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Secondary-School Student Transversal Skills in Mathematics. Comparison Between Teacher Assessment and Student Self-Assessment

Gatis Lāma

University of Latvia, Latvia

ABSTRACT

In order to ensure attainment of educational objectives, the development of transversal skills has been identified as a key component of learning. The future is uncertain, and it is difficult to predict, which knowledge and skills will be needed for life. Education must not only prepare young people for work but also encourage the development of skills that are essential for students to become active and responsible citizens. The uncertainty about the future also changes accents in education by increasing the importance of transversal skills in secondary education, including in the subject of mathematics. In view of the fact that learning in school is mostly carried out in specific subjects and the context of the subject influences the expression of transversal skills, it is necessary to assess the student degree of transversal skill development in a specific subject. Therefore, the study assessed transversal skills of secondary school students in mathematics. Student transversal skills were measured from two perspectives: teacher assessment and student self-assessment. The mean values of pupils' self-assessment were significantly higher than that of teachers. However, the analysis of the results shows the similarities between teacher assessment and student self-assessment as transversal skills that are evaluated higher are the same. Both teachers and students have highly evaluated their analysis and collaboration skills. Also, transversal skills that are evaluated as least developed by teacher and students are the same. Both teachers and students have evaluated their problem-solving skills and creativity as the less developed among all measured transversal skills. Although average values of teacher assessments and student self-assessments vary, there is consistency in both assessments, indicating that both students and teachers are well aware of students' transversal skill development level. However, students' self-assessments mean value tends to be higher than mean value of student assessment by teacher.

Keywords: secondary school, self-assessment, mathematics, transferable skills, transversal skills

Introduction

Globalization and the rapid development of technologies has led to changes in our daily lives. The new generation needs to be integrated into an environment characterized by density and diversity (Rongraung et al., 2014). We have significantly changed way of life, work, and activities, especially in education (Khan et al., 2018). As a result, today's education system faces a difficult challenge: improving students' transversal skills to enable them to continue their education at the next level, enabling them to enter the labour market successfully (Mohd Rasli, 2020) and, if necessary, to learn remotely (Lāma & Lāma, 2020, Lāma, 2021, Baranova et al., 2021, Slišāne et al., 2021). The United Nations (UN)Sustainable Development Goals 2030 Education Section aims to provide inclusive and high-quality education and promote lifelong learning opportunities (UNESCO, 2016). The learning of different learning strategies already in the secondary education phase is of particular importance (Ananiadou & Claro, 2009), that provides effective and appropriate learning outcomes for all young people and provides a basis for lifelong learning (UNESCO, 2016). Lifelong learning can complement the necessary knowledge and skills, thus, allowing to adapt to the changing world. However, the success of lifelong learning, including non-formal education, requires transversal skills. Although transversal skills are essential to be fully integrated into society and the working environment, studies show that many have not improved their skills sufficiently (Mitsea et al., 2021, Majid et al., 2012). Given the importance of transversal skills, it is important to improve them from early childhood (Rubene, 2018) and specially at school. This would allow a student to focus on personal means that enable them to enter the labour market more easily later (Heckman & Kautz, 2012). Different terms are used to describe transversal skills, such as, 21st-century skills, general competencies, key competences, soft skills etc. Transversal skills, even if developed in a specific context, should be considered as skills to be used in different disciplines, situations, and contexts (Economou, 2016) Transversal skills are cross-disciplinary and go beyond a specific area or curriculum. (Flora, 2014). However, transversal skills highlighted in different frameworks vary significantly (Rodriguez et al., 2021). Binkley analysed 12 current transversal skill frameworks and developed a 21st century skill taxonomy, that highlighted skills that would ensure each readiness for changes. Skills have been grouped according to the needs of human everyday life in today's society and categorized into four broad domains: ways of thinking, ways of working, tools for working, ways of living in the world (Binkley et al., 2010).Pellegrino and Hilton approached transversal skill categorization from the perspective of human behaviour and divided transversal skills into three broad areas: cognitive, intrapersonal, interpersonal (Pellegrino & Hilton, 2012). However, the recommendations of the European Union set out eight key competences for life-long learning, that citizens need

for healthy and sustainable lifestyles, employment, active citizenship, and social inclusion (European Commission, 2019).

The diversity of perspectives creates difficulties, when we try to compare transversal skills across different framework structures. For example, when it is necessary to identify the most appropriate or relevant skills in a specific field.

