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Learning mathematics via WhatsApp social network in Bagroup national project: Students' perceptions

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Abstract

This paper describes students' perspectives about the possible learning opportunities they experienced when participating in a WhatsApp group project created to help prepare for the final secondary school Bagrut (matriculation) exam in mathematics. "Bagroup" project was initiated by the Ministry of Education and the Center for Educational Technology and launched as a national project three months before Bagrut examination. It was meant to serve as an additional environment for learning mathematics and provide an online tool during which teachers presented specific problems via blended learning, and students had the opportunity to ask questions, present problems with which they were having difficulty, and receive feedback from teachers and peers. To obtain a complete picture of the students' points of view, we used a mixed-method research model. Quantitative data were obtained via a questionnaire with Likert statements and open questions, and qualitative data were obtained by observing four Bagroup study groups over the three-month period. Factor analysis revealed three categories of factors: those contributing to learner's emotional needs, those that promote learning, and those that inhibit learning. The findings may have implications for improving distance and remote learning.

Keywords: social network, socio-emotional learning, learning mathematics, high-school students

INTRODUCTION

Importance of Communication Skills in Learning Mathematics

The teaching-learning process relies on successful communication between teachers and students and between students and their peers. When communication is encouraged, students are better able to organize, analyze, evaluate, and express their mathematical thinking and strategies and compare it to others. They learn the importance of using proper, accurate mathematical language (National Council of Teachers of Mathematics [NCTM], 2000). Thus, it is important for teachers to initiate discourse between students. It is also important that teachers make use of diverse tools for explaining mathematical concepts and how to solve problems, and for ensuring that students can exhibit proper mathematical reasoning and raise persuasive arguments, while simultaneously developing the students' conceptual understanding and procedural fluency (NCTM, 2009, 2019). Precise communication allows students to better describe their mathematical ideas to their peers, their teachers, and others (Putra et al., 2020). It allows students to understand representations of mathematical objects and allows teachers to identify student creativity and motivation in mathematics (Tong et al., 2021). Respectful communication means that each student's idea is taken seriously and that everyone can ask questions, make statements, and express their ideas (Ainscow, 2020; Chapin et al., 2013; Joswick & Taylor, 2022; Tong et al., 2021).

OECD (2018, 2019) has emphasized the need to enhance "21st century competencies" and has recommended integrating new approaches into traditional subjects like mathematics. Required competencies include critical thinking, collaboration, problem-solving, creativity, etc. and the ability for effective communication.

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Contribution to the literature

- The current study focuses specifically on the integration of the WhatsApp social network in teaching and learning mathematics in the *Bagroup* a national project.
- The research underscores that learning mathematics via WhatsApp social network in the *Bagroup* project contributes to the learners' emotional needs because their anonymity allows them to ask any question without fear.
- The research highlights that learning via WhatsApp social network in the *Bagroup* project as an additional learning environment contributes to collaboration and equitability opportunities in learning mathematics.
- The study proposes a model and research tools that can be used for conducting similar studies.

Familiarity with communication tools and environments was one of the challenges of education systems during the spread of the COVID-19 pandemic (Klemer et al., 2023; Saadati et al., 2021; Sofianidis et al., 2021), which led to the sudden shutdown of face-to-face teaching. The integration of online social networks such as WhatsApp into education allowed teachers and students to communicate, however, they and their teachers had to quickly adapt to the challenges of managing online learning environments (Morsidi et al., 2021).

Learning via Social Networks

In recent years, social networks have become widespread and are often the principal platform for communication between family, friends, organizations, interest groups, and the like. Naturally, they have also begun to spread into educational systems (Calderón-Garrido & Gil-Fernández, 2022; Durgungoz & Durgungoz, 2022; Nida et al., 2020) and provide innovative opportunities for teaching and learning, which, when taking place over a social network, leads to a more open, dynamic learning environment that encourages peer-to-peer knowledge sharing (Biton & Segal, 2021) as opposed to traditional learning, where knowledge is primarily transferred from teacher to students (Borba et al., 2016).

Learning in a social network enables online discussions between learners and creates opportunities for them to notice, present, share, interpret, and use theoretical and practical knowledge that is dynamically organized during interactions (Borba et al., 2016; Durgungoz & Durgungoz, 2022; Engelbrecht et al., 2020; Nida et al., 2020). However, only about 40% of teachers use social networking sites on a consistent basis for educational purposes (Calderón-Garrido & Gil-Fernández, 2022).

The most commonly used social networking sites, in order of rating, are WhatsApp, YouTube, Instagram, and Facebook, each of which offer availability and the possibility of immediate feedback (Boyd, 2010; Greenhow & Askari, 2017; Kizel, 2019). WhatsApp, in particular, is a highly popular virtual meeting place for youth and adults as a result of a number of factors, including ease of managing communication, its accessibility to existing groups, and the simplicity of building groups (Bouhnik & Deshen, 2014; Naidoo & Kopung, 2020; Rosenberg & Asterhan, 2018).

Greenhow and Askari (2017) published a survey of a decade of educational K-12 research literature that studied how learning and teaching using innovative technological environments such as social networks and the Internet has led to a transformation in the mathematics classroom and how such technologies are perceived and used. The authors pointed out that there is a lack of basic research that focuses on learning in innovative technological environments (such as social networks) and emphasized the need for more such studies to discover teaching-learning opportunities that may not have yet been recognized. Although in recent years there has been an influx of research focusing on the benefits of using social media for promoting and supporting learning, the majority focus on post-secondary contexts relating to pre- and in-service teachers' professional development (e.g., Dyson et al., 2015; Naidoo & Kopung, 2016; Sendurur et al., 2015; Yeo, 2014) or on developing virtual communities for supporting and monitoring in-service teachers (Moodley, 2019). However, this growing body of empirical research suggests that the use of digital social platforms such as WhatsApp can also be instrumental in teaching and learning any type of content knowledge, including mathematics (Biton & Segal, 2021; Bouhnik & Deshen, 2014; Durgungoz & Durgungoz, 2022; Greenhow & Lewin, 2016; Morsidi et al., 2021).

