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Measurement of Learning Outcomes in Mathematics in Relation to Choosing a Role Model

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Abstract

The measurement of learning outcomes in mathematics in the context of selecting a role model is not widely discussed in the literature on the subject. The results of the literature review presented in the theoretical part of the article, investigating factors related to school achievements, led to the conclusion that having a personal role model may also be related to the scholastic achievements of students. The article outlines a definitional approach to the concept of authority, attaching particular attention to the role of significant persons – role models – in the educational process. Among others, Maria Dudzikowa's concept of authority, which is strictly related to the education process, is presented. According to her, the process of education involves becoming a role model for students and becoming a role model itself is a trimodal relationship. It takes place between the subject, the object, and the "domain of authority" (Dudzikowa, 2008, 2010). Becoming a role model for a student may be linked to their later educational achievement. The aim

of the article is to examine the relationship between selecting a role model and the results of a mock exam and the final grade in mathematics at the fourth level of the Polish Qualifications Framework. The main research problem was encapsulated in the question: What are the relationships between the choice of a role model and learning outcomes in mathematics? The study relied on the survey method (Pilch & Bauman, 2001). A total of 3,388 students in the last year of secondary school taking part in the practice *matura* (school-leaving exam) in mathematics at the basic level participated in the nationwide survey (online research). After completing the math exam, the students were asked to answer an open question: Who is the greatest role model for you? The analysis of the test results indicates the existence of a relationship between choosing a role model and one's grade in mathematics, but it was not statistically significant. The results indicate the need for a deeper investigation into the issue of educational achievements in the context of authority. It would also be worth asking students why someone is a role model for them. This could identify additional factors related to school achievement.

Keywords: role model, teacher, school, education, mathematics, students' mathematical knowledge and skills

Introduction

The issues discussed in this article concern school achievements and their relationship to having a significant person – a role model. In order to outline the subject of the article, we refer to the concept of scholastic achievements, pointing to factors related to them and the concept of authority. In the literature on the subject, school achievements are defined as

the result of the didactic and educational process that students owe to the school, and thus the level of students' mastery of knowledge and skills, the development of their abilities, interests, and motivation, shaping their beliefs and attitudes; school achievements also include such formal effects of school work

as passing an exam, graduating from a year or school, and getting a profession [translated by the author]. (Okoń, 2007, p. 292)

Another definition is offered by Krystyna Kuligowska, who perceives school achievement as “beneficial changes both in the student’s instrumental sphere (in information resources, intellectual abilities, and the ability to use this information in action) and in the directional sphere (in their motivation to act, in aspirations, feelings, and attitudes)” [translated by the author] (Kuligowska, 1984, p. 67). School achievement is measured at school by means of continuous assessment and final grades, as well as external exams. Using appropriate tools, teachers measure students’ knowledge and skills acquisition.

An analysis of the literature on the subject shows that school achievements are related mainly to individual factors – age, gender, or place of residence (Pilch et al., 2013) – access to preschool education (Szlendak, 2003), socioeconomic status (Coleman, 1968; Dolata, 2008; Dolata et al., 2013, 2014, 2015; Firkowska-Mankiewicz, 2011; Karwowski & Dziedziewicz, 2012; Konarzewski, 2012; Kwieciński, 1975, 1980; Pilch, 2013; Pokropek & Sikora, 2015; Reynolds & Walberg, 1992a, 1992b; Smolińska-Theis, 2008, 2014; Szymański, 1973, 2010; Smulczyk 2019; cf. Karwowski, 2013), parents’ status-related educational expectations of their children (Karwowski, 2013), and family *habitus* (Karwowski & Dziedziewicz, 2012, as cited in Karwowski, 2013). They also depend on the student’s activity and past achievements, meaning that a student with better past achievements will do better in the future (Karwowski, 2013; Niemierko, 2021). Maciej Karwowski (2013) points out that most of the differences in students’ results on exams and tests (both high- and low-stakes exams and tests) can be explained by variables related to the student as a person rather than those for which the school and class are responsible (Karwowski, 2013, p. 126; cf. Hattie, 2009; Marzano et al., 2000). Moreover, he indicates that apart from individual factors, school achievements may also be influenced by factors unrelated to the individual traits of a student, such as quality of education, length of education (Szlendak, 2003), peer environment, teacher’s functioning, school climate, in-school and interschool selection processes

(Kwieciński, 1975, 1980, 2002; Nyczaj-Drag, 2009), etc. He emphasizes the significance of these factors for student achievement, as well (Karwowski, 2013, p. 127). The results of studies carried out by Mirosław J. Szymański (1973), Zbigniew Kwieciński (1975, 2002), and others confirm the link between the sociocultural status of the family and factors related to the quality of schoolwork with the educational achievements of students. The most comprehensive model of school achievement, called the productivity model, was developed by Herbert J. Walberg (1981), who asserted that school performance is influenced by nine factors. They can be divided into three groups: 1) individual factors – a student's predispositions, past achievements, motivation, and age-determined development, 2) didactic factors – education in terms of the amount of time devoted to learning and the quality of education, and 3) social factors – class environment, home stimulation, peer influence, and external influences (primarily the media). The research conducted by Walberg using this model indicates a considerable impact of past achievements and the home environment on student achievement (Walberg & Reynolds, 1992a, 1992b, as cited in Karwowski, 2013). Therefore, it can be concluded that research consistently identifies students' abilities and status factors as being most closely related to school achievement.

