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Evaluation and Students' Self-assessment of Transversal Skills in Secondary School Mathematics. Case Study in Latvia

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Abstract: To provide qualitative and sustainable education school reforms are taking place in many countries around the world. The transition to competence-based learning also alters expectations for learning outcomes. To ensure student-centred learning, it is necessary to equip them with transversal skills required to: address subject content challenges, use different teaching and learning methods; address everyday life problems. The aim of the study is to assess students' transversal skills in secondary school mathematics. There were 50 participants in the study, who ware all studying mathematics at an in-depth level. Transversal skills were measured in action with a test as well as with student self-assessment. While test results showed that students excel in interpretation skills, collaboration skills and digital skills, analyzation skills tested at high levels in students' self-assessment. There is no strong correlation between student self-assessment and student performance evaluated by test. Consequently, it can be concluded that the overall development of transversal skills in secondary school mathematics are sufficient, but it is necessary to understand the inconsistency between self-assessment and performance evaluated by test so that the factors affecting the development of transversal skills can be further analysed.

Keywords: Transversal skills, secondary school, mathematics, transferable skills

Introduction

The UN (United Nations) Sustainable Development Goals for 2030 aims to provide inclusive and qualitative education and to promote lifelong learning opportunities (United Nations, 2015). In this way, one of the priorities is to identify a safe learning environment where equal and respectful individuals may develop their potential (United Nations, 2015). The future is uncertain, and it is difficult to predict what kind of knowledge and which skills will be needed for life (OECD, 2018), leading to lifelong learning (Ananiadou & Claro, 2009; OECD, 2018; UNESCO, 2016) and life-wide (UNESCO, 2016) as learning priorities. The learning of different learning strategies is of particular importance at an early stage in secondary education (Ananiadou & Claro, 2009). Education should not only prepare young people for work but also encourage the development of the students need to become active and responsible citizens (OECD, 2018; Council of Europe, 2018). To ensure attainment of educational objectives, the development of transversal skills has been identified as a key component of learning. The European Commission has identified eight key skills needed for lifelong learning (European Commission, 2019). UNESCO puts forward transversal skills for the implementation of the UN Sustainable Development Goals, identifying the importance of transversal skills for both life-long learning and emphasizing their role in achieving success in the academic environment and workplaces (Care & Luo, 2016; Care, Vista, & Kim, 2019). On the other hand, the taxonomy of skills developed by Binkley highlights the 21st century skills, which provides everyone's readiness for rapid change and is required to address the challenges of this century (Binkley et al, 2010), by setting out four broad skill groups. Looking at the importance of transversal skills in the context of Latvia, the Skola 2030 (*School 2030*) launched a review in 2018 of learning curriculums in all classes and in all subjects. A changed learning approach, as well as a learning content, highlights the role of transversal skills, adequately describing the need for modern society to live in a world that is constantly changing, thereby also making it necessary for students to change and adapt to the economic, political, social and cultural variability (School 2030, 2018), by highlighting the transversal skills as a tool to overcome these challenges.

The transversal skills identified in the various studies represent the overall trend in society's variability and set out the development of specific transversal skills as the learning objectives to be achieved, but a major problem remains: the promotion of development of transversal skills. Gordon refers to a number of ways of integrating transversal skills into the learning process: in a specific subject

(specific subject approach), including in the curriculum as a separate subject with specific objectives and formal means of training for the development of skills; integrated into all traditional subjects (cross-subject approach), in extra-Curricular activities (extra-Curricular approach) (Gordon, etc., 2009).

In Latvia, like many other countries around the world, a learning model has chosen to implement transversal skills in all traditional subsects (School 2030, 2018), but transversal skills in scientific literature have not been analysed from the perspective of a specific subject. Therefore, it is significant to understanding each subjects' objectives and content suitability for the development of specific transversal skills, in order to develop the appropriate transversal skills and to successfully integrate them into the learning content.

