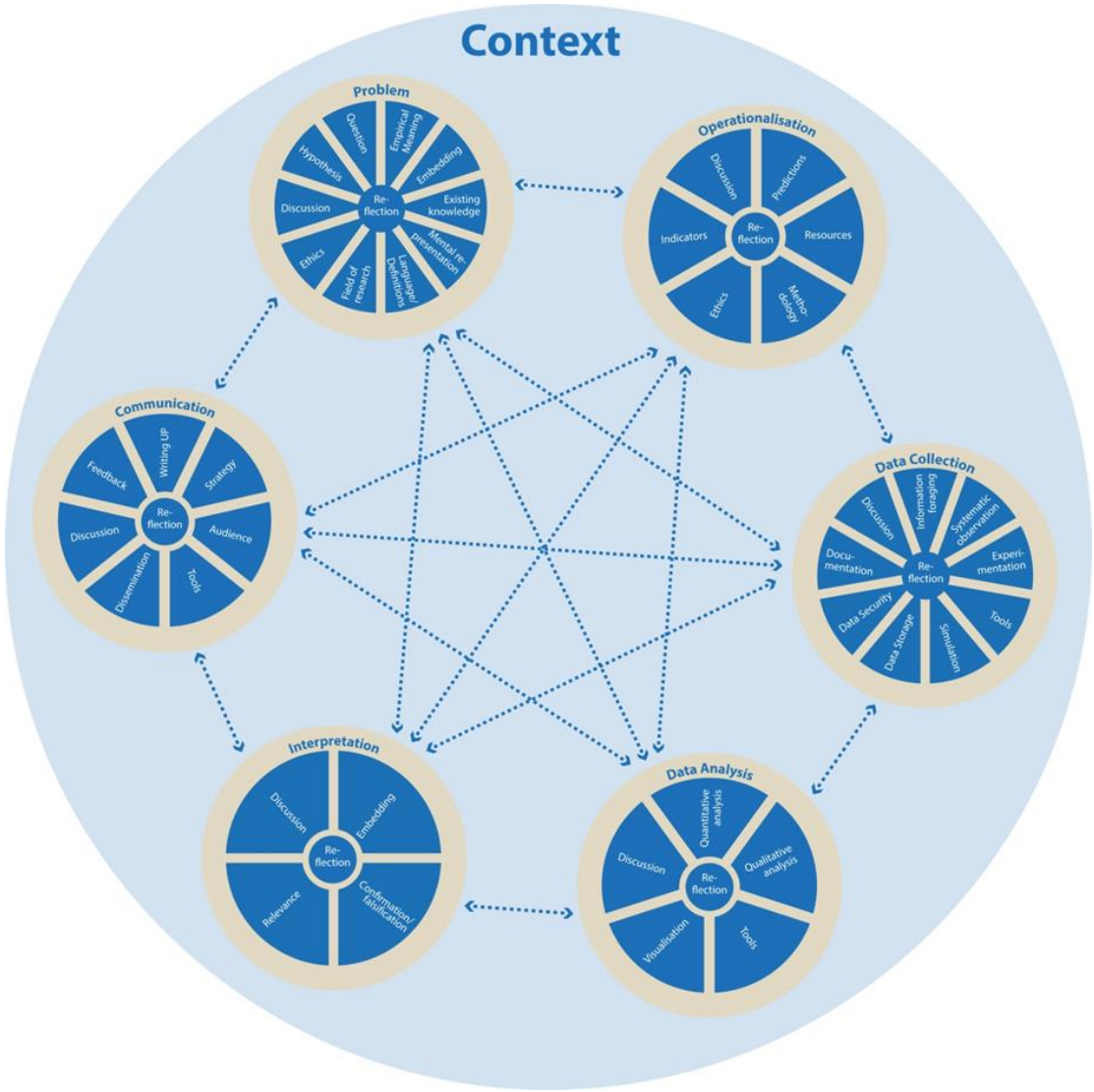
Data Analysis (processing): Quantitative analysis (Statistical methods/analysis); Qualitative analysis; Tools; Visualisation; Discussion/Argumentaion; Reflection

Interpretation: Embedding (Embedding into existing theories/results/domain knowledge (classification)); Confirmation/falsification (of the initial question/hypothesis); Relevance (of the results); Discussion/Argumentation; Reflection

Communication: Strategy; Audience; Tools; Dissemination (Events/Presentation/Publication); Discussion/Argumentaion; Feedback (Receiving and reacting); Writing up; Reflection

All the IBL model phases are placed in the context where the different aspects of inquiry can take place.

Figure 1: *The weSPOT IB model on which the ELITe professional learning activities are based on*



IBL skills & competences practiced through weSPOT IBL learning activities

Skill is seen as a goal oriented and well organised behaviour which is developed through practice and gradually becomes automated. Skill is a much narrower term compared to competence and focuses on the ability to use the knowledge to accomplish a task. **Competence** on the other hand is defined as a set of observable performance dimensions, including individual knowledge, skills, attitudes, and behaviours, as well as collective team, process, and organizational capabilities, that are linked to high performance.

Skills related to the IB learning activities as identified in the WeSPOT project -and adopted by the ELITe project - are the following:

- Analytical skills to research a topic, develop a project plan and timeline, and draw conclusions from research results.
- Science skills to break down a complex scientific system into smaller parts, recognize cause and effect relationships, and defend opinions using facts.
- Comprehension, read and understand scientific and technical materials.
- Experimentation skills to know the different methodologies and processes required.
- Mathematic skills for calculations and measurements.
- Attention to detail to follow a standard blueprint, record data accurately, or write instructions.
- Technical skills to troubleshoot the source of a problem, repair a machine or debug an operating system, and computer capabilities to stay current on appropriate software and equipment.
- Presentation skills
- Cooperation skills to listen to others needs or interact with project partners.
- Creative skills/abilities to solve problems and develop new ideas.
- Leadership skills to be able to lead a team.
- Organization skills to keep track of lots of different information.
- Metacognitive skills

Competencies related to the IB learning activities as identified in the WeSPOT project -and adopted by the ELITe project - are the following:

Research competence: To have research competence one should be able to apply a variety of analytical skills, mathematical and technical skills, experimentation skills and knowledge, sometimes to apply creative skills to obtain a solution, presentation skills, collaboration and communication skills especially if working within a team and so on.

Problem solving: Problem solving is a competence that requires several skills, knowledge and behaviours to be performed well. For example, to solve problems effectively one must have the skill to define the problem, have knowledge of all possible solutions, and exhibit behaviour that enables him or her to make a decision. Problem solving competence can be applied to technical as well to non-technical tasks/areas.

Communication: Communication is really a competency that relies on a combination of certain skills, behaviour and knowledge. To communicate effectively, for example, a person may need to understand cultural diversity, have advanced language skills, behave with patience have technical skills regarding different presentation media etc.

Critical thinking: Critical thinking includes a wide range of cognitive skills and intellectual dispositions needed to interpret, analyse, and evaluate arguments, problems and systems, and then to synthesize, evaluate, and explain an appropriate response. This response may be innovative and go beyond standard conventions.

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