A student's achievements are also related to the socioeconomic status of their family (Pilch, 2013; Smolińska-Theiss, 2015). It is worth mentioning here that parents from families with a higher socioeconomic status tend to behave in ways that emphasize the subjectivity of children (talking with the child, justifying restrictions, and asking the child's opinion) and they place higher demands on their children. These elements, regardless of the status, translate into the intelligence of the child (Karwowski, 2013, p. 143). Socioeconomic status also correlated more strongly with mathematical and verbal achievement than with overall achievement (Bradley & Corwyn, 2002; Karwowski & Dziedziewicz, 2012; Karwowski, 2013; Sirin, 2005).

Apart from intelligence and socioeconomic status, another factor related to school results is the personality of the student, two aspects in particular: perseverance (the dimension of the personality factor of

conscientiousness) and curiosity (the dimension of openness to experience) (Poropat, 2009; cf. Karwowski, 2013). Distinct significance is attached to factors such as self-efficacy and belief in one's abilities, motivation, learning skills, optimism, or creative abilities (Karwowski, 2013, pp. 144–145). Factors related to the local school environment (such as the wealth of the commune, the level of unemployment, or the expenditure on education) have a lower impact on school achievement (Dolata et al., 2013, 2014, 2015). Factors that relate to the functioning of the school and that influence school achievement also include a positive attitude toward the subject, the atmosphere of the school/class (Fullan, 2009; Karwowski, 2013; Konarzewski, 2012), the teacher and their didactic solutions and teaching styles (Hattie, 2009; Hattie & Timperley, 2007; Karwowski, 2013; Piwowarski, 2011), and the relationships between teachers and students (Karwowski, 2013, p. 173). The research on scholastic achievement indicates the dominant role of personal factors and those related to the socioeconomic status of the family, though factors related to the quality of the school or the teacher – in the Walberg model included in the educational and social factors – should not be ignored.

The review of the literature for factors related to school achievement led to the conclusion that having a role model may also be a related factor (Eshel, 1991; Metz, 1978). In the literature on the subject, a role model is defined as

a model of an ideal member of a given social group, determined by a set of norms and ideas related to performing specific social roles. It is defined by authorities recognized in a given community. Most often it is a set of coherent life goals, motivations for actions, and specific behaviors and personality traits. (Rynio, 2017, p. 17)

The literature on the subject features studies that comprehensively describe the etymology of the word *role model* and the typologies and functions of authority (Bocheński, 1993; Metz, 1978; de Tchorzewski, 2017; Tuziak, 2010; Weber, 1958; Witkowski, 2009; Skarga, 2007), as well

as the concept of authority with regard to teachers (Dudzikowa, 1995, 2007, 2008, 2010; Jagielska, 2021; Kwiatkowska, 2008; Łukasik, 2021). The aim of the article is not to make a detailed analysis of the meaning of authority, but to focus on the meaning of role models for students in the context of school achievement.

The value of a role model becomes fundamentally important especially in periods of accelerating and sudden changes and emerging crises – changes that concern not only social aspects, but also economic and technological ones. Each change creates a “new” reality that the individual must follow, to which the individual must get accustomed, in times when we are dealing with a crisis of authority. In this new reality, new role models are created. The emerging new opportunities create changes in the selection of role models. Living in the era of “permanent change” contributes to the fact that contemporary people are accompanied on a daily basis by “disturbances and reorientation in the axio-normative system, and authority is one of the mechanisms of shaping a new social order and a new axiological system, searching for the meaning of life and making important choices and re-evaluations in this area” [translated by the author] (Tuziak, 2010, p. 53).

