

Hierarchy of Needs of Persistent Mathematics and Science Teachers

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Abstract In many countries, the shortage of teachers — mainly of mathematics or science teachers — has become an alarming phenomenon over the years. Many studies have sought to explore the roots of this phenomenon. Whereas most studies have focused on the magnitude and determinants of this shortage, the purpose of this study was to investigate the factors that motivate individuals' decision to become mathematics or science teachers, and the mechanism that supports their continuous engagement in the profession. Data was collected through either a non-anonymous phone call or an online survey. The survey questionnaire consists of four parts. The first part included background information. In the second part, participants rate their motives for selecting teacher training in general and teacher training in mathematics or science in particular. The third part includes items concerning professional identity and the fourth part deals with participants' attitudes towards the shortage of mathematics and science teachers. Findings indicated that teaching-career decisions are mostly related to intrinsic motivations and personal tendencies. Many participants chose to become teachers as a result of idealistic motives, involving a sense of a mission, the desire to work with young generation, as well as the wish to experience professional fulfilment and develop special interests and proficiency in mathematics or science. Moreover, these features are known to predict positive professional engagement. High levels of internal motivation tend to increase teachers' sense of satisfaction and appreciation, professional efficacy, and confidence in their career decision. The results suggest that retention among mathematics and science teachers may be classified through a pyramid of needs, which has three layers. The first layer, the basis of the pyramid is comprised of personal needs embedded with intrinsic motivations. The second layer involves the extrinsic motivations, meaning the occupational needs. Decent occupational conditions are needed as a security net, to ensure the continuous development of a caring, enriching and meaningful approach to the educational endeavour. The third layer encompasses the aspects of professional engagement - professional identity needs.

Keywords: *teachers shortage, teacher career decisions, mathematics and science teachers, hierarchy of need*

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1. Introduction

Over the years, the shortage of teachers has become an alarming phenomenon in many countries [1,2]. Few educational issues have received more attention than the challenge of stuffing classrooms. Many studies have sought to explore the roots of this phenomenon and its implications for teaching and learning. Some explanations have viewed this phenomenon through an organizational perspective [3,4], others have emphasized an economic perspective [5,6], or a population-growth perspective [7], and even a teacher-training perspective [8,9]. All of them have expressed a concern for the ability of schools to adequately staff classrooms with qualified teachers. This concern is greater in regard to teachers of mathematics and science.

In the United States, every year, there is a shortage of more than 45,000 teachers in mathematics and science

[7,10]. Moreover, the yearly turnover of teachers in these fields comes to approximately 25,000 and more than 40% of novice teachers decide to leave the profession [11]. Similarly, in Australia around 40% of the science teachers quit teaching in early stages of their career [12]. In Israel, the Central Bureau of Statistics [13] indicated a growing shortage of teachers, particularly in mathematics and science.

1.1. Determinants of the Mathematics and Science Teacher Shortage

Many principals find it more difficult to hire mathematics and science teachers than teachers of any other field of study. According to Ingersoll and colleagues [6,14], the main source of this state of affairs is primarily the shortage in candidates who wish to train in these fields. This problem is compounded by two simultaneous demographic trends: the increasing number of veteran teachers of mathematics and science who are approaching

retirement age, on the one hand, and on the other hand, the population growth, which means that there is increased enrolment in schools. Over the years, many national and local initiatives were implemented in an attempt to recruit new mathematics and science teachers to address this shortage. Career change programs were established in many teacher education colleges for this purpose. These programs offer academically talented candidates in study fields for which there is a high demand, including mathematics and science, various expeditious tracks for switching to a teaching career. Other programs offer supplementary courses in mathematics or science for teachers who are already qualified in other fields. Some schools also recruit teachers from other districts or even from overseas [14], and others tend to increase teaching loads of the teachers on staff [3]. Nonetheless, these initiatives did not solve the problem; still many classes are taught by teachers who are not qualified in the relevant field [6].