Transversal skills are skills that go beyond a specific area or curriculum. They have interdisciplinary characteristics (Flora, 2014). Transversal skills are the specific skills needed to be prepared for the challenges of life and work of the 21st century (Moto, Ratanaolarn, Tuntiwongwanich, & Pimco, 2018) and needed to be able to tackle global challenges (Irwanto, Saputro, Rohaeti, & Prodjosantoso, 2018) as well as promoting students' inclusion in the self-regulated learning process (Lāma, 2021).

However, it should be acknowledged that it is not possible to separate learning structure and subject content from development opportunities to develop transversal skills as they are closely connected. This points to the need to redefine transversal skills specifically in secondary school mathematics. In the analysis of the various math programmes, Lāma offers to define transversal skills in math from the perspective set out in the curriculum, bearing in mind the challenges posed by modern life and dividing them into three broad groups (Lāma & Andersone, 2021):

1. Transversal skills required to address secondary school mathematical challenges
2. Transversal skills required for the use of different teaching methods
3. Transversal skills needed for everyday life

The study is designed as a pilot study aimed at identifying the development of students' transversal skills in secondary school mathematics for students that study mathematics at an in-depth level and to find out the difference between students transversal skills demonstrated in action and student self-assessment.

Methodology

50 students participated in the study: 25 students of 11th grade, 25 students of 12th grade. Secondary education in Latvia is 3 years (grades 10, 11 and 12). All participants in the study are studying math at an in-depth level.

The transversal skills of secondary school students in mathematics were assessed:

1. in action with an established set of mathematics tasks for which the students were given 80 minutes to complete (test);
2. student self-assessment (self-evaluation survey).

The Transversal skills of secondary school students in mathematics were defined with nine most important transversal skills, which were divided into three broad groups:

1. Transversal skills required to address secondary school mathematical challenges
   - analyzation skills (2 criteria),
   - interpretation skills (2 criteria),
   - decision-making skills (2 criteria),
2. Transversal skills required for the use of different teaching methods
   - collaboration skills (2 criteria),
   - communication skills (2 criteria),
   - planning skills (2 criteria),
3. Transversal skills needed for everyday life

- creativity (2 criteria),
- problem solving skills (2 criteria),
- digital skills (3 criteria).

The self-assessment questionnaire consisted of 19 questions, while the test consisted of 6 different type of composite tasks. Students self-assessed their transversal skills on the 4-point Likert scale (1- poor, 2- fair, 3- good, 4- excellent). The assessment of students' transversal skills in action with test was measured using the same criteria and the score was converted to the corresponding levels (poor <16% of total points; fair 17%-50% of total points; good 51%-83% of total points; excellent 84%-100% of total points). The value of each transversal skill consists of the mean value of the corresponding criteria rounded to two decimal places. In the study Cronbach alpha was calculated to measure internal consistency of the Likert scale, the mean values of students' transversal skills, the relative distribution of students' skills across levels, as well as a Spearmen rank correlation between the self-assessment of students' transversal skills and the results achieved in action in the test. IBM SPSS Statistics Version 27 and Python 3.8 were used for data processing and analysis.

Results and Discussion

In order to determine the internal consistency of the Likert scale, a Cronbach alpha coefficient was calculated.

Consistency of the Likert scale (19 parameters) corresponds to high or very high reliability:

- secondary school students' self-assessment of transversal skills (student survey). $\alpha = 0.800$;
- secondary school students' transversal skills evaluation in action (test), $\alpha = 0.837$

By analysing students' test results of transversal skills required to address secondary school mathematical challenges, one can conclude, that students have well developed interpretation and analyzation skills (Figure 1). Specifically, interpretation skills should be highlighted as 74% of students achieved excellent result in the test. This indicates the ability of students to see phenomena in a wider context. The relationship between interpretation skills and analyzation skills which are also well developed among participants (excellent 40%) also points to the consistency of the results.