An individual’s choice of a particular person as a role model is a manifestation of their recognition of certain qualities that are accepted and admired by other people. Authority manifests itself in being recognized as a role model worth following. In this study, it was assumed that authority means having these features: predispositions which give an individual the advantage of exerting influence over a group or individual. According to Tadeusz Aleksander, the concept of authority also denotes a psychosocial phenomenon consisting in trusting and respecting a specific person or institution, recognizing their high substantive competences and moral values, personal dignity, earnestness, and rank, and perceiving their kindness, friendliness, and diligence (Aleksander, 2002, as cited in Tuziak, 2010). Authority is the emergence of a relationship between the superior individual (the role model), the subject of influence (the recipient of authority), and the existing area of influence (Dudzikowa, 1995; Metz, 1978; Weber, 1958). According to Tuziak,

the essence of this relationship is the recipient's acceptance and recognition of the values represented by the selected role model, taking into account the subjective nature of this relationship and the assumption that it is an objective social fact which plays an integrating, controlling, and motivating role in the sphere of human activities [translated by the author]. (Tuziak, 2010, p. 57)

The notion of authority always means recognizing someone as a person worth imitating, someone who is a model of conduct, and ascribing to that person exceptional features that are worth following (Jagielska, 2021). This, in turn, regardless of its nature, serves to gain an advantage over other people, whether in good faith or bad (de Tchorzewski, 2017, p. 194). According to Andrzej de Tchorzewski, researchers of authority distinguish various types:

- capacity-based authority, possessed by people with exceptional talents, skills, or special competences
- moral authority, wherein people receive respect for their conduct in accordance with generally recognized ethical values and norms
- formal authority, relating to people performing an important function (de Tchorzewski, 2017, p. 194, as cited in Jagielska, 2021)

In this study, we focus on the role models selected by students and their relationship to the students' achievement. In the case of students, the role model may be a teacher. Studies show that teachers become a role model in the teaching process and that authority is not acquired. It is the teacher who, through their actions and behavior, becomes a specific role model. The way they work and behave contributes (or not) to their being recognized as a role model in the eyes of the students. The students participate in the teacher becoming a role model; they decide who is a role model and to what extent (Jagielska, 2021; Kwiatkowska, 2008; Łukasik, 2021).

Being a role model for students in terms of the educational process and educational achievement does not only involve teachers. It concerns

all significant others who play a role in the process of gaining knowledge. In this sense, the definition developed by Maria Dudzikowa, similar to that proposed by Max Weber (1958), is important from the perspective of the theoretical approach to authority. According to her, becoming a role model is a trimodal relationship taking place between the subject, object, and the “domain of authority.” The subject is a person who trusts someone, assigns them high competences in a certain area, and allows that person to influence them. The object is the one whose influence is embraced by the subject because of their credibility and competence. The “domain of authority” is the area in which that person is competent and credible, that is, where this relationship takes place. If this trimodal relationship comes about, then one can speak of the emergence of a role model (Dudzikowa, 2008, p. 8; Dudzikowa, 2010, p. 10; cf. Jagielska, 2021). In the educational process, this trimodal relationship may lead to the later educational achievements of students. A person who is a role model for a student exerts a significant influence over them and motivates them to act. A role model is assigned certain specific features and competences. Perceiving this competence builds trust. A relationship of trust is a relationship of following a role model. A student’s role model can be a teacher. Numerous studies have confirmed this relationship (Dudzikowa, 2008, 2010; Dżerdżon, 2011). Some point to the role of a teacher’s authority in students’ achievement and improved grades (Bandura & Wood, 1989; Brophy & Good, 1986; Eshel, 1991; Metz, 1978; Pace & Hemmings, 2006; Pintrich & de Groot, 1990). A teacher’s position of authority for students is related to the construction of educational and career paths (Jagielska, 2021; Łukasik, 2021).

By analyzing various aspects of students’ achievements, in this article we try to indicate the links between students’ achievements and the people who are their role models. These studies seem to be an attempt to answer the questions of whether, during a crisis of authority, young people have any significant people in their lives who are important to them and how having such a person relates to their school achievements.

The aim of the article is to examine the relationship between the selection of a role model and the results on a mock exam and the final grade

in mathematics at the fourth level of the Polish Qualifications Framework. The main research problem was phrased in the question: What are the relationships between choosing a role model and the learning outcomes in mathematics? The analysis is important from the viewpoint of knowledge because there is a lack of research in Poland on the relationship between role models and school achievements.