Transversal skills in secondary school are determined by the curriculum. Gordon et al. points to a number of ways in which transversal skills can be integrated into the school curricula:

- As a specific subject. Include transversal skill development as a separate subject with specific objectives and formal means of training,
- In all existing subjects (cross-subject approach). Identifying and developing transversal skills according to the specific content of each subject,
- As extra-Curricular activities. Identifying transversal skills as part of school life and targeting different types of out-of-class classes (UNESCO Bangkok Office, Asia and Pacific Regional Bureau for Education, 2015; Gordon et al., 2009).

In Latvia, like in several other countries, the cross-subject approach is used to improve students' transversal skills. It also makes it necessary to define transversal skills more narrowly in each given subject. It is essential to take into consideration objectives of each subject and the appropriateness of the content when defining transversal skills and integrating them in day-to-day activities, otherwise students might not be able to develop them.Three broad domains of transversal skills can be identified based on the analysis of scientific literature and mathematics (Lāma & Andersone, 2021, Lāma, 2022):

- Transversal skills required to address secondary school mathematical challenges
  - analyzation skills,
  - interpretation skills,
  - decision-making skills.
- Transversal skills required for the use of different teaching methods
  - collaboration skills,
  - communication skills,
  - planning skills.
- Transversal skills needed for everyday life
  - creativity,
  - problem-solving skills,
  - digital skills.

The proposed classification of transversal skills stems from the objectives set out in the curriculum, the specific nature of the day-to-day work and the content of the subject-matter of mathematics, but is not to be regarded as ambiguous.

In spite of the importance of transversal skills in the learning process, the issue of improving and assessing them is still ongoing (Rodriguez et al., 2021).

The importance, development and assessment of transversal skills in secondary schools that is shared among students and teachers is therefore becoming an essential element.

Consequently, the aim of this study is to:

- to evaluate the secondary school student transversal skills in mathematics from students' and teachers' perspectives,
- to compare student self-assessment with teacher assessment.

Methodology

Transversal skills in secondary school mathematics were assessed by using online survey. To distribute the survey, a publicly available list of schools was found. Next, by searching through official school web pages, contacts were found for each school. The dissemination of the questionnaire followed the following steps:

- An email letter was sent to all of the secondary schools in the sample, which accompanied:
  - a teacher's questionnaire link, that was requested to be sent to all secondary school mathematics teachers;
  - a student's questionnaire link, requested to be sent to all secondary school students.
- One month later, a repeated request to participate in the study was sent to schools from which no teacher or student had shown activity.

The list of publicly available schools consisted of 183 schools, but some of them had already been reformed into primary schools and some of them had already been closed. In total, 643 secondary school students and 110 secondary school mathematics teachers from 134 Latvian secondary schools participated in the study. The study considered all ethical research standards in accordance with the General Data Protection Regulation (GDPR). The survey was anonymous and participation in it was completely voluntary.

Question Pro was used for data collection and SPSS, MS excel, and Python was used for data analyses. The online survey focused on 9 different students' transversal skills: analyzation skills (2 statements), interpretation skills (2 statements), decision-making skills (2 statements), collaboration skills (2 statements), communication skills (2 statements), planning skills (2 statements), creativity (2 statements), problem-solving skills (2 statements), digital skills (2 statements).

The online survey consisted of 19 statements, which were evaluated on a 4-point Likert scale (1-poor, 2-fair, 3-good, 4-excelent).

The assessment of each transversal skill was defined as the mean value of the corresponding statements rounded to an integer. The teachers' and students' questionnaires consisted of same statements, with the exception of students being asked to assess their transversal skills while teachers were asked to assess their

students' transversal skills. Data was analysed through descriptive statistics. To determine the questionnaire's reliability, Cronbach's alpha values were calculated for students and teachers' questionnaire separately. Additionally, Mann-Whitney *U* test was carried out to determine the difference between students' self-assessments and student evaluation by teachers.

Results

To determine Likert's scale internal consistency, Cronbach's alpha values were calculated. Both for student questionnaire ($\alpha = 0.871$) and for teacher questionnaires ($\alpha = 0.866$) internal consistency was very good.