Learning via WhatsApp social network motivates learners to collaborate with their peers over the Web (Biton & Segal, 2021; Pocan et al., 2023), take advantage of the various online environments, expedite their learning through interaction between the group's members, and employ anonymous active or passive learning. For the K-12 student, it can foster teacher-student or student-student interactions. Feedback is often immediate and focuses on their difficulties. They are exposed to the mathematical ideas of their peers, which can promote collaboration and develop communities of inquiry. Students perceive WhatsApp group as a safe place for informal relationships and personal disclosure (Kizel, 2019) and a platform, where they can share ideas without fear. In addition, students

feel that this environment breaks down social hierarchies and boundaries and provides an attentive, flexible environment, where they have the freedom to choose whether to respond or not (Biton & Segal, 2021; Freeman et al., 2016; Kizel, 2019; Naidoo & Kopung, 2020).

Furthermore, as a result of the accessibility of new smartphone technologies, students now have diverse opportunities for learning, improving reading skills, and cultivating critical thinking (for example, needing to evaluate the reliability of the extensive information they are exposed to) (Schleicher, 2019). WhatsApp environment is an important tool for exposing students to a wide repertoire of thinking strategies and task-solving tactics, which can improve their creative thinking.

Blended Learning

Social networks have led to the implementation of what is termed "blended learning" (Borba et al., 2016; Engelbrecht et al., 2020), that is, a combination of frontal classroom-based learning with online (synchronous or asynchronous) elements. Blended learning comprises a set of methods that can include collaborative activities, flipped classrooms, and online instruction via applications and social networks. It invites students to engage in a variety of activities. It fosters excitement and joy and better interaction with teacher and peers. Having to put effort into acquiring knowledge may increase students' motivation and allow them to develop their own opinions, use a variety of skills to improve their understanding, consider new ideas, improve reading comprehension and critical reading of their peers' explanations, and self-regulate their learning while trying to express their idea in anonymous environment (Bahri et al., 2021; Biton & Segal, 2021; Engelbrecht et al., 2020; Holley & Oliver, 2010; Nida et al., 2020; Quinn & Aarão, 2020; So & Brush, 2008).

More empirical evidence is still needed to determine the effectiveness of integrating social media into online or blended mathematical instruction (Engelbrecht et al., 2020). Also, mathematics teachers and educators must become better aware of how to use and implement WhatsApp as a social network and how to consider the emotional and social aspects of this method (Schleicher, 2019).

Learning in each Bagroup study group used synchronous and non-synchronous "blended learning" sessions (Garrinson & Vaughan, 2008; Nida et al., 2020; Schwartz et al., 2017; Tella, 2014) based on the constructivist approach (Honebein, 1996), which invites experimentation and research by the learners to build knowledge.

Socio-Emotional Learning

Socio-emotional learning (SEL**)** is the process of acquiring the skills necessary to manage the emotions involved in displaying empathy, defining, and achieving goals, establishing positive relationships, and facing challenging situations. There are five categories: self-awareness, self-management, social awareness, communication skills, and responsible decision-making. SEL occurs in parallel with other learning processes (Collaborative for Academic, Social and Emotional Learning [CASEL], 2003; Weissberg et al., 2015). Developing SEL skills allows students to identify and analyze their emotions and calm themselves when frustrated. It also allows them to feel safe to ask questions when they need help (CASEL, 2022).

SEL develops when learners are given the autonomy to manage their learning and enhance their decision-making skills through communication with peers while receiving support, respect, cooperation, and empathy (Deci & Ryan, 2012; Ryan & Deci, 2000; Tong et al., 2021). Having autonomy means that the teacher allows them to choose how to learn from a variety of options and even decide on their learning goals. By being provided, among other things, with a variety of learning methods and materials, they can choose how to best promote their understanding processes (Kamour & Altakhayneh, 2021; Sears et al., 2022). Teaching behaviors that support student autonomy include creating time for independent work, providing opportunities for students to express themselves, praising and encouraging student effort, providing cues when a student seems stuck, and listening to the student's questions and comments (Reeve, 2006; Reeve & Jang, 2006).

Developing SEL skills is especially essential for learning mathematics because of the negative feelings students often display towards this discipline (Lewis, 2013; McLeod, 1992). When students with healthy SEL skills are faced with a problem in solving a mathematical exercise, they will be able to calmly assess their existing knowledge, seek new strategies to solve the problem, and translate their insights into a solution. They will be able to consider their peers' approaches to problem-solving, evaluate proposed solutions, experiment with various ideas to better understand the problem, and share their ideas with others (Sears et al., 2022).

Joswick and Taylor (2022) noted the link between SEL and classroom discussions because social awareness means students implement social norms: they are respectful to their peers and their teacher when discussing ideas, listen empathetically, and express their ideas clearly. They will also ask one another questions to make sure they have grasped how their peers are thinking. Technology offers enormous opportunities for real-time discussion and assessing and tracking students' SEL progress over time. The potential is huge as it allows reaching large numbers of people instantly and simultaneously (Weissberg et al., 2015).

BAGROUP PROJECT: LEARNING USING WHATSAPP

WhatsApp Bagroup project (hereinafter referred to as "Bagroup") was initiated in 2016 by the Center for Education Technology in the Ministry of Education in Israel to offer a learning environment for high school students preparing for their math matriculation ("*Bagrut*") exams. It began in the Facebook environment (Biton et al., 2014) and progressed with the integration of WhatsApp application. The initiative for Bagroup project was following a sharp decrease in the number of students studying high school mathematics and taking the matriculation exam at the highest level. There are three levels of mathematics matriculation exams in Israel: the three-unit level is the lowest and the five units is the highest. The current study was conducted among WhatsApp groups with students in grades 11 and 12 who were studying for five-unit level matriculation, The students who learning at this level were required to study a larger number of topics at the highest level of complexity. The questions on the matriculation exams at these levels require a solid understanding of the subjects alongside the connectivity between different concepts and subjects.

Success in the five-unit-level mathematics matriculation exam enables admission to in-demand faculties at universities and eventually higher remuneration from employment (Fried et al., 2018; Zeedan & Hogan, 2022). Therefore, many students are eager to succeed at this level, and the State of Israel is interested in providing learning opportunities that will lead to success in the matriculation exam at this level for all students.

The project aimed to help students in the five-unit-level mathematics succeed by providing professional support beyond school hours. Most importantly, it enabled these students with low socioeconomic status to receive educational support (thus bypassing the need for expensive after-school tutors), thereby reducing gaps, and promoting equal opportunities for all the five-unit-level mathematics students preparing for matriculation. Participation in the project was free of charge.