Far worse results students have achieved in decision making. Only 12% of participants demonstrated excellent decision-making skills, and 60% achieved good level. However, in general, the results are very high, which could be due to the fact that students in classes have chosen to learn mathematics at an in-depth level.

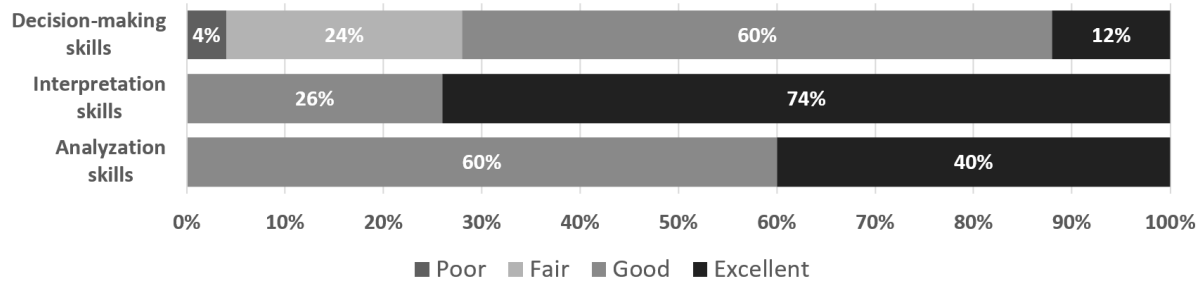

Figure 1. Transversal skills required to address secondary school mathematical challenges. Student level based on test scores.

Comparing the results of the students test and self-assessment some similarities can be seen (Figure 2). Students have highly evaluated their analyzation skills (excellent 28%, good 44%) and interpretation skills (excellent 70%, good 26%) and slightly lower decision-making skills (excellent 20%, good 68%).

However, students in self-assessment, as opposed to the results reported in the test, have evaluated analyzation skills as most developed among transversal skills required to address secondary school mathematical challenges. This could be due to the fact that analyzation and interpretation skills are closely linked, and, therefore, students often face difficulties to distinguish them.

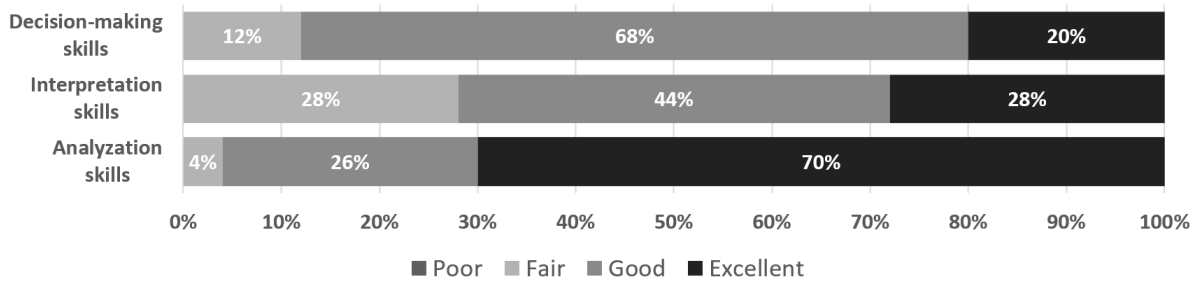

Figure 2. Transversal skills required to address secondary school mathematical challenges. Student self-assessment

By analysing test results of transversal skills required for the use of different teaching methods (Figure 3) it may be concluded, that most of the students have excellent collaboration skills as 74% of participants has achieved excellent score and 24% good score. Communication skills (excellent 22%, good 54%) and planning skills (excellent 28%, good 68%) has also been well developed. Results point to the fact that participants are accustomed to working with different learning methods and to planning their own work. The global pandemic might have played a role in the development of planning skills. Students had to be responsible for planning their learning process as well as collaborate and communicate between themselves, and also with teachers. Further research is necessary to investigate this assumption.