By analysing the mean values of the students transversal skill self-assessment, it can be concluded that students have highly valued transversals skills such as: analyzation skills ($\underline{x} = 3.26$, $SD = 0.71$), collaboration skills ($\underline{x} = 3.11$, $SD = 0.86$), communication skills ($\underline{x} = 3.02$, $SD = 0.72$) (Table 1).

Table 1. Mean value, median and standard deviation of students' self-assessment and student assessment by teachers

Transversal skills	Students' self-assessment	Student assessment by teachers
Analyzation skills	Mean = 3.26 Median = 3 St.Dev. = 0.71	Mean = 2.95 Median = 3 St.Dev. = 0.53
Interpretation skills	Mean = 2.78 Median = 3 St.Dev. = 0.81	Mean = 2.49 Median = 2 St.Dev. = 0.65
Decision-making skills	Mean = 2.95 Median = 3 St.Dev. = 0.78	Mean = 2.43 Median = 2 St.Dev. = 0.55
Collaboration skills	Mean = 3.11 Median = 3 St.Dev. = 0.86	Mean = 2.77 Median = 2 St.Dev. = 0.73
Communication skills	Mean = 3.02 Median= 3 St.Dev. = 0.72	Mean = 2.63 Median = 3 St.Dev. = 0.57
Planning skills	Mean = 2.96 Median = 3 St.Dev. = 0.76	Mean = 2.93 Median = 3 St.Dev. = 0.44
Creativity	Mean = 2.74 Median = 3 St.Dev. = 0.75	Mean = 2.36 Median = 2 St.Dev. = 0.60
Problem-solving skills	Mean = 2.35 Median = 2 St.Dev. = 0.82	Mean = 2.19 Median = 2 St.Dev. = 0.61
Digital skills	Mean = 2.79 Median = 3 St.Dev. = 0.76	Mean = 2.56 Median = 3 St.Dev. = 0.63

These are also three only transversal skills for which the mean value of students' self-assessment exceeds 3. Teachers have highly evaluated transversal skills like analyzation skills ($\underline{x}$ = 2.95, *SD* = 0.53), planning skills ($\underline{x}$ = 2.93, *SD* = 0.44, collaboration skills ($\underline{x}$ = 2.77, *SD* = 0.73). Two of the three most highly evaluated transversal skills in teacher and student assessments are the same. In addition, students' planning skills, that are evaluated by teachers relatively high, are highly evaluated by students as well with mean value just below 3. This points to the fact that the opinion of students and teachers on which of the transversal skills are better developed among students are relatively similar. When comparing the median, it can be concluded that, in both the students' self-assessment and the teachers' assessment, the median of analyzation skills, collaboration skills and communication skills is 3.

There is also similar trend in teacher and student assessments, comparing least developed transversal skills. Student has assessed as the least developed transversal skills, such skills like problem-solving skills ($\underline{x}$ = 2.35, *SD* = 0.82), creativity ($\underline{x}$ = 2.74, *SD* = 0.75) and interpretation skills ($\underline{x}$ = 2.78, *SD* = 0.81). While creativity and interpretation skill evaluation is quite similar with other skills, students self-assessed their problem-solving skills lot lower. Similarly, teachers believe that students have less developed transversal skills like problem-solving skills ($\underline{x}$ = 2.19, *SD* = 0.61), creativity ($\underline{x}$ = 2.36, *SD* = 0.60) and decision-making skills ($\underline{x}$ = 2.43, *SD* = 0.55). It can also be concluded that the teachers have evaluated student problem-solving skills as lowest among all transversal skills. It should be stressed that in this study, problem-solving skills were defined as skills needed for everyday life. Problem solving consisted of two evaluation criteria: understanding the problem or students' skill to turn everyday problem into mathematical problem and reflection about problems solution or students' skill to evaluate the solution of the task.

However, it should be stressed that the use the mathematics in the day-to-day problem-solving should be considered as one of the most important skills enabling students to transfer their mathematical skills and knowledge and to use them after school graduation. It indicates to the need to focus much more on developing problem-solving skill in secondary school mathematics. It should be stressed that only for problem-solving skills the median of students' self-assessments is 2, but in teacher assessment for all three above mentioned skills (problem-solving skills, creativity, decision-making skills) median is 2. This indicates that more than half of the teachers thinks that their students' skills should be considered as poor or fair. By comparing the students' transversal skill self-assessment with the teachers' evaluation, it is important to highlight that the student self-assessment mean values for all transversal skills are higher and the median is higher or equal to that of teachers.