Another approach to explain mathematics and science teachers' shortage indicates that the primary problem in staffing classrooms is not recruitment; rather, it is more a matter of retention. This approach is based on the high rate of mathematics and science teachers' attrition, in comparison to these rates in other disciplines [14,15]. For instance, researchers have shown that only 4% of new mathematics and science teachers perceived teaching as a long-term career [16]. Others have suggested that the relatively higher proportion of teacher attrition in these fields is caused by the availability of alternative career opportunities in the technological industry and in the engineering or business sectors [17,18,19]. Indeed, turnover among mathematics and science teachers is constitutes a significant problem in terms of school staffing. Theoretical research has claimed that some degree of turnover or career change is inevitable, and sometimes turnover can have a positive effect on individuals and organizations [20,21]. However, high rates of turnover and mobility may generate negative consequences for the human capital structure in this field as well as for job satisfaction. Extensive research has identified a relationship between retention and job satisfaction [16,22,23]. Thus, employees who experience high levels of dissatisfaction at work are more likely to leave the organization completely, whereas satisfied employees are committed to the organization and less likely to leave their jobs [24,25].

1.2. Teacher Job Satisfaction

The pioneering study of Herzberg, Mausner and Snyderman, conducted towards the end of the 1950s, developed the conceptual framework of the motivational aspects for job satisfaction [26]. This theory is linked to Maslow's Theory of Hierarchy of Needs, which claims that job satisfaction derives from lower order (hygiene factors) needs and higher order needs (motivation). These needs are divided into extrinsic aspects (e.g., salary, autonomy and working conditions), and intrinsic aspects (e.g., performance, recognition, personal growth, and professional development). The classical 'Self-Determination' theory, recognized by Deci and Ryan [27,28], asserts that when these two aspects are suitably addressed, positive

motivational outcomes are generated. These outcomes, which are complemented by external rewards and the gratification of psychological needs, lead to a strong sense of fulfilment, belonging, self-efficacy, and confidence in one's personal choices. Evans distinguished between job fulfilment and job comfort [13]. The job fulfilment stems from the employee's assessment of how well the job is performed, while job comfort is measured by the employee's perceptions of the job conditions and the surrounding circumstances.

Many studies suggest that teachers are more motivated by intrinsic factors than by extrinsic factors [23,29,30]. This is not meant to imply that extrinsic factors are not important for teachers; on the contrary, the absence of extrinsic factors can lead to dissatisfaction and to low motivation. As documented in previous studies, low occupational conditions, especially a small salary, have been found to be related to teacher shortage and attrition [31,32,33]. Nevertheless, "money is not the be all and end all". Scholars have found that only one of five young teachers who decided to leave teaching did so as a result of bad occupational conditions [34]. Similarly, another study examined job satisfaction among 81 teachers in South Carolina and found no correlation between salary and job satisfaction [35]. It has also been suggested that increasing teachers' salaries would be of limited benefit. In an exploratory study conducted among 102 undergraduate students majoring in mathematics, science, and engineering in the United States, the researcher found that salary did not play an important role in choosing a teaching career [36]. Moreover, governmental policies meant to provide external incentives, such as financial rewards, did not adequately resolve the problem of teacher satisfaction or attrition [22].

Teachers' intrinsic needs are related to both the personal and the organizational dimensions. As for the personal dimension, Frase explained that many teachers are drawn to the teaching profession due to sense of a mission, particularly the desire to work with children, and to help young people learn [37]. More recent studies have also shown that the desire to work with children is a primary and influential motive in the decision to choose a teaching in education [36,38,39,40]. Accomplishing this goal may generate positive consequences for teachers, leading to an improved sense of self-efficacy. Teachers with a strong sense of professional self-efficacy are more open to new ideas and innovative methods, which may be better suited to meet the needs of their students, and simultaneously may help further improve their professional performance [41]. Teachers with a strong sense of professional self-efficacy deal better with workload stress [42] and tend to remain in the teaching profession [43,44,45]. Other factors that generate job satisfaction and increase personal intrinsic motivation include a sense of a challenge and meaningfulness, expression of creativity, and opportunities for learning and professional growth [46,47].