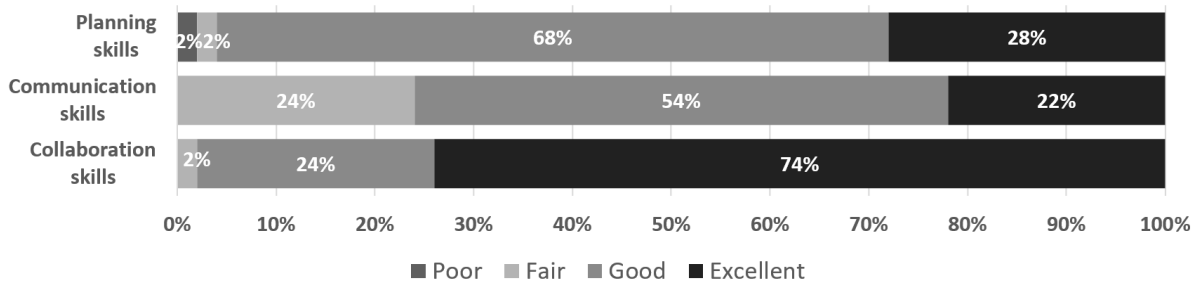

Figure 3. Transversal skills required for the use of different teaching methods. Student level based on test scores.

When comparing the results of student's transversal skills required for the use of different teaching methods evaluated by test and self-assessment, it can be concluded that communication skills and planning skills have been assessed similarly (Figure 4). However, students have self-evaluated collaboration skills lower than they have actually achieved in test. In comparison, in test 74% have reached excellent level but only 36% of students has self-assessed their skills as excellent. This could be linked to past experience where collaboration might have failed. Collaboration, if it is not well structured, can create difficulties for students. Further studies are needed to confirm the hypothesis.

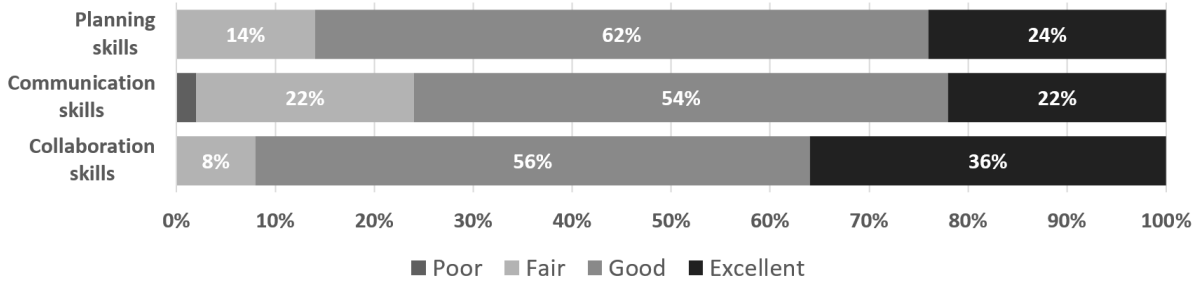

Figure 4. Transversal skills required for the use of different teaching methods. Student self-assessment

By analysing test results of transversal skills needed for everyday life, one can conclude, that students have very high digital skills as 84% achieved excellent result (Figure 5). Problem solving (22% excellent, 48% good) and creativity (26% excellent, 52% good) has been developed similarly. Problem solving in some degree includes creativity in particular dealing with everyday problems. Some students have even achieved lowest possible level (poor 2%).