It can therefore be concluded that students may have overestimated their skill level. In addition, the students' transversal skills self-assessments are more dispersed as for each skill student self-assessment standard deviation is greater than standard deviation in teacher assessment.

By analysing results of Whitney-Mann U test it can be concluded that for almost all transversal skills H0 is rejected and therefore there is a significant difference between students' self-assessment and student assessment by teachers (Table 2.)

Only for planning skills H1 hypotheses- there is a statistically significant difference between teacher assessments and students' self-assessments- are accepted. This points to the fact that in most of the cases there is a significant difference between teacher assessment and the students' self-assessment. Researchers, in their analysis of students' transversal skill self-assessment, comparing the self-assessment of university students from different fields, point to the fact that students' self-assessment is not always increasing with higher level of competence (Slišāne et al., 2022, Rubene et al., 2021).

Table 2. Comparison of students' transversal skills self-assessment and student transversal skills assessment by teachers. Whitney-Mann U test

Transversal skill	Group	*N*	Mean rank	Sum of ranks	*U*	*Z*	*P*
Analyzation skills	SSA	643	391.58	251784.00	25992.0	−4.90	0.000
	SST	110	291.79	32097.00			
Interpretation skills	SSA	643	388.88	250049.50	27726.5	−3.9	0.000
	SST	110	307.56	33831.50			
Decision-making skills	SSA	643	398.47	256219.00	21557.0	−7.1	0.000
	SST	110	251.47	27662.00			
Collaboration skills	SSA	643	390.56	251127.00	26649.0	−4.4	0.000
	SST	110	297.76	32754.00			
Communication skills	SSA	643	393.34	252918.00	24858.0	−5.5	0.000
	SST	110	281.48	30963.00			
Planning skills	SSA	643	378.98	243681.00	34095.0	−0.7	0.505
	SST	110	365.45	40200.00			
Creativity	SSA	643	393.24	252856.00	24920.0	−5.4	0.000
	SST	110	282.05	31025.00			
Problem-solving skills	SSA	643	383.07	246313.00	31463.0	−2.0	0.045
	SST	110	341.53	37568.00			
Digital skills	SSA	643	386.33	248410.00	29366.0	−3.1	0.002
	SST	110	322.46	35471.00			

*SSA – Students' self-assessment
** SST – Student assessment by teachers

On the contrary, students are able to be aware of what really means highly advanced skills and are able to assess themselves more objectively. This is also indicated by the analyses of transversal skill relative distribution by levels. Students more often assess their skills as excellent compared to teachers (Figure 1).

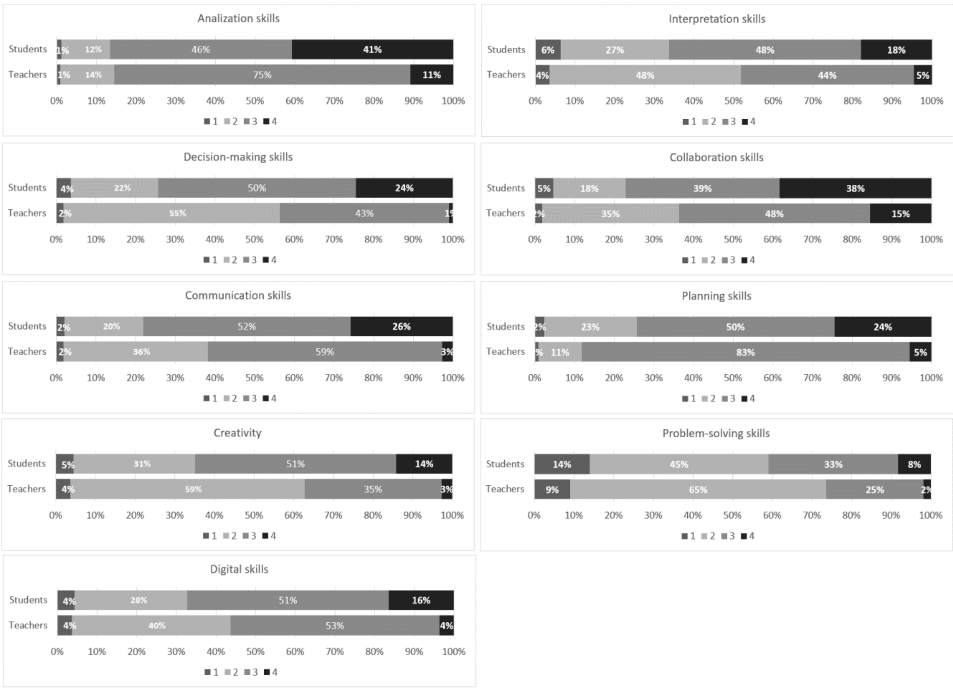

Figure 1. Students' transversal skills self-assessment and student transversal skills assessment by teachers relative distribution