Internal factors influence the development of significant motivation even at the pre-service stage, before becoming full-fledged teachers. A study conducted in the Australian educational system analysed pre-service teachers' decisions to become mathematics or science teachers [12]. The results revealed that more than one third of the

participations (36%) mentioned an altruistic purpose as their reason for pursuing a career as a mathematics or science teacher. They expressed a wish to make a difference in the lives of young people. Job conditions were mentioned as a second reason. In this manner, only 39 of the 150 responders referred to salary and holidays. Around 70% of the participants claimed that they chose to specialize in teaching mathematics or science out of a passion for and a connection to these fields.

On the organizational dimension, researchers have found that administrative support, collaborative interaction with colleagues, empowerment, participation in job decisions, and autonomy predicted teachers' career decisions [23,48,49,50,51,52]. These features enhance performance and productivity, improve self-esteem, morale, and professional self-efficacy, and are likely to ensure teacher retention. For instance, the findings of a study involving 134 elementary-school teachers in a southern town in the USA indicated that the principal's professional support, high availability, understanding of teachers' personal needs, and assistance whenever needed, increased teachers' job satisfaction and commitment to the school [53]. In another study that interviewed 54 teachers, the author highlighted the importance of staff collegiality in generating a safety net for personal and professional development [54].

1.3. Mathematics and Science Teachers in the Israeli Educational System

In Israel, as in many other countries, there is a constant shortage of teachers in various fields of study. Data on this issue are not conclusive, and there are many discrepancies between formal measures provided by the Israeli Central Bureau of Statistics and the data derives from the Israeli Ministry of Education [3]. Nevertheless, all indicators show a significant shortage in mathematics and science [55]. The main field of study with a similarly significant shortage of teachers is English. Many under-qualified teachers teach these fields of study at all school levels. In a 2010 report, the author found that only 18.3% of the mathematics teachers and 37.1% of the science teachers in the elementary-school system had appropriate training [56]. Additionally, evidence from the Research and Information Center of the Knesset [9] indicates a shortage of about 300 mathematics teachers and 150 science teachers in the secondary-school secular educational system.

About six hundred new mathematics and science teachers graduate teacher-training programs every year [57]. These figures raise the question: why is there still a shortage of mathematics and science teachers? This situation still prevails, because many education-college graduates (about 30%) decide not to pursue a career in teaching [56], and because many in-service teachers decide to quit teaching. A new study of teacher attrition in the Israeli educational system, based on a representative sample, showed that the rate of attrition among teachers who acquired an academic degree in science and engineering (58.6%) or in exact sciences (23.4%) is higher relative to other fields of study [58].

The result is that many pupils in the Israeli educational system are either being taught mathematics and science by

an under-qualified teacher or are not able to study these fields at an advanced level. Indeed, the percentage of high-schools specializing in advanced courses in mathematics and science has declined in recent years. To deal with this predicament, the Ministry of Education has developed a new program to promote mathematics and science studies in an advance level. Nevertheless, without assuring the quality of the instruction by encouraging qualified trained teachers to enter and remain in the teaching profession, educational reforms are not likely to progress and succeed.

While most of the literature on this topic has focused on the magnitude and determinants of this shortage, our study attempts to understand the mathematics and science teachers' shortage through the perceptions of the teachers themselves concerning their career. It addresses these issues through motivational theories. This perspective aims to understand what are the mathematics and science teachers' motivations for choosing this career, and to what extent these teachers become engaged to the profession. Understanding these issues may develop new paths, new methods, as well as a new paradigm by which to reduce turnover rates and keep qualified mathematics and science teachers in the classrooms.

Research Questions:

1. How do mathematics and science teachers explain the increased shortage of teachers in their field?
2. What were their motivations for choosing a career as mathematics and science teachers?
3. To what extent do mathematics and science teachers develop a sense of professional engagement?