Methodology and Research Questions

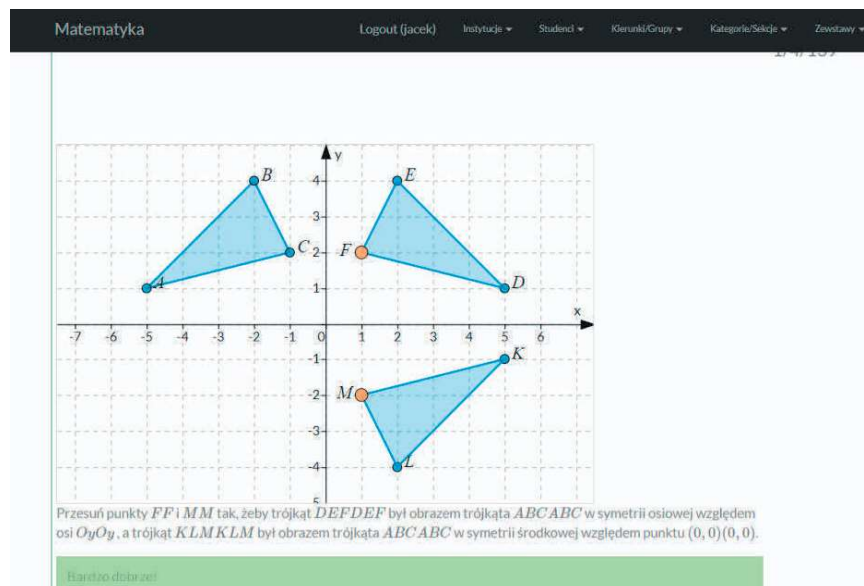
Invitations to participate in an online, real-time mock final exam was sent to all secondary schools in Poland. School data came from the database of the Education Information System (*System Informacji Oświatowej*). A total of 261 secondary schools from all voivodships participated, which was approximately 3%. The participants of the study were students in the last year of secondary school, aged 18 years.

We will now discuss the distribution of the number of high school graduates in relation to the number of graduates taking the final exam (*matura*) in mathematics in 2021, using the data presented in the Central Examination Board (CKE) report, *The Matriculation Examination Report 2021: Mathematics* (Kozak, 2021). The data applies to both the basic and extended levels of the *matura*. In the original report, the data are divided by place of residence into villages and towns with up to 20,000 inhabitants, towns/cities with 20,000 to 100,000 inhabitants, and cities with over 100,000 inhabitants. In the summary below, we present a total category for towns and villages with up to 20,000 inhabitants. At the time of writing, we do not have the 2022 data on the number of graduates in relation to the town/city size. Therefore, we use the CKE data from 2021, as they are very similar (Table 1).

Table 1. Comparison of the number of students taking the mock exam and final exams, by the number of inhabitants

Number of inhabitants	Mock exam (2022)		Matura exam in math (2021)	
	Number of test-takers	Percentage	Number of test-takers	Percentage
under 20,000	821	24.23	70,714	20.31
20,000–100,000	1,413	41.71	126,780	36.41
over 100,000	1,154	34.06	150,742	43.29

A list of specific learning outcomes in mathematics was compiled. Then so-called generator tasks (Stańdo, 2019) were designed, measuring the assumed learning outcomes. The online exam consisted of 35 tasks. For an example task, see Figure 1. All tasks were in line with the core curriculum for general education. A special IT system assessed the open tasks (e.g., the location of points; Fig. 3). The mock online exam in mathematics for the basic level took place May 10–14, 2022. At the time appointed by school principals, the students solved tasks and entered the results on a computer, tablet, or smartphone. Each student received their results immediately after the exam.

Figure 1. Sample task from the online test

A total of 3,388 students participated in the study (over 1% of the entire population of high school graduates). The participating students were asked to fill out a questionnaire voluntarily and anonymously. The questionnaire was completed by 1,059 respondents, which accounted for approximately 31% of the participants.

The research questions of the study were as follows:

1. What role models are chosen by students in Poland at the fourth level of the Polish Qualifications Framework?

To answer the first research question, we asked the students the following question: Who is the greatest role model for you? It should be noted that this was an open-ended question.

2. What are the relationships between choosing a role model and the learning outcomes in mathematics?

In the study, we collected the end-of-year school grades in mathematics (scale from 1 to 6) and the results from the online mock exam.

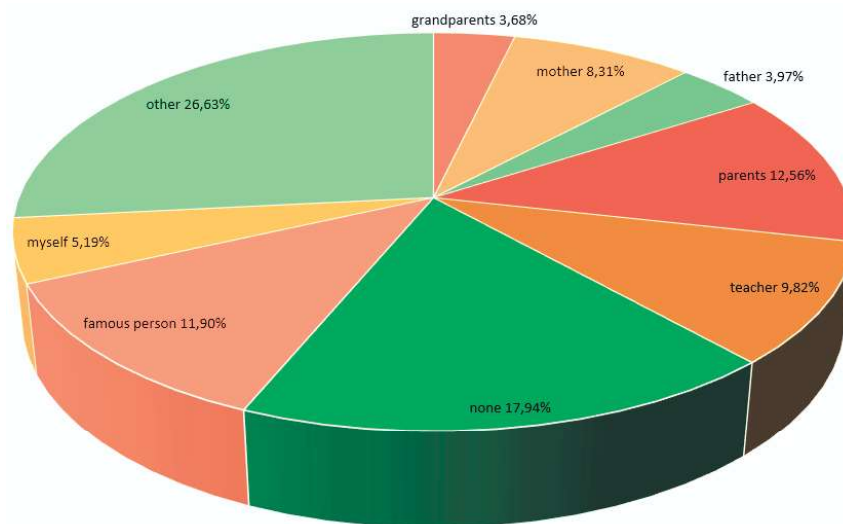
The question about the role model was open-ended. The responses were divided into appropriate categories. For example, if the answer provided was “mum,” “mummy,” or “my dearest mum” and there was no indication of another family member, the answer was classified as “mother.” If the answer was “parents” or “mum and dad,” then it was classified as “parents.” Responses that did not fall into any of the categories discussed in the Results section were classified as “other.”