While 11% of teachers note that students' analyzation skills in mathematics are excellent over 1/3, or 41% of pupils believe that their analytical skills are excellent. More than 3 times more frequently, students have assessed their analyzation skills as excellent. A similar assessment relationship is observed for the most of the assessed transversal skills, where students assess their transversal skills 3-4 times more frequently as excellent compared to teachers. However, particular emphasis should be given to decision-making skills, communication skills and planning skills assessments. While teachers consider these skills to be improved at the highest level in 1%-5% of the cases, the pupils themselves assess these skills as excellent in 24%-26%. This points to a very significant difference in awareness and could hinder the development of transversal skills. It would

therefore be necessary to raise shared awareness among students and teachers about how well-developed decision-making skills, communication skills and planning skills should be considered excellent.

Discussion

The results of the study indicate that student transversal skills in mathematics should be improved. The results of the study indicate that there is a fundamental difference between the students' self-assessments and teacher evaluations. The level of students' transversal skills in mathematics measured by students' self-assessment is relatively high, while it is significantly lower in teacher assessment. Although the results show that pupils are able to identify transversal skills that would need to be improved, unlike teachers, a large proportion of students are unable to understand what the highest level (excellent) of assessment means.

As part of the study, statements were defined relatively broadly, yet they highlighted exactly the skill being assessed. Although transversal skills are interdisciplinary, they can be expressed in concrete action and context. Students may lack the ability to perceive and understand the skills assessment by linking it to the practical activity to be performed in the classroom. It might have influenced they perception of their transversal skills, compared to teachers, a significantly higher proportion of students assessed their transversal skills as excellent, which could indicate that students themselves are unable to identify their learning needs at school age and could lead to incorrect learning objectives. This could cause serious difficulties and knowledge gaps if it will be necessary to return to remote learning.

Further studies are needed to explain in more detail the reasons for differences in teacher and students' assessments and to understand what they are associated with. It is necessary to find an explanation at which extent high students' self-assessment is associated with the specific features of self-assessment as an assessment tool and whether self-assessment accuracy can be improved, for example by paying more attention during school hours on explaining the assessment criteria and allowing students to practice assessment themselves more often.

Conclusions

The development of transversal skills in schools is considered to be one of the key learning goals to allow students to successfully continue learning in universities, to better integrate into the labour market and to respond to the challenges of rapid change. The study assessed 9 transversal skills of students in mathematics by students' self-assessment and teacher assessment. The results of the study allow the following conclusions to be drawn:

- Nearly all students self-assessed almost all transversal skills as good. The students' self-assessment median for of 8 out of 9 rolling skills is 3 (good) and the mean value for these skills ranges from 2,74 to 3,26 (4-point Likert scale).
- Teacher evaluations of students are significantly worse. For only 5 out of 9 rolling skills assessments, the median is 3 (good), while for the other four measured transversal skills it is 2 (fair). The mean values for all measured transversal skills are also below 3.
- Teachers' and students' assessments vary significantly. Whitney-Mann U test indicates that for 8 out of 9 measured transversal skills p value is below 0,05, that indicates that there is significant difference between students' self-assessment and student assessment by teachers. It would therefore be necessary to increase the focus on the development of students' assessment skills.
- The lowest rated transversal skill in both students' self-assessment ($\underline{x} = 2.35$, $SD = 0.82$) and teacher assessment ($\underline{x} = 2.19$, $SD = 0.61$) is problem-solving. Problem-solving skills were defined as skills for everyday life and included skills that are necessary to transform everyday problems into mathematical problems. Both students and teachers are well aware that everyday problem solving mathematically poses significant difficulties and it can lead to a theoretical mathematical knowledge that is not applicable after school graduation. This requires more attention to mathematical modelling tasks and the development of cross-curricular links between mathematics and other school subjects

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