The advantages were five-fold:

(1) **immediacy**: any student who experienced difficulty with the material could get immediate response from a teacher or other students,

(2) **equality**: WhatsApp technology is free, meaning that every member of the student body could access it and participate,

(3) **mobile learning**: the smartphone supplemented classroom instruction anywhere and anytime in the student's natural environment,

(4) **encouragement**: better understanding and feelings of capability, increasing self-confidence, and

(5) **variety**: students were exposed to a multitude of learning and problem-solving methods.

STUDY PURPOSE & RESEARCH QUESTIONS

The current study is part of a broader study about the many facets of Bagroup project. This paper focuses on the students' perceptions of Bagroup program, its goal being to identify and characterize students' perceptions of the program.

Research Questions

1. What did students perceive to be the main factors involved in learning in Bagroup project (via WhatsApp)? What factors affect students' perception of learning via WhatsApp in Bagroup program and of the learning environment itself?
2. What correlation, if any, is there between the three constituent factors that students feel characterize WhatsApp environment and to what extent?

METHOD

Participant Recruitment

Students

A call went out to the entire population of Israeli high school students who learned in five-unit-level mathematics, inviting them to experience learning in WhatsApp groups alongside other students across the country and under the guidance of expert teachers. Participating in Bagroup project would allow them the opportunity to study anonymously with a different teacher and peers and get answers to their questions at any time of the day. Approximately 4,000 students expressed interest in participating. 40 groups were formed so that in each group of about 100 students there were no more than ten from the same school, thus ensuring a heterogeneous country-wide population in each group. All the students in a group were studying at the same part of matriculation level five-unit-level mathematics (held at the end of the 11th grade [part A] and 12th grade [part B]), and each was also studying mathematics in their regular class in school (see **Figure 1**), meaning that a student would be participating concurrently both in their dedicated class-based WhatsApp group and in the specific Bagroup group to which they had been assigned (with students and teachers whom they did not personally know).

Teachers

40 teachers participated in the study. They were selected based on recommendations of mathematics pedagogical instructors (on behalf of the supervisor of mathematics teaching in the Ministry of Education).

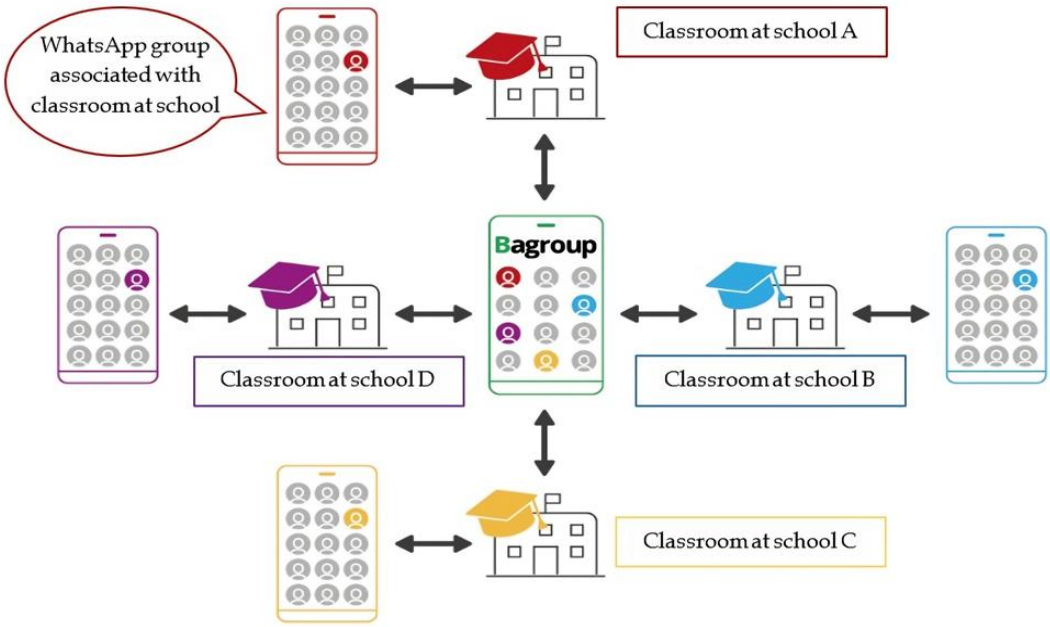

Figure 1. Illustration showing students participating in two learning environments: Regular classroom & Bagroup project via WhatsApp (Source: Authors' own elaboration)

All had at least five years of experience teaching mathematics. Concurrent with their participation in Bagroup project, they also taught mathematics in regular classrooms in school. The teacher moderating a particular Bagroup group did not personally know any of the students and had no information about their academic abilities, nor which schools they attended.

Pedagogical coordinators

The pedagogical coordinators had extensive experience in teaching high school mathematics. Alongside a team of experts, they designed the teaching program for each level of matriculation. A syllabus was created, and appropriate digital teaching material was located from a variety of recognized, approved websites and offered to the teachers. These included PowerPoint presentations, ready-made widgets that visually and dynamically illustrate mathematical concepts and processes, information pages, worksheets, and more.

From time to time, the pedagogical coordinators monitored the learning-teaching processes in the various groups with the assistance of additional teachers. They were in continuous contact with teachers to address any challenges and to suggest ways of solving and coping.

Administrative coordinator

Responsibility for all technical and technological aspects of group organization was that of the administrative coordinator and a team of experts. They ensured that each group comprised students who did not learn in the same class at school, managed the technological design of WhatsApp groups, matched each group with a teacher, and identified and provided immediate response to any technological malfunctions or difficulties. This backup allowed teachers freedom to concentrate on the learning-teaching process.

Duration

The project was initiated approximately three months before and continued up until Bagrut exam. Many messages pertaining to scholastic content, questions, solutions, and explanations were sent.

Learning & Teaching Process

The specific learning program for each group was designed by the pedagogical coordinator. For each topic, two or three 45-minute WhatsApp synchronous lessons were held during which the assigned teacher presented the topic, shared applicable files, invited written discussion, and emphasized significant points. They could make use of the materials suggested by the coordinator or supply any other educational materials. They also posted daily questions about the pre-defined topic to be solved within the group.