Results

The description and statistical inference are based on 1,059 questionnaires concerning the link between the test takers’ mathematics exam results and indication of a role model. The respondents indicated various people or groups as their role models. We start with the initial analysis of the survey results.

The largest group of students – a total of 28% – indicated a family member as a role model (parents, mum, dad, grandparents, or other family member). The teacher was a role model for 10%, while a famous person was chosen by 12% of the respondents. The answer “I don’t have one”/“none” was given by 18% of the respondents; 5% indicated themselves as their own role model. Over a quarter of the respondents indicated someone else as their role model (see Figure 2).

Figure 2. Role models



Figures 3 and 4 present the arithmetic means of the exam results for the respondents, grouped by the role model they chose. It is worth emphasizing that these averages were calculated for groups of various sizes. For example, the number of students who indicated their mother as a role model was 42, while the group indicating “other” role models numbered 286. The same situation applies to the average grades in mathematics. Thus, more detailed analysis should be carried out using appropriate statistical tests. The analysis was performed with the software program RStudio, version 2021.09.1, R version 4.1.2.

The test results are difficult to relate to existing studies. In the 2009 report from the Center for Public Opinion Research (CBOS, 2009), data for the general population are presented, but the age group of young people is not singled out. In that report, the respondents pointed to their parents

(52% of the respondents) as a role model. Second in line was John Paul II (17%), then their grandparents (6%), spouse (6%), and teacher (5%). According to the latest survey conducted by Kantar Public in 2022, family members also enjoy the greatest authority (approx. 6%). As mentioned above, these are the results of research conducted in Poland on the general population. It is difficult to relate them to the results presented herein, concerning high school graduates. However, it can be assumed that the finding that family members are recognized as a role model is confirmed.

Figure 3. Role models and average exam scores

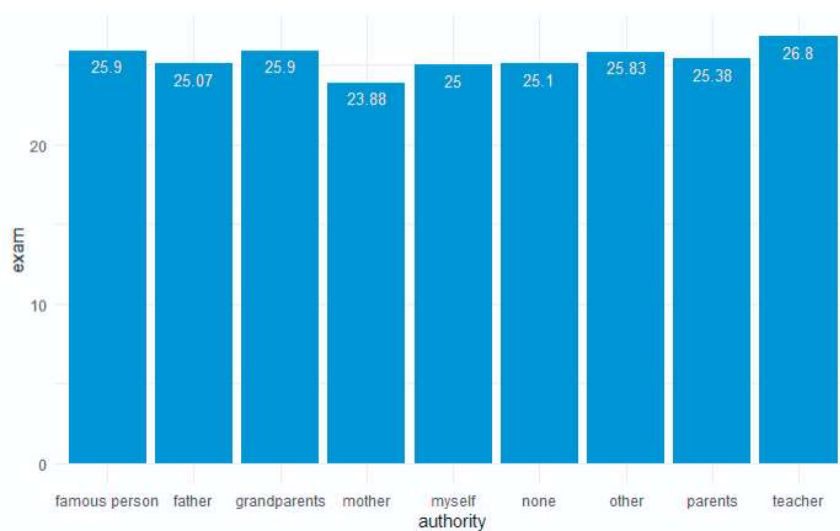
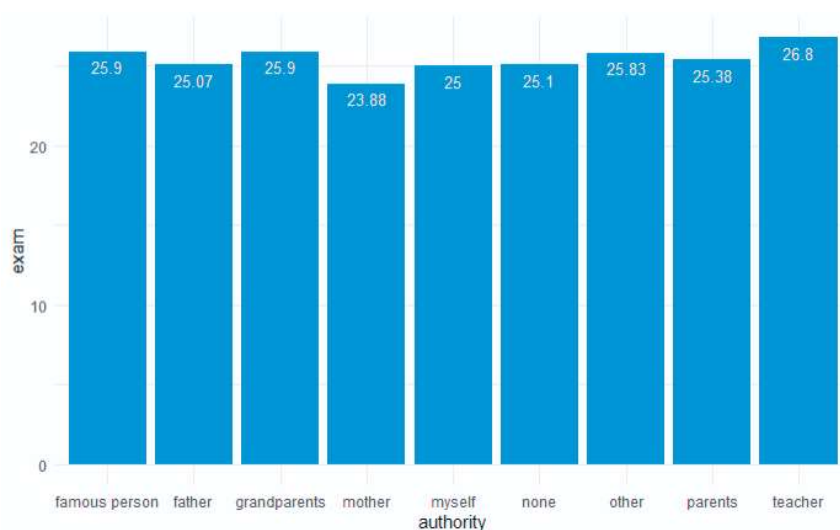
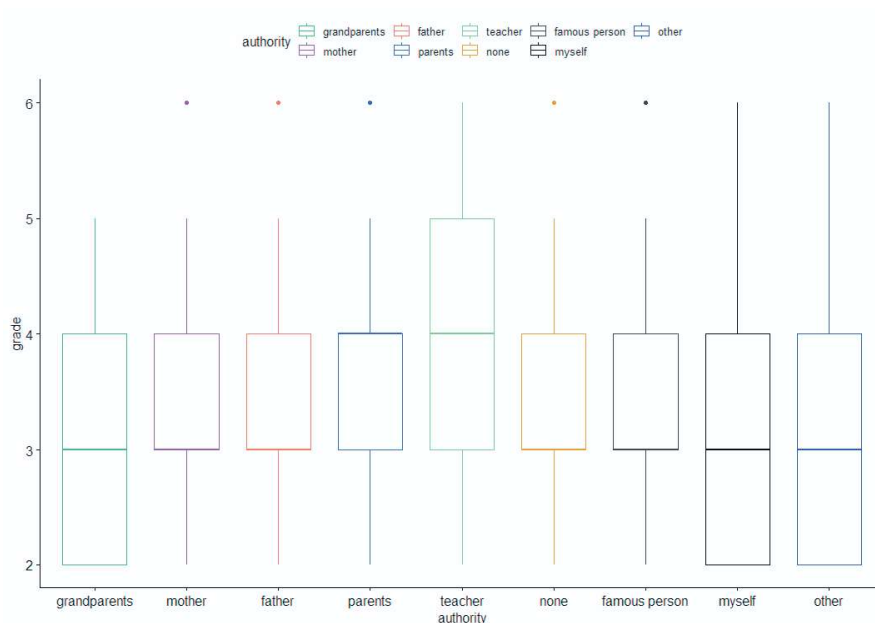