2. Materials and Method

2.1. Participants

Data were collected in one of the largest teacher education colleges in Israel, located in the country's central region. Teacher-training programs in this college are offered in various disciplines, including mathematics and science, and they aim to prepare candidates to teach in the secular school system. Each year, approximately 50 new mathematics and science teachers graduate from the program. The sampling framework included 467 teachers in this discipline who graduated between 2003-2013. Phone numbers and/or e-mails were collected from the college administrative authorities; however, 116 graduates could not be traced. The data collection method was either through a non-anonymous phone or an online survey. From the 351 graduates that were located, 122 consented to participate (35%); of these, 51 graduates were certified to teach mathematics and 71 graduates were certified to teach science.

The majority of participants were women (89%), almost half of them held a master's degree (43%). Moreover, 83 of the 122 participants were teaching in elementary schools, and the other 39 were teaching in secondary schools. Only four of the participants (3.3%) belonged to the Arab minority sector. The average number of years of experience among the participants was 10.94 years (*range*: 1-28 years; *SD* = 6.36); 19 were new teachers in the educational system (1-5 years of experience).

2.2. Questionnaire and Variables

A survey questionnaire was prepared using the following pre-existing questionnaires: retention and attrition among teachers [17], satisfaction, employment and educational growth [59], and teacher supply and demands [3]. The newly devised questionnaire consisted of four parts. The first part was used to obtain background information (gender, education, and year of birth); the second part required teachers to rate their agreement (on a Likert-like scale ranging from 1= 'do not agree' to 5 = 'agree completely') with listed items expressing possible motives for selecting teacher training in general and teacher training in mathematics or science in particular. In the third part, participants were asked to rank (also on a Likert-like scale ranging from 1 to 5) their agreement with 12 items concerning professional identity. The fourth part was intended to identify participants' attitudes towards the shortage of mathematics and science teachers.

Three major clusters were identified:

1. Motives for selecting teacher training - this cluster consisted of two variables: (a) sense of mission (3 items, $\alpha = .76$) and (b) occupational conditions (8 items, $\alpha = .86$).
2. Motives for selecting teacher training in mathematics or science - this cluster consisted of two variables: (a) personal development (3 items, $\alpha = .69$) and (b) career opportunities (7 items, $\alpha = .71$).
3. Professional engagement - this cluster consisted of four variables: (a) professional satisfaction (3 items, $\alpha = .74$), (b) professional appreciation (2 items, $\alpha = .75$), (c) professional efficacy (3 items, $\alpha = .70$), and (d) confidence in one's professional choice (4 items, $\alpha = .68$).

3. Results

3.1. Attitudes towards Teachers' Shortage

Similar to former studies, half of the participants in the current study (51.8%) indicated that their school was facing a shortage of teachers in mathematics and science; 19.3% said it occurred in both fields, while 22.8% said it was only in science, and 9.4% said the shortage was only in mathematics. According to the participants (Figure 1), the causes of teachers' shortage in the field of mathematics and science involve general matters of the

teaching role, especially the substantial workload (20.4%) and the less-than-attractive work conditions (15.7%). In their answers to an open-ended question, participants elaborated on this issue, explaining that routine teaching is extremely demanding, stressful, and includes many formal requirements and administrative work that is not directly related to teaching. All of these factors, combined with the non-rewarding status and the small salary, eventually result in a shortage of teachers. Consequently, according to the participants, many teachers leave the profession, on the one hand, while on the other hand, the supply of candidates is rather low. The following are some examples from participants' responses: "Many formal demands from the Ministry of Education, many external exams, endless administrative work, no pleasure in teaching --only achievements and scores"; "Inappropriate rewards, disrespectful attitudes conveyed by the educational system and the parents"; "I believe teacher shortage is growing due to the heavy workload, followed by poor remuneration, which causes many people to decide not to enrol in a teacher-training program".