Students had access to the group 24/7 and could communicate using text, voice, or video messages. They could upload photos, exercises, presentations, and more. They were also free to ask any question on any subject from the curriculum: difficulties in understanding concepts, a question from their homework, theoretical content for which they needed more explanation, etc. Although the group was overseen by one single teacher to ensure consistency, in fact, most of the learning was peer-to-peer: the main role of the teacher was to monitor interactions within the group and, if necessary, point out any details that seemed to be overlooked or answer any question that had not yet been answered by the students themselves.

Data Collection

This was a mixed-method study (Creswell, 2014). The major source of data was the responses to the online questionnaires distributed at the end of the three-month learning period to which 152 students (out of the total 4,000 who participated in the project) responded, i.e., a nonprobability sampling method based on participants' availability and willingness to respond to questionnaire.

The questionnaire was designed by five experts in mathematics education (the pedagogical coordinator, the first author of this paper, and three other researchers in mathematics education) who also ascertained the validity of its structure and content, determined whether each item in the questionnaire was relevant to the current study, and examined the necessity of each item for answering the research questions. At the end of the process items, which attained least 80% agreement of the judges were selected.

In its final form, the questionnaire comprised nine open-ended questions and 12 six-point Likert statements ranging from one (strongly disagree) to six (strongly agree). The open-ended questions invited students to share a memorable experience or an episode they had in any of WhatsApp interactions. They were also asked what they thought were the most obvious advantages and disadvantages of using WhatsApp for learning high school mathematics, and any specific characteristics of WhatsApp that made the mathematical content more accessible to the students.

Students' responses to the open questions were analyzed and coded for themes by the authors through content analysis. A factor analysis with varimax rotation analysis was used to reveal how WhatsApp learning environment was perceived by the students.

Data analysis (frequencies, percentages, means, and standard deviations) of Likert statements allowed tracking the factors that students believed promoted or hindered learning in this environment. The results of the analyses were validated and verified by three expert judges (researchers in mathematics education) until agreement was reached on the categorization.

FINDINGS

Overall Findings (First Question)

Regarding the first research question, the factor analysis yielded three overall factors that explain 58% of the variance in the responses (see **Table 1**). These were: factors that contribute to the emotional needs of the learner (five statements, explain about 25% of the variance), factors that promote learning (four statements, explain an additional 20% of the variance), and factors that hinder learning (two statements, explain an additional 8% of the variance).

Table 1. Factor analysis with varimax rotation for items regarding learning environment in WhatsApp & means (Ms) & standard deviations (SDs) of categories & statements (n=152)

	M	SD	Variables			
Category 1: Contribution to e**motional needs** of learner.	3.51	1.15	%	25.99	C%	25.99
			R	α=.79		
• I **managed to follow** lesson during WhatsApp discourse.	3.46	1.65	.768			
• I **managed to understand material in** WhatsApp environment at same level as in a regular class.	3.84	1.30	.750			
• WhatsApp allows **participation without fear of making errors.**	3.73	1.68	.714			
• **Written discourse** in WhatsApp is **preferable** over verbal discourse in a regular class.	2.80	1.53	.582			
• Learning through WhatsApp allowed me to meet my **specific needs** as a learner more than in a regular class.	3.72	1.61	.515			
Category 2: Factors that **promote** learning.	3.81	1.13	%	19.94	C%	45.93
			R	α=.74		
• Learning through WhatsApp allows me to **learn from others more** than in a regular class.	3.99	1.61	.741			
• **Lesson plan** via WhatsApp is **different** from lesson plan of a regular class.	4.65	1.40	.640			
• Learning via WhatsApp **improved my mastery of available technologies** for learning mathematics.	3.27	1.68	.519			
• I invested **more time & effort** in mathematics in WhatsApp project compared to in a regular class.	3.04	1.68	.516			
• In future, **WhatsApp will become an important tool for students for learning math.**	4.09	1.67	.447			
Category 3: Factors that **hinder** learning.	3.09	1.29	%	12.13	C%	58.06
			R	ρ=.28 & p<.000		
• There is some mathematical content t**hat cannot be explained** via WhatsApp.	3.53	1.73	.809			
• **I cannot manage to cooperate** with other students' way I do in a regular class.	2.66	1.47	.706			

Note. %: Percentage of variance explained by factor; C%: Cumulative percentage of explained variance; & R: Reliability

Table 2. Levels of student agreement with statements concerning contribution of Bagroup WhatsApp environment to learner's emotional needs

Statement	A	SA	D
I managed to follow the lesson during the WhatsApp discourse.	48.7	37.5	13.8
I managed to understand material in WhatsApp environment at same level as in a regular class.	59.9	35.5	4.60
WhatsApp allows participation without fear of making errors.	55.3	32.3	12.5
Written discourse in WhatsApp is preferable over the verbal discourse in a regular class.	28.3	45.4	26.3
Learning via WhatsApp allowed me to meet my specific needs as a learner more than in a regular class.	53.9	35.6	10.5

Note. A: Agree; SA: Somewhat agree; & D: Disagree

Table 3. Levels of student agreement with statements relating to factors in Bagroup WhatsApp environment that promote learning

Statement	A	SA	D
Learning via WhatsApp allows me to learn from others more than in a regular class.	82.2	15.2	2.6
The lesson via WhatsApp is different from the lesson of a regular lesson.	63.1	28.3	8.6
Learning via WhatsApp improved my mastery of available technologies for learning mathematics	63.8	27.6	8.6
I invested more time & effort in math in WhatsApp project compared to students in a regular class.	44.7	34.9	20.4
In the future, WhatsApp will become an important tool for students for learning math.	36.2	41.4	22.4

Note. A: Agree; SA: Somewhat agree; & D: Disagree

Table 4. Levels of student agreement with statements relating to factors in Bagroup WhatsApp environment that inhibit learning

Statement	A	SA	D
There is some mathematical content that cannot be explained via WhatsApp.	51.4	31.5	17.1
I cannot manage to cooperate with other students the way I do in a regular class.	31.6	38.8	29.6

Note. A: Agree; SA: Somewhat agree; & D: Disagree

Table 5. Correlations among three factors (n=152)

	Emotional needs	Factors that promote learning
Factors that promote learning	ρ=.66, p<.000	
Factors that hinder learning	ρ=-.19, p=.017	ρ=-.14, p=.084

Each group of factors was analyzed separately to determine the distribution of agreement. For ease of presentation, the original six Likert scores were reduced to three levels: disagree (all answers originally scored as "1"), somewhat agree ("2" or "3" combined), and agree ("4," "5," or "6" combined).