Figure 4. Role models and average final grades in math



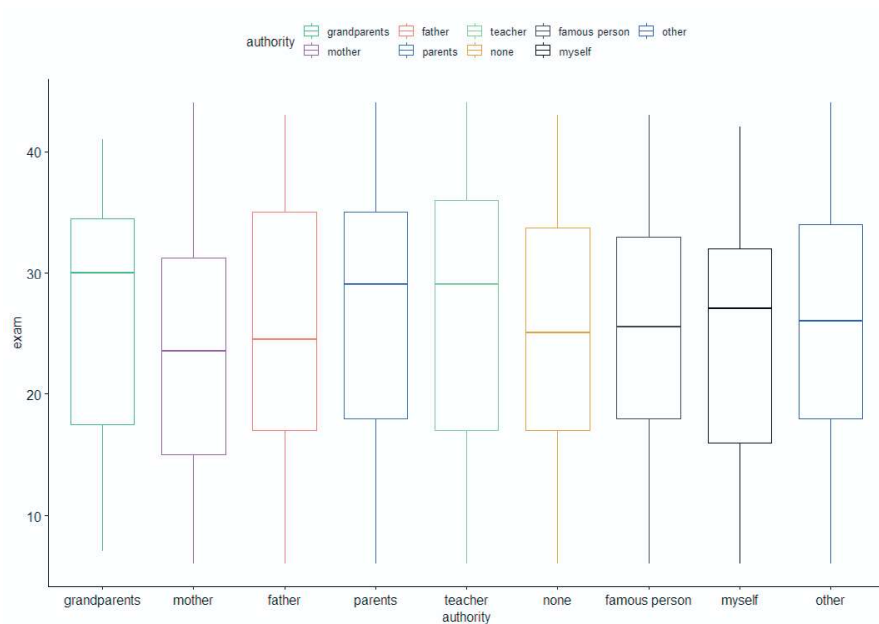
Let us compare the average results of school grades in mathematics and the average results of the online exam, divided into groups according to the indicated categories. We analyzed the differences between the means in individual groups, which were statistically significant. In the study, we assumed a significance level of 0.05. Due to the lack of normality of the data, as verified with the Shapiro–Wilk test, we used the non-parametric version of the test, namely the Kruskal–Wallis test. It should be emphasized that this test can determine whether the means in the study groups are equal (i.e. the p-value is higher than the assumed significance level) or different (the p-value is lower than the assumed significance level). The analysis of math grades in the nine groups shows that there were statistically significant differences between groups of students choosing different types of role model. This can be seen in both Figure 5 and the result of the Kruskal–Wallis test (p-value: 0.01156).