One fifth of the participants (20.4%) also pointed out the particular complexity of mathematics and science teaching as a major reason for the teacher shortage in these fields. According to their views, mathematics and science are perceived by students, parents, and even by the teachers themselves as particularly difficult, demanding, and challenging disciplines. Following a difficult and negative experience related to the study of maths or science, students develop a negative attitude towards these fields. Consequently, teaching these subjects involves many additional challenges, and teacher candidates in higher education tend to avoid specializing in these fields. As one of the participants stressed: 'These fields are very demanding, complex and hard to be taught. They require high level of proficiency, rich knowledge and a lot of preparation, especially in laboratories, tours, exams etc.', and later added, 'teacher training in mathematics is much more difficult than in any other discipline, which is why many people avoid it'. Another participant claimed that 'People avoid teaching these fields because of poor experiences and poor learning outcomes in their childhood... Mathematics and science are considered threatening, especially in high school; very few people are drawn to these fields'; and her colleague: "we are talking about very complex fields of study: many students associate these fields with bad feelings and frustrating experiences they had in primary school, and they don't want to teach them".

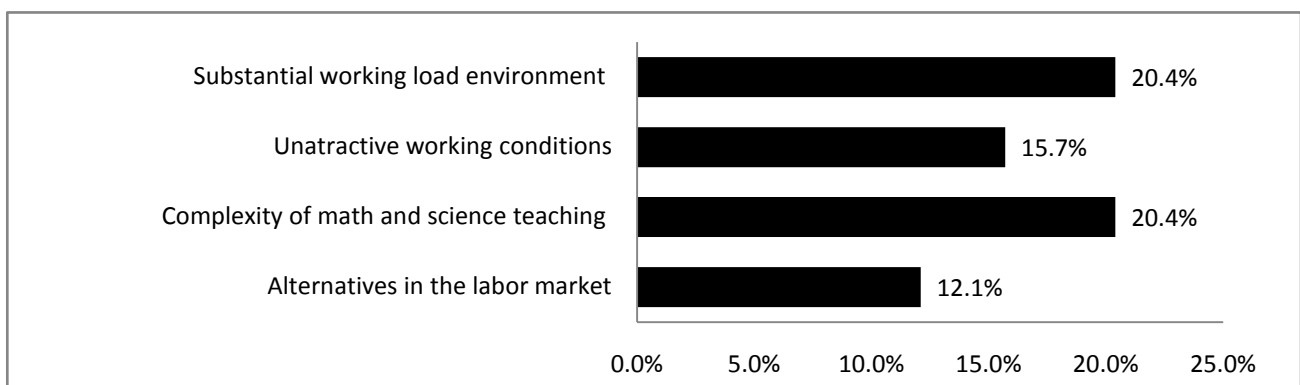


Figure 1. Reasons for teacher shortage in mathematics and science

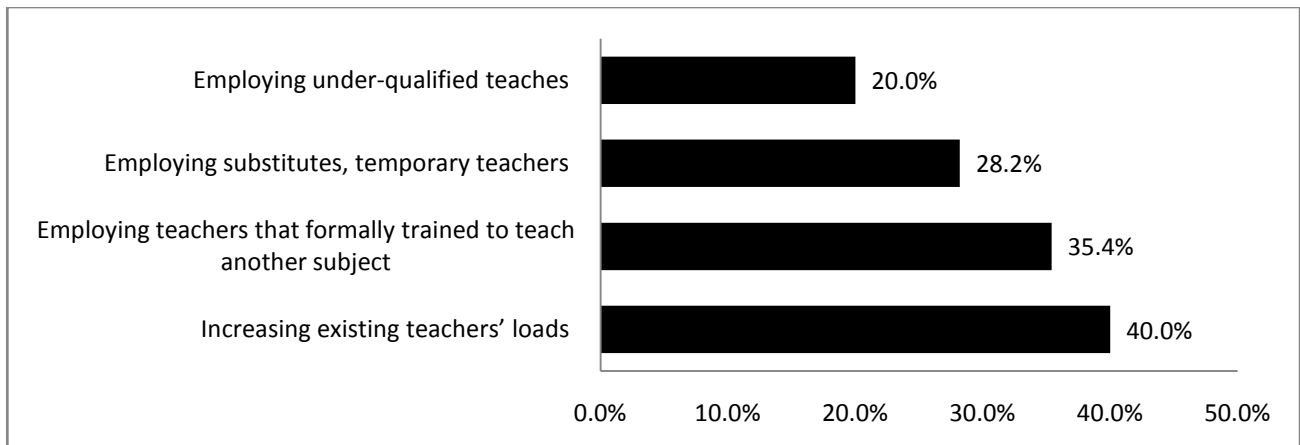


Figure 2. Strategies for dealing with teachers' shortage at schools

The fourth reason for the teacher shortage in mathematics and science according to 12.1% of the participants stressed factors beyond the educational system, namely, the fact that the labour market offers more lucrative employment opportunities for these teachers. The participants explained that people with a strong educational background in mathematics or sciences have a wide range of career choices open to them, including some that can lead to highly rewarding positions, none of which have to do with the education system. For example, participants noted *many students [with an undergraduate degree] in these fields prefer to work in the high-tech industry, where they will be able to enjoy appropriate salaries* and *'people who are interested in mathematics and science are not usually interested in teaching; they have many other alternatives, especially in the high-tech industry'*.

Participants were also asked to rate (on a Likert-like scale ranging from 1 = 'do not agree' to 5 = 'agree completely') the degree to which their school principal used each of the four strategies shown in Figure 2, to manage the shortage in mathematics and science teachers (see Figure 2). As shown, 40% of the teachers participating in the current research mentioned the increase in the workloads of existing teachers as a strategy to address the shortage of mathematics and science teachers in their schools. Another common strategy, according to 35.4% of the participants, was to employ teachers who had originally trained to teach another subject. Many participants also indicated that employing substitute teachers or teachers in temporary positions (28.2%) or even under-qualified teachers (20%) were common approaches taken by their schools. This pattern was similar among teachers employed in both elementary and secondary schools. Indeed, principals tend to make local compromises to overcome teacher shortages in both mathematics and science, in order to ensure learning continuity.