A Breakdown of Three Factors

Table 2, **Table 3**, and **Table 4** present the distribution of answers in each of the three categories–emotional needs, promote learning, hinder learning, respectively.

The most notable disagreement was regarding the preference of the written discourse in WhatsApp over regular discourse in a classroom. However, only about one-quarter of the students disagreed, meaning that about 75% thought it was preferable. As can be seen from **Table 3**, the vast majority of students seemed satisfied with WhatsApp platform and believed that despite its difference from regular classroom learning, it was beneficial for learning, especially with regard to peer learning, and will become more important in the future.

As can be seen from **Table 4**, the issue of expressing mathematical notation seemed a hindrance to about 80% of the respondents.

Correlations Between Three Factors (Second Question)

To deepen the understanding of the students' learning in WhatsApp environment, the correlation between the three components identified in the factor analysis was examined using the Spearman test (correlation between ratings–ρ1). The results are shown in **Table 5**.

From **Table 5**, one can see that the more students agree that WhatsApp environment contributes to their emotional needs, the more they consider that it promotes learning, and the more they agree that it contributes to both their emotional needs and promotes learning, the less they tend to agree with the two factors that may hinder learning.

A positive high significant correlation (ρ=.66, p≤.000, n=152) was found between factors contributing to the emotional needs of the learner and factors that promote learning. In addition, a negative low significant correlation was found between factors contributing to emotional needs and factors that hinder learning (ρ=-.19, p=.017, n=152). A negative low insignificant correlation was found between factors that promote learning and factors that hinder learning (ρ=-.14, p=.084, n=152).

Meaning, the more that students agree that WhatsApp environment contributes to their emotional needs, the more they agree that it promotes learning; the more they agree that it contributes to both their emotional needs and promotes learning, the less they tend to agree with the two factors that may hinder learning.

DISCUSSION

The present study helps answer the call of Engelbrecht et al. (2020), who, based on their literature survey, suggested that more empirical evidence is needed to determine the effectiveness of online or blended instruction that integrates innovative information and communication technology (such as social media) in mathematics classrooms at all levels.

The aim of the current study was to determine students' perceptions of learning in WhatsApp social network as part of their participation in Bagroup project, as described above. The findings of the factor analysis point to three aspects: how the environment meets their socio-emotional needs, aspects that promote learning, and aspects that hinder learning.

Socio-Emotional Aspects

Like Durgungoz and Durgungoz's (2022) study, which describes the integration of WhatsApp social network into high school math studies over the course of two years, the findings of the current study also indicate that students perceive WhatsApp to be a good platform for learning outside of school hours. This, despite that the current program took place over a relatively short time span of a few months. The findings also reinforce the positive perception of WhatsApp's environment for learning that is suggested by the findings of Morsidi et al. (2021) and Pocan et al. (2023), which suggest that students perceive WhatsApp environment as one that increases motivation and allows them to develop their communication and collaboration skills.

It is important to remember that the students who participated in the current study are, according to Morin (2016), the "Internet generation," often called Generation Z, born after 2000, and the internet is a crucial part of their lives. They are attached to their smartphones and are used to managing their learning through social networks and mobile technology.

It is also important to note the innovation presented in the current study, namely, the method by which WhatsApp groups of students were assembled so that the approximately 100 members (students and teachers) in each group were strangers to each other. We found similar anonymity in the studies of Kizel (2019) and Naidoo and Kopung (2020) (high school philosophy students and pre-service mathematics teachers, respectively). However, in many of the studies we discovered, WhatsApp group was populated by students in the same class (see, for example, Durgungoz & Durgungoz, 2022; Nida et al., 2020), meaning that there was no sense of anonymity. The result of the current study suggests that the anonymity was a significant factor that contributed to positive socio-emotional aspects because students could feel free to ask any question, make any statement, and express any idea in a non-judgmental environment, something that is necessary for successful learning (CASEL, 2022; Deci & Ryan, 2012; Ryan & Deci, 2000).

Didactic Aspects

With respect to didactic issues, the vast majority of students who answered the questionnaire reported that they were able to understand the topics taught in WhatsApp environment at the same level as in the classroom and that they were able to follow the discourse taking place in the group and cope with the challenges in learning. They communicated with the others in the group and with a teacher they do not know while self-managing their difficulties, challenges, and more. They could participate at any given time and get an immediate response. Learning in a group with a professional teacher and 100 additional students aiming to sit for the same matriculation exam and striving for the same goal provided ongoing, continuous support to cope with any difficulty and challenge. The effect was to encourage the students to continue to invest more time and effort in the learning process. In fact, about 77% of the students agreed fully or to some extent that they did so compared to their regular class. From this, it can be concluded that these students were more motivated to learn, which corroborates with what was suggested by Durgungoz and Durgungoz (2022) and Schleicher (2019), that is, that employing technology such as a WhatsApp environment enables students access to a rich, varied collection of material that can serve as a platform for exploration and deeper understanding of the content being studied.

Most importantly, many of the respondents (97%) reported that learning in WhatsApp environment allowed them to learn from others even more than in a regular classroom. This may be because the students in Bagroup project were exposed to a richer array of ideas, solutions, and explanations than in the regular classroom. This relates to technology-based learning processes and collaborations as described by Borba et al. (2016) in which group learners share, respond, and learn from the accumulated knowledge of all the group members rather than from the teacher. The exposure to mutually shared ideas, explanations, and solutions from a large number of learners, encourages participants to examine them all, which contributes to understanding the subjects under study better and developing better communication abilities, mathematical literacy, and critical thinking skills, similar to what Schleicher (2019) has claimed, "*the more knowledge that technology allows*

students to search and access, the more important becomes deep understanding and the capacity to make sense of content" (p. 14).