Figure 5. Analysis of mathematics grades, by selected role model



We did not observe any statistically significant differences in the exam results between the groups of students according to their chosen role models. The Kruskal–Wallis test returned a p-value of 0.6208 (Figure 6).

Figure 6. Analysis of math exam results, by selected role model

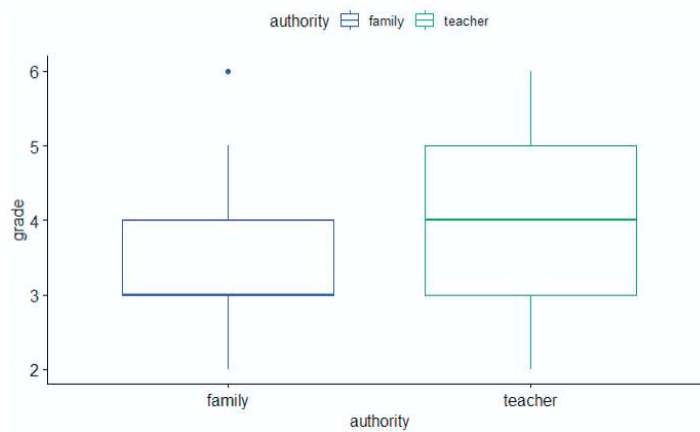


It follows from the above results that there was a correlation between the choice of role model and the grade in mathematics, but there were no significant differences in the exam grades in relation to the choice of role model. Below, we compare the following subgroups:

1. family member vs. teacher – scores in both groups were statistically significant
2. mother vs. both parents – scores in both groups were statistically significant
3. teacher vs. lack of role model – scores in both groups were statistically significant
4. teacher vs. self – borderline case

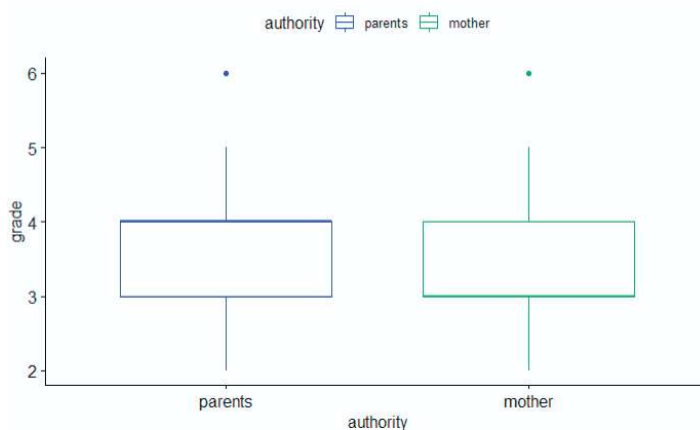
For analysis, we selected those students who chose as a role model a family member versus a teacher. The category of “family” includes mom, dad, parents, grandparents, or someone from the family. The Kruskal–Wallis test (p -value: 0.02607) revealed a statistically significant difference between the mean scores in these two groups. The comparison is presented in Figure 7.

Figure 7. Results of math exam for selected groups depending on the role model selected



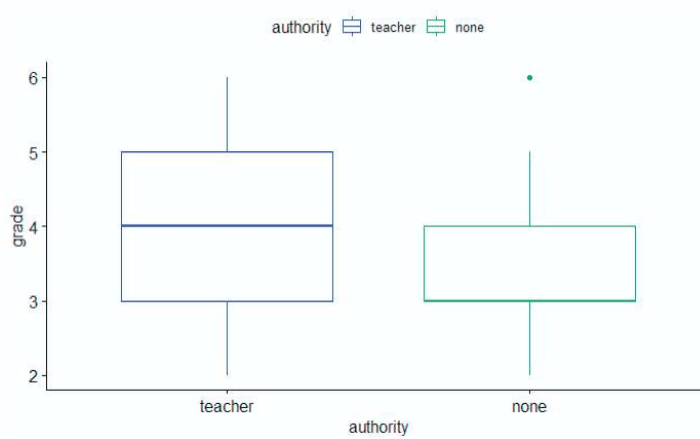
For the analysis of those students who chose “parents” versus “mother” as a role model, the Kruskal–Wallis test (p-value: 0.02493) showed a statistically significant difference between the mean scores in the two groups. The comparison is presented in Figure 8.