3.2. Motivations for Becoming Mathematics or Science Teachers

As was mentioned in the Background section of this article, in order to reduce the teacher shortage in these fields and to ensure that mathematics and science teachers choose to remain in the educational system, it is necessary to discover their initial motivations were for choosing a

career in teaching mathematics and science. First, we examined participants' motivations for becoming teachers in general. The findings indicate two main reasons: a sense of a mission and the job conditions (Table 1).

The findings suggest that a large proportion of the participants decided to choose teaching out of a sense of a mission. They mainly expressed a desire to work with children (88.5%) and to educate the younger generation (85.3%). Another reason for choosing teaching, though less common, was related to the job conditions. In this manner, almost half of the participants selected a career in teaching to ensure job security (48.3%), because it offers a suitable combination of career and family (45.1%) and because of convenient work hours (44.3%). One third of them were attracted to the prospect of relative occupational autonomy (33.6%), decent social conditions (33.6%) and belonging to a governmental organization (29.5%). The availability of a promotional channel was selected as a major reason for choosing a career in teaching by only one quarter of the participants. The salary, however, was rarely mentioned as a main factor in this decision (2.4%).

We also asked the participants regarding their motivations for becoming a mathematics or science teacher (Table 2), two main motivations emerged: personal development and career opportunities. A large proportion of the participants indicated personal development as a major reason for choosing to pursue a career as a mathematics or science teacher. Almost all of them (95.1%) indicated that it was their wish to specialize in these fields, due to their interest in them (90.1%), and the belief that the study field of choice suited their particular personality (87.7%). By comparison, career opportunities as a motivating factor was assigned lower scores. A little more than a half of the participants said that a degree in mathematics or science requires a high level of studies in (63.1%), which helps develop a foundation that is imperative for a career in numerous disciplines (56.6%). Moreover, the link between teaching mathematics or science and the labour market was not consistent: many participants indicated that they decided to join the teaching profession because it provides numerous occupational opportunities (43.5%), presumably within the educational system, yet only one quarter (25.4%) of the participants explained their occupational choice as a key to finding new opportunities in the labour

market, and very few (4.9%) agreed that it could help them find employment in the high-tech industry.