Technological Skills

The international education community has been occupied with the need to prepare high school graduates for the constantly changing unpredictable world of the 21st century. 21st century competencies include the capabilities to think critically, reason logically, function as a member of a team working to achieve a common goal, exhibit creativity, and clearly express innovative ideas, etc. OECD (2018, 2019) has recommended integrating new methods into traditional disciplines such as mathematics. The findings indicate that the project contributed to the development of learners' technological literacy: over 90% of the respondents reported that, to one degree or another, learning via WhatsApp improved their mastery of available technologies for learning mathematics.

Equitability

The model we presented allows equal opportunities for all, first, because participation was unrelated to their economic situation (Espinoza, 2007), and second as a result of the anonymity factor. Learning in the project allows every student who so desired to aim for success in mathematics and the mathematics *Bagrut*.

Availability & Accessibility

Engelbrecht et al. (2020) emphasized the importance of the accessibility that the social network affords, especially when learners live geographically distant from their peers. Accessibility also refers to today's ubiquitous availability of the mobile phone, enabling continuous and immediate contact with other learners as well as constant access to others' solutions to a given problem, observing interactions between peers, and more.

The availability and accessibility afforded by the project was not only due to the social network located on the smartphone in the palm of every student, but also due to the availability and accessibility of a group of 100 students in the group to answer any question, consult, and deliberate 24/7. Availability and accessibility also refer to additional teaching methods and learning opportunities from teachers and peers who offered different explanations than what the student obtained in their regular classroom.

Factors That Hindered Learning

Despite the many advantages inherent in Bagroup project, the findings also indicated two factors that hindered learning: that some mathematical content cannot be explained via WhatsApp and that cooperation was difficult. Indeed, some mathematical content simply does not lend itself to explanation over WhatsApp since it is virtually impossible to easily type mathematical content on a mobile phone, thus hindering the communication of mathematical processes. Thus, the "ease of use" mentioned in the literature (e.g., Durgungoz & Durgungoz, 2022; Engelbrecht et al., 2020; Nida et al., 2020) by which WhatsApp is presented as an engine that facilitates the flow of messages, collaboration, and knowledge between learners is actually inaccurate when it comes to the discipline of mathematics because of the specific impediment.

The second factor was mentioned by about 70% of the respondents, who stated that, to one extent or another, that they could not manage to cooperate with other students the way they do in a regular class. It is possible that this difficulty stems from anonymity and the absence of face-to-face communication that would better facilitate collaboration with familiar peers.

CONCLUSIONS

Overall, the students who responded to the questionnaire showed a positive attitude to Bagroup project. The use of WhatsApp facilitated continuous communication between learners from different areas of the country who were striving for a common goal (success in the matriculation exam) and provided an equitable environment in which any question or difficulty could be posted to the group and receive (almost) immediate response, somewhat reminiscent of a vCoP (Moodley, 2019). Other benefits were exposure to additional teaching approaches, diverse ways of explanation, and a myriad of learning opportunities and resources. Additionally, were the socio-emotional benefits of participating in a non-judgmental atmosphere.

As noted above, the current study is part of a broader study focusing on both students' and teachers' perceptions of Bagroup project (Biton et al., 2022a, 2022b). Given the positive attitudes, a program such as Bagroup can offer a solution to communication problems that arise during times of emergency (such as with the COVID-19 pandemic) by providing an alternate safe environment for teaching and learning mathematics besides the classroom at school.

Another contribution of this study is the questionnaire it provides, which has been tested for validity and reliability and that can be used as a research tool in other studies to trace students' perception of learning in various social networks.

Study Limitations & Suggestions for Further Studies

The current study was conducted in the framework of Bagroup project in which 4,000 students from across the country participated. A limitation of this study is the relatively small number of students (152) who answered the questionnaire compared to the number of students

who participated overall. Although the analysis of the answers to the questionnaire indicated a variety of perspectives regarding the process of learning mathematics in Bagroup project, one must be aware that the results presented do not represent the entire population of participants.

Despite this research limitation, we believe that the contribution of the present study can be expressed in that one can use the model and the research tools presented in this study, while conducting similar studies regarding other areas of education and at the same time, take the required measures to achieve a much higher percentage of the participant responders.

Similar studies that integrate the use of WhatsApp social network might be conducted not only in high school in preparation for matriculation exams but also at other levels and in other educational frameworks. For example, a similar model could be integrated into math studies in middle school as part of a national support system to furnish students with additional learning opportunities beyond those in school. This would be especially helpful in the transition year from middle school to high school when students usually show difficulty.

In addition, it would be interesting for researchers in mathematics education in other countries to conduct similar studies integrating the model and research tool (questionnaire) and compare students' perceptions.

It would also be valuable to conduct research that compares teachers' and students' perceptions of teaching/learning mathematics using WhatsApp. We would love to read about and cooperate with such studies in the future.

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REFERENCES

Ainscow, M. (2020). Promoting inclusion and equity in education: Lessons from international experiences. *Nordic Journal of Studies in Educational Policy, 6*(1), 7-16. https://doi.org/10.1080/20020317.2020.1729587

Bahri, A., Idris, I. S., Muis, H., Arifuddin, M., & Fikri, M. (2021). Blended learning integrated with innovative learning strategy to improve self-regulated learning. *International Journal of Instruction, 14*(1), 779-794. https://doi.org/10.29333/iji.2021.14147a

Biton, Y., Hershkovitz, S., & Hoch, M. (2014). Learning with Facebook: Preparing for the mathematics Bagrut - A case study. In C. Nicol, P. Liljedahl, S. Oesterle, & D. Allan (Eds.), *Proceeding of PME 38 and PME-NA 36* (vol. 2, pp. 161-168). PME. https://files.eric.ed.gov/fulltext/ED599759.pdf

Biton, Y., & Segal, R. (2021). Learning and teaching mathematics with online social networks: The case of Facebook. In *Teacher Education - New Perspectives*. IntechOpen, https://doi.org/10.5772/intechopen.95998

Biton, Y., Segal, R., & Fellus, O. (2022a). Students' perceptions of learning mathematics in the WhatsApp environment through the Bagroup project. In J. Hodgen, E. Geraniou, G. Bolondi, & F. Ferretti (Eds.), *Proceedings of the Twelve Congress of the European Society for Research in Mathematics Education* (pp 1319-1326). Free University of Bozen-Bolzano. https://hal.science/hal-03745590/document