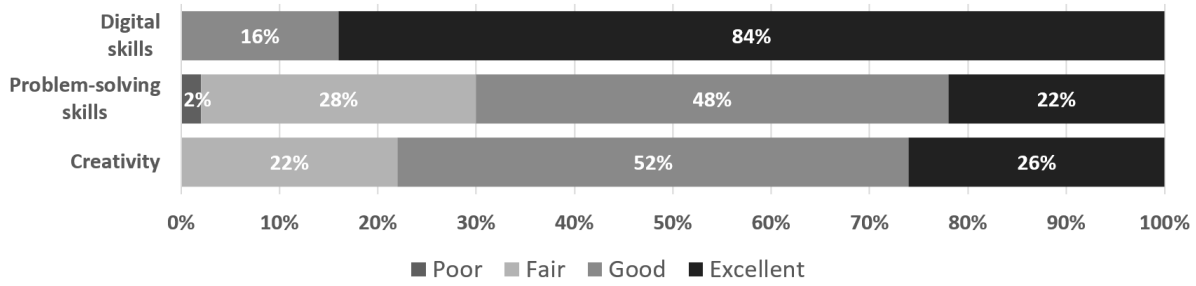

Figure 5. Transversal skills needed for everyday life. Student level based on test scores.

When comparing the results of student's transversal skills required for everyday life evaluated by test and self-assessment, it can be concluded that problem-solving skills and creativity have been evaluated similarly (Figure 6), but there is considerable difference between students' digital skill self-assessment and achieved results in the test. Only 10% of students have self-assessed their digital skills as excellent, but 84% of them has achieved excellent score in test. This could be due to the fact that pupils have previously carried out significantly more difficult tasks in the learning process.

As one of the factors that might be associated with the low evaluation is the relatively rare use of digital technologies in their lessons. In mathematic lessons digital technologies are usually used for highly sophisticated modelling and are rarely associated with skills required for searching and evaluating information, which forms the basis for digital skills in the context of the study. However, the reasons for the low self-assessment of pupils' digital skills should be examined in further studies, by examining the use of digital skills of students in day-to-day activities.

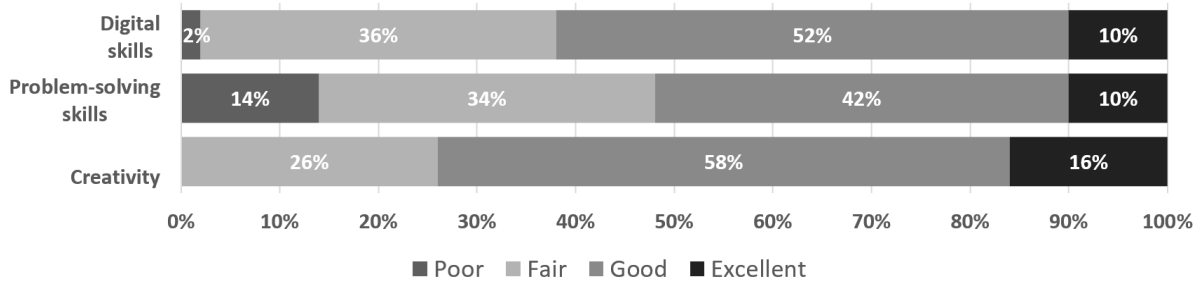

Figure 6. Transversal skills needed for everyday life. Student self-assessment

By analysing students' transversal skill mean values and standard deviation, it can be concluded that students have developed interpretation skills (mean 3.61, SD 0,43), collaboration skills (mean 3.63, SD 0,41) and digital skills (mean 3.79, SD 0,24) better than other skills (measured by test). This could be due to the fact that the learning process is changing in line with everyday life necessities. By comparing the mean values achieved by students in the test with their self-assessment, it can be concluded that digital skills have been assessed very differently.

The lowest score in test students achieved in decision-making (mean 2.61 SD 0.67). And it should be highlighted that data is quite polarised. Results are in line with previous study that shows that decision making skills are skills that have not been well developed among secondary school students (Lāma, 2020). Further studies would be necessary to explore why the students have failed to develop their decison-making skills and how to improve them.