In the next step, we examined the motivations for choosing a teaching career comparing between the

mathematics and science teachers in the study who persisted in the educational system (stayers) and those who decided to leave the profession (dropouts). Findings are presented in Figure 3.

Table 1. Motivations to Become a Teacher

	% High Rating	M	SD
Sense of a mission			
Wish to work with children	88.5%	4.48	.84
Ambition to educate the young generation	85.3%	4.38	.88
Ethics and values	76.3%	4.20	.93
Occupational conditions			
Job security	48.3%	3.28	1.17
Allowing a suitable combination between family and career	45.1%	3.30	1.26
Convenience working hours	44.3%	3.20	1.22
Occupational autonomy	33.6%	2.94	1.17
Decent social conditions	33.6%	3.05	1.16
Governmental organization	29.5%	2.70	1.27
Promotional channel	26.2%	2.71	1.15
Salary	2.4%	1.18	.91

Table 2. Motivations to Become a Teacher in Mathematics and Science

	% high rating	M	SD
Personal Development			
Wish to specialize in mathematics or science	95.1%	4.79	.64
Interest in mathematics or science	90.1%	4.56	.74
Suitable area of knowledge	87.7%	4.38	.93
Career Opportunities			
High level of studies	63.1%	3.70	1.12
Imperative foundation for career in numerous disciplines	56.6%	3.52	1.12
Numerous occupational opportunities	43.5%	3.20	1.21
Former advanced studies in mathematics or science in high school	29.5%	2.42	1.63
A key to finding new opportunities in the labour market	25.4%	2.66	1.29
Influence of friends and family	12.3%	1.95	1.23
Assists in finding employment in the high-tech market	4.9%	1.20	.54

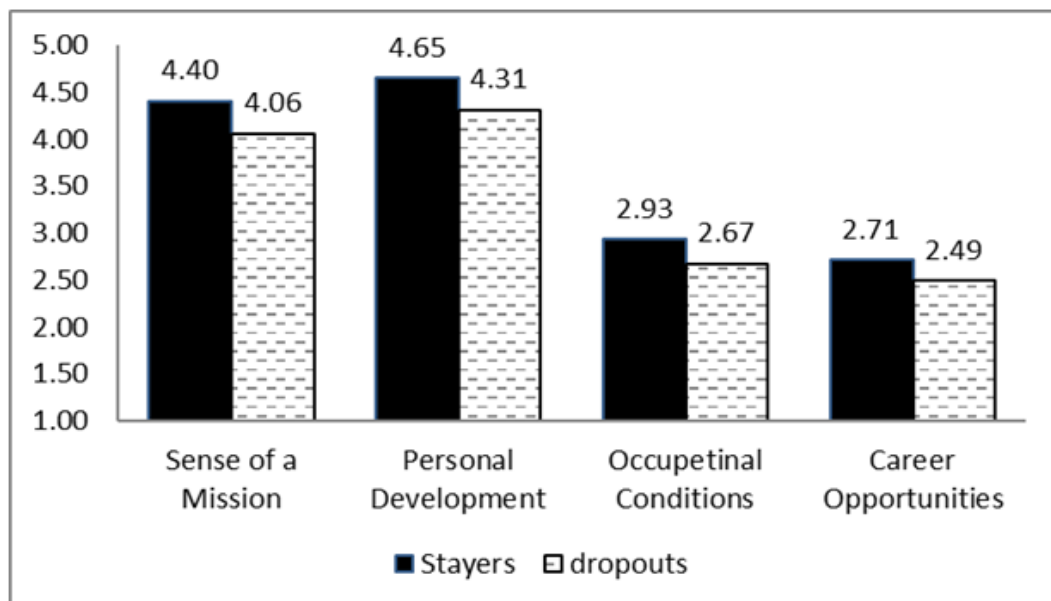


Figure 3. Differences between stayers' and dropouts' motivations for choosing a teaching career (Standard deviation range is 0.50-0.99, ***p<.001)

The only differences between the two groups that were significant were related to the intrinsic factors (sense of mission and personal development). Although participants in both groups expressed a high level of sense of mission and the expectation to experience personal development when they decided to join the teaching profession, the stayers assigned higher scores to sense of mission ($t = 2.38, p < .05$) and personal development ($t = 2.56, p < .05$) than did the dropouts. In the occupational dimension, however, no difference was found between stayers and dropouts. Occupational conditions and career opportunities were a minor incentive to become a teacher in both groups.