Segal, R., & Biton, Y. (2022b). Teachers' perceptions of teaching and learning mathematics in the WhatsApp environment through the "Bagroup" project. In J. Hodgen, E. Geraniou, G. Bolondi, & F. Ferretti (Eds.), *Proceedings of the Twelfth Congress of the European Society for Research in Mathematics Education* (pp. 2610-2617). Free University of Bozen-Bolzano. http://erme.site/wp-content/uploads/2023/02/indexPROCEEDINGS.pdf

Borba, M. C., Askar, P., Engelbrecht, J., Gadanidis, G., Llinares, S., & Sánchez-Aguilar, M. (2016). Blended learning, e-learning, and mobile learning in mathematics education. *ZDM Mathematics Education, 48*, 589-610. https://doi.org/10.1007/s11858-016-0798-4

Bouhnik, D., & Deshen, M. (2014). WhatsApp goes to school: Mobile instant messaging between teachers and students. *Journal of Information Technology Education. Research, 13*, 217. https://doi.org/10.28945/2051

Boyd, D. (2010). Social network sites as networked publics: Affordances, dynamics, and implications. In P. A. Zizi (Ed.), *Networked self: Identity, community, and culture on social network sites* (pp. 39-58). Routledge.

Calderón-Garrido, D., & Gil-Fernández, R. (2022). Pre-service teachers' use of general social networking sites linked to current scenarios: Nature and characteristics. *Technology, Knowledge and Learning,*

28, 1325-1349. https://doi.org/10.1007/s10758-022-09609-7

CASEL. (2003). *Safe and sound: An educational leaders' guide to evidence-based social and emotional learning (SEL) programs*. Collaborative for Academic, Social and Emotional Learning.

CASEL. (2022). Fundamentals of SEL. *Collaborative for Academic, Social and Emotional Learning*. https://casel.org/what-is-sel/

Chapin, S. H., O'Connor, M. C., & Anderson, N. C. (2013). *Classroom discussions: Using math talk to help students learn, grades 1-6*. Math Solutions Publications.

Creswell, J. W. (2014). *Qualitative, quantitative and mixed methods approach*. SAGE.

Deci, E. L., & Ryan, R. M. (2012). Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In R. M. Ryan (Ed.), *The Oxford handbook of human motivation* (pp. 85-107). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195399820.013.0006

Durgungoz, A., & Durgungoz, F. C. (2022). "We are much closer here": Exploring the use of WhatsApp as a learning environment in a secondary school mathematics class. *Learning Environments Research, 25*(2), 423-444. https://doi.org/10.1007/s10984-021-09371-0

Dyson, B., Vickers, K., Turtle, J., Cowan, S., & Tassone, A. (2015). Evaluating the use of Facebook to increase student engagement and understanding in lecture-based classes. *Higher Education, 69*, 303-313. https://doi.org/10.1007/s10734-014-9776-3

Engelbrecht, J., Llinares, S., & Borba, M. C. (2020). Transformation of the mathematics classroom with the Internet. *ZDM, 52*, 825-841. https://doi.org/10.1007/s11858-020-01176-4

Espinoza, O. (2007). Solving the equity–Equality conceptual dilemma: A new model for analysis of the educational process. *Educational Research, 49*(4), 343-363. https://doi.org/10.1080/00131880701717198

Freeman, B., Higgins, K. N., & Horney, M. (2016). How students communicate mathematical ideas: An examination of multimodal writing using digital technologies. *Contemporary Educational Technology, 7*(4), 281-313. https://doi.org/10.30935/cedtech/6178

Fried, M. N., Perl, H., & Arcavi, A. (2018). Highlights in the development of education and mathematics education in the state of Israel: A timeline. In N. Movshovitz-Hadar (Ed.), *Israel mathematics education K-12* (pp. 3-19). World Scientific. https://doi.org/10.1142/9789813231191_0001

Garrinson, D, R. & Vaughan, N, D. (2008). *Blended learning in higher education: Framework, principles and guidelines*. John Wiley & Sons, Inc. https://doi.org/10.1002/9781118269558

Greenhow, C., & Askari, E. (2017). Learning and teaching with social network sites: A decade of research in K-12 related education. *Education and Information Technologies, 22*(2), 623-645. https://doi.org/10.1007/s10639-015-9446-9

Greenhow, C., & Lewin, C. (2016). Social media and education: Reconceptualizing the boundaries of formal and informal learning. *Learning, Media and Technology, 41*(1), 6-30. https://doi.org/10.1080/17439884.2015.1064954

Holley, D., & Oliver, M. (2010). Student engagement and blended learning: Portraits of risk. *Computers and Education, 54*(3), 693-700. https://doi.org/10.1016/j.compedu.2009.08.035

Honebein, P. C. (1996). Seven goals for the design of constructivist learning environments. In B. B. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 11-24). Educational Technology Publications.

Joswick, C., & Taylor, C. N. (2022). Supporting SEL competencies with number talks. *Mathematics Teacher: Learning and Teaching PK-12, 115*(11), 781-791. https://doi.org/10.5951/MTLT.2021.0347

Kamour, M., & Altakhayneh, B. (2021). Impact of a counseling program based on social emotional learning toward reducing math anxiety in middle school students. *International Journal of Curriculum and Instruction, 13*(3), 2026-2038.

Kizel, A. (2019). I–Thou dialogical encounters in adolescents' WhatsApp virtual communities. *AI & Society, 34*, 19-27. https://doi.org/10.1007/s00146-017-0692-9

Klemer, A., Segal, R., Miedijensky, S., Herscu-Kluska, R., & Kouropatov, A. (2023). Changes in the attitudes of mathematics and science teachers toward the integration and use of computerized technological tools as a result of the COVID-19 pandemic. *EURASIA Journal of Mathematics, Science and Technology Education, 19*(7), em2295. https://doi.org/10.29333/ejmste/13306

Lewis, G. (2013). Emotion and disaffection with school mathematics. *Research in Mathematics Education, 15*(1), 70-86. https://doi.org/10.1080/14794802.2012.756636

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575-596). Macmillan Library Reference.