Table 2

Mean value, standard deviation and spearman rank correlation of students' transversal skills

Transversal skills	Student evaluation with test		Student self-assessment		Spearman rank correlation
	Mean	St.Dev.	Mean	St.Dev.	
Transversal skills required to address secondary school mathematical challenges					
Analyzation skills	3.31	0.32	3.38	0.49	0.39

Transversal skills	Student evaluation with test		Student self-assessment		Spearman rank correlation
	Mean	St.Dev.	Mean	St.Dev.	
Interpretation skills	3.61	0.43	2.76	0.69	0.35
Decision-making skills	2.61	0.67	2.80	0.57	0.28
Transversal skills required for the use of different teaching methods					
Collaboration skills	3.63	0.41	3.07	0.59	0.04
Communication skills	2.98	0.64	2.71	0.73	0.28
Planning skills	3.21	0.52	2.82	0.58	0.25
Transversal skills needed for everyday life					
Creativity	2.94	0.72	2.65	0.66	0.27
Problem-solving skills	2.91	0.70	2.20	0.73	0.31
Digital skills	3.79	0.24	2.62	0.63	-0.09

Spearman rank correlation between each skill measured by test and by students themselves was identified to determine, whether students were able to assess their transversal skills objectively.

None of the measured transversal skills had strong correlation between skill measured by test and student self-assessment. There is moderate correlation between test results and students' self-assessment for analyzation skills ($r = 0.39$, $p = 0.05$), interpretation skills ($r = 0.35$, $p = 0.01$), problem-solving skills ($r = 0.31$, $p = 0.03$). This points to the limitations of the student's self-assessment results. However, the interpretation of the results should consider a number of influential factors. The most important thing is to mention the high mathematical preparedness of students, which allowed students to cope relatively easily with mathematical tasks, which are also intended for students without specialized and advanced mathematical knowledge and skills. When discussing the results with students and trying to find out what factors students had considered when selecting the relevant assessment, students stressed that the longer period of time was taken in account when assessing their transversal skills and that the assessment is not based solely on the tasks offered in the test. Another factor that influenced students' self-assessment was the frequency of the use of skills in their previous learning process, which not only allowed the development of skills, but was taken into account in the student self-assessment as a factor of the quality of transversal skill. Further studies are needed to identify the extent to which students' self-assessment reflects the actual state of their transversal skills.

Conclusions

To ensure sustainable and high-quality education, it is essential to provide students with transversal skills that enable them to learn and to continue their learning throughout their lives on their own. The analysis of 50 students' skills measured in action with test and the self-assessment of students' transversal skills leads to some important conclusions:

- Students have achieved very high results in test for skills such as: interpretation skills (excellent 74%), collaboration skills (excellent 74%), digital skills (excellent 84%). These are essential skills that allow students to successfully participate not only in mathematic lessons but also in today's difficult circumstances. However, students decision-making skill results are lowest (excellent-12%), but still should be considered as good.
- Students self-assessed their analyzation skills (excellent 70%) higher than all other transversal skills, while they have assessed their digital skills relatively low (excellent 10% and mean 2.62). This indicates the need for further studies to find out why there is such a difference between the students' self-assessment and achieved results in test.
- There is no strong correlation between student self-assessment and achieved results in a test for any of the measured transversal skills. There is moderate correlation between analyzation skills ($r = 0.39$, $p = 0.05$), interpretation skills ($r = 0.35$, $p = 0.01$), problem-solving skills ($r = 0.31$, $p = 0.03$). Consequently, further studies are needed to explain the reasons for low correlation.

Students' transversal skills in secondary school mathematics may be considered good, but it is important to understand how they can be further developed, particularly by highlighting skills in which students' performance is lower. The ability of students to objectively assess their skills, which forms the basis for the self-directed or self-regulated learning process, is also essential. It is, therefore, necessary to clarify the teaching and learning methods and the activities which help to improve students transversal skills and the role of the subject content in the development of the student transversal skills in secondary school mathematics.

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