Figure 8. Results of the math exam for selected groups depending on the role model selected



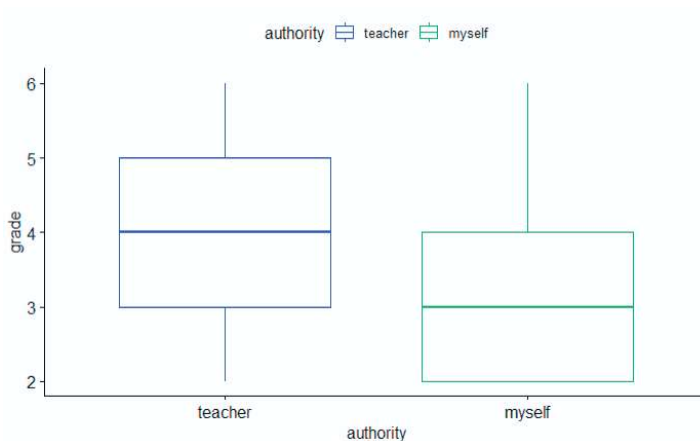
For the analysis of those students who chose their teacher as a role model versus those who stated that they have no role model, the Kruskal–Wallis test (p-value: 0.02196) showed a statistically significant difference between the mean scores in the two groups. The comparison is presented in Figure 9.

Figure 9. Results of the math exam for selected groups depending on the role model selected



For the analysis of those students who chose their teacher as a role model versus those who chose themselves as the role model, the Kruskal–Wallis test (p-value: 0.08046) indicated no statistically significant difference between the groups at the significance level of 0.05. The comparison is presented in Figure 10.

Figure 10. Results of the math exam for selected groups depending on the role model selected



The results are difficult to relate to any existing studies. Our analysis of the literature on the subject indicated a lack of research on the relationship between the type of role model chosen by students and their results in mathematics. The research results presented herein are

therefore innovative and indicate a link between role models and achievements. The analysis conducted by Karwowski (2013) points to the existence of a link between family environment and school achievements. He drew on the results of a study by Reynolds and Walberg (1992), among others. However, he focused on, for example, parental education and its relationship to school achievement – not on role models. It would be worth further analyzing the link between exam results and role models. The results indicate that there are no statistically significant differences.

Discussion and Conclusion

Authority plays an important role in the lives of young people. Research shows that young people identify the existence of significant people in their lives. When considering authority on a personal scale, it should be noted that it is a crucial aspect in interpersonal relationships, due to the fact that it may be an important source of behavioral patterns, attitudes, and ways of thinking and acting (Tuziak, 2010). This study shows that there is a link between having a role model and achieving learning outcomes in mathematics. The conclusions encourage further exploration of the issue. The analysis of the literature on the subject reveals the existence of various factors related to school achievements, including intelligence, the student's personality (such factors as persistence, curiosity, self-efficacy, motivation, optimism, or creativity), the socioeconomic and cultural status of the family, or factors related to the school environment (Karwowski, 2013, pp. 144–145).

From the perspective of this study, it is the factors related to the school environment that are worth emphasizing. In Walberg's model (1981), among the factors connected with student achievement are social factors that relate to the school environment, as well as those that relate to the family environment, peers, and external factors – primarily the media. These social factors are an area in which one can look for role models. A role model can be a teacher, parents, peers, or people associated with the media, i.e., TV celebrities, influencers, politicians, or the clergy.

These are people whose personality traits and behavioral patterns have such a strong influence on young people that they become significant for them. The emergence of a role model can affect many areas of a young person's life, including educational achievement. Therefore, it is worth conducting further research on the factors that determine students' choice of a role model. It is also worth investigating how the role models of contemporary youths are changing. The authors have already attempted to conduct a study of changes in the choice of role model over the years. In mid-May 2022, another study was carried out (covering around 4,000 students), this time on students in the last year of primary school. This study will present another challenge for us to conduct a comparative analysis.

The results have important implications for education, especially today, as teachers are observed to be losing their authority (Łukasik, 2021; Jagielska, 2021). The results indicate that having a role model within the family is related to school achievements. Thus, it can be concluded that the quality of the family environment is likewise related to the results in mathematics. The results of this study confirm those obtained by Reynolds and Walberg (1992). It could be useful to include these results in the discussion on teacher education. Particular attention should be paid not only to the subject-related preparation for conducting classes, but also to the broader pedagogical preparation of teachers (Łukasik, 2019; Łukasik et al., 2020) and the emphasis on relationship-building skills (Łukasik, 2020a, 2020b). Strengthening teacher education in this area can translate into an improvement in the quality of the school environment, another factor responsible for school achievement (Reynolds & Walberg, 1992).

The study has some limitations. The questionnaire concerned the mock exam in mathematics, while the influence of a role model in relation to other subjects (e.g., in the case of the humanities) was not studied. The survey questions did not include any questions about gender; therefore, the analysis could not deal with this feature. There were also no questions about the justification for the choice of role model. In the future, a more thorough study taking into account these limitations could be planned. This type of study could well be used to track changes in the choice of role models among high school students.

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