Moodley, M. (2019). WhatsApp: Creating a virtual teacher community for supporting and monitoring

after a professional development program. *South African Journal of Education, 39*(2), 1-10. https://doi.org/10.15700/saje.v39n2a1323

Morin, R. (2016). The many faces of the digital generation. *Curatti*. https://www.curatti.com/digital-generation/

Morsidi, S., Abu Samah, N., Abdul Rahman, K. A., Mohamad Ashari, Z., Jumaat, N. F., & Abdullah, A. H. (2021). WhatsApp and its potential to develop communication skills among university students. *International Journal of Interactive Mobile Technologies, 15*(23), 57-71. https://doi.org/10.3991/ijim.v15i23.27243

Naidoo, J., & Kopung, K. J. (2016). Exploring the use of WhatsApp in mathematics learning: A case study. *Journal of Communication, 7*(2), 266-273. https://doi.org/10.1080/0976691X.2016.11884907

Naidoo, J., & Kopung, K. J. (2020). Technology for the 21st century: Exploring the use of WhatsApp Instant Messaging for pre-service teachers' learning of mathematics. *International Journal for Technology in Mathematics Education, 27*(2), 83-97.

NCTM. (2000). *Principles and standards for school mathematics*. National Council of Teachers of Mathematics.

NCTM. (2009). *Guiding principles for mathematics curriculum and assessment*. National Council of Teachers of Mathematics.

NCTM. (2019). *Asking questions and promoting discourse*. National Council of Teachers of Mathematics.

Nida, N. K., Usodo, B., & Saputro, D. R. S. (2020). The blended learning with WhatsApp media on mathematics creative thinking skills and math anxiety. *Journal of Education and Learning, 14*(2), 307-314. https://doi.org/10.11591/edulearn.v14i2.16233

OECD. (2018). The future of education and skills: Education 2030. *OECD*. https://www.oecd.org/education/2030-project/

OECD. (2019). Future of education and skills 2030. *OECD*. https://www.oecd.org/education/2030-project/teaching-and-learning/learning/learning-compass-2030/OECD_Learning_Compass_2030_Concept_Note_Series.pdf

Pocan, S., Altay, B., & Yasaroglu, C. (2023). The effects of mobile technology on learning performance and motivation in mathematics education. *Education and Information Technologies, 28*(1), 683-712. https://doi.org/10.1007/s10639-022-11166-6

Putra, N., Asmar, A., & Yerizon. (2020). Development of mathematics learning tools based on RME approach to improve mathematical communication skills of class VIII students in junior high schools. *International Journal of Progressive Sciences and Technologies, 18*(2), 160-165. https://doi.org/10.52155/ijpsat.v18.2.1544

Quinn, D., & Aarão, J. (2020). Blended learning in first-year engineering mathematics. *ZDM Mathematics Education, 52*, 927-941. https://doi.org/10.1007/s11858-020-01160-y

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *The Elementary School Journal, 106*(3), 225-236. https://doi.org/10.1086/501484

Reeve, J., & Jang, H. (2006). What teachers say and do to support students' autonomy during a learning activity. *Journal of Educational Psychology, 98*(1), 209. https://doi.org/10.1037/0022-0663.98.1.209

Rosenberg, H., & Asterhan, C. S. (2018). "WhatsApp, Teacher?"–Student perspectives on teacher-student WhatsApp interactions in secondary schools. *Journal of Information Technology Education: Research, 17*, 205-226. https://doi.org/10.28945/4081

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78. https://doi.org/10.1037/0003-066X.55.1.68

Saadati, F., Giaconi, V., Chandia, E., Fuenzalida, N., & Rodríguez Donoso, M. (2021). Beliefs and practices about remote teaching processes during the pandemic: A study with Chilean mathematics teachers. *EURASIA Journal of Mathematics, Science and Technology Education, 17*(11), em2023. https://doi.org/10.29333/ejmste/11201

Schleicher, A. (2019). *PISA 2018: Insights and interpretations*. OECD Publishing.

Schwartz, C. S., Morge, S. P., Rachlin, S. L., & Hargrove, T. Y. (2017). A blended online model for instruction: The North Carolina story. In M. B. McGatha, & N. R. Rigelman (Eds.), *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning* (pp. 69-76). Information Age Publishing.

Sears, R., Bay-Williams, J., Willingham, J. C., & Cullen, A. (2022). Symbiosis: Social and emotional learning & mathematics learning. *Mathematics Teacher: Learning and Teaching PK-12, 115*(11), 770-780. https://doi.org/10.5951/mtlt.2022.0081

Sendurur, P., Sendurur, E., & Yilmaz, R. (2015). Examination of the social network sites usage patterns of pre-service teachers. *Computers in Human Behavior, 51*, 188-194. https://doi.org/10.1016/j.chb.2015.04.052

So, H. J., & Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. *Computers &*

Education, 51(1), 318-336. https://doi.org/10.1016/j.compedu.2007.05.009

Sofianidis, A., Meletiou-Mavrotheris, M., Konstantinou, P., Stylianidou, N., & Katzis, K. (2021). Let students talk about emergency remote teaching experience: Secondary students' perceptions on their experience during the COVID-19 pandemic. *Education Sciences, 11*(6), 268. https://doi.org/10.3390/educsci11060268

Tella, A. (2014). Globalisation, blended learning, and mathematics education: Implications for pedagogy in tertiary institutions. In N. P. Ololube (Ed.), *Advancing technology and educational development through blended learning in emerging economies* (pp. 190-211). IGI Global. https://doi.org/10.4018/978-1-4666-4574-5.ch011

Tong, D. H., Uyen, B. P., & Quoc, N. V. A. (2021). The improvement of 10th students' mathematical communication skills through learning ellipse topics. *Heliyon, 7*, E08282. https://doi.org/10.1016/j.heliyon.2021.e08282

Weissberg, R. P., Durlak, J. A., Domitrovich, C. E., & Gullotta, T. P. (2015). Social and emotional learning: Past, present, and future. In J. A. Durlak, C. E. Domitrovich, R. P. Weissberg, & T. P. Gullotta (Eds.), *Handbook of social and emotional learning: Research and practice* (pp. 3-19). The Guilford Press.

Yeo, M. M. L. (2014). Social media and social networking applications for teaching and learning. *European Journal of Science and Mathematics Education, 2*(1), 53-62. https://doi.org/10.30935/scimath/9400

Zeedan, R., & Hogan, R. E. (2022). The correlation between budgets and matriculation exams: The case of Jewish and Arab schools in Israel. *Education Sciences, 12*(8), 545. https://doi.org/10.3390/educsci12080545