3.3. Teachers' Engagement

A high level of professional engagement was found to be a key factor in increasing retention behaviour among teachers (e.g. [23,60]). Therefore, the purpose of the final question was to explore to what extent the participants, the mathematics and science teachers, had developed a sense of professional engagement. We focused on four aspects: professional satisfaction, professional appreciation, professional efficacy and confidence in one's professional choice (Table 3).

Mathematics and science teachers who responded to the research questionnaire seem to be professionally satisfied. Most of them expressed a feeling of fulfilment and contentment about achieving their professional goals. They also reported being highly appreciated by the school principal (92.2%) and by their colleagues (85.2%). As for

their professional efficacy, almost all of the participants (96.5%) evaluated their role vis-a-vis their students as meaningful and significant, while giving a more moderate rating to their teaching performance (60.9%) and professional development (60.0%). Moreover, most participants seemed to be confident in their professional choice to become teachers. Many expressed their intention to continue teaching (74.8%), and did not consider withdrawing from the profession (66.7%). In general, it appears that they view teaching as a desirable profession only to a moderate extent: less than half of the cohort (38.8%) said they had no desire to work in another profession.

Does the motivation to become a teacher predict professional engagement? In order to answer this question, a multivariate model was used (Table 4). The results indicate that the intrinsic motives are positively correlated to professional engagement. Career decisions that involve a sense of mission increases teachers' satisfaction, sense of appreciation, efficacy and confidence in the career path, while the wish to achieve personal development has a positive effect on satisfaction and appreciation only. In contrast, a different trend emerged concerning the extrinsic motives. As shown, the motivation to attain career opportunities and good occupational conditions via teaching did not predict professional engagement. An exception was the positive effect of occupational conditions on two components - efficacy and confidence in the career decision, which --results suggest-- can be influenced by obtaining good occupational conditions. The other variables were added to the model as controls.

Table 3. Professional Engagement among Mathematics and Science Teachers

Factor	% High Rating	M	SD
Professional Satisfaction			
Teaching is right for me	89.5%	4.41	.72
I feel I am following my mission	84.3%	4.20	.96
I am satisfied as a teacher	70.0%	4.01	.96
Professional Appreciation			
I feel appreciated by my colleagues	92.2%	4.37	.73
I feel appreciated by the school principal	85.2%	4.17	.90
Professional Efficacy			
I feel meaningful and significant to my students	96.5%	4.39	.63
I perform well in teaching	60.9%	3.67	.93
I develop my professional skills	60.0%	3.61	1.18
Confidence in the Professional Choice			
I intend to continue teaching in the future	74.8%	3.99	1.14
I do not consider withdrawing from teaching	66.7%	4.04	1.08
I do not wish to work in another profession	38.8%	3.23	1.30

Table 4. Linear Regression to Estimate the Effect of the Motivation to Become a Teacher on Professional Engagement

Factor	Satisfaction	Appreciation	Efficacy	Confidence in the Professional Choice
Sense of Mission	.55***	.22#	.53***	.51***
Personal Development	.24***	.37***	.04	.05
Occupational Conditions	-.01	-.12	.22**	.29*
Career Opportunities	-.06	-.02	-.06	-.08
Teach Science (vs. Math)	.02	-.04	-.07	.05
Teach Intended Discipline	.33#	.59*	.28	.11
Veteran (vs. Novice) Teacher	.38***	.27	.63***	.56*
Elementary (vs. Secondary) School	-.004	.06	-.03	-.03
Women (vs. Men)	-.12	-.14	-.16	-.13
Constant	1.03*	2.42**	.84	-.01
R ²	.48	.23	.40	.19

#p<.07, *p<.05, **p<.01, ***p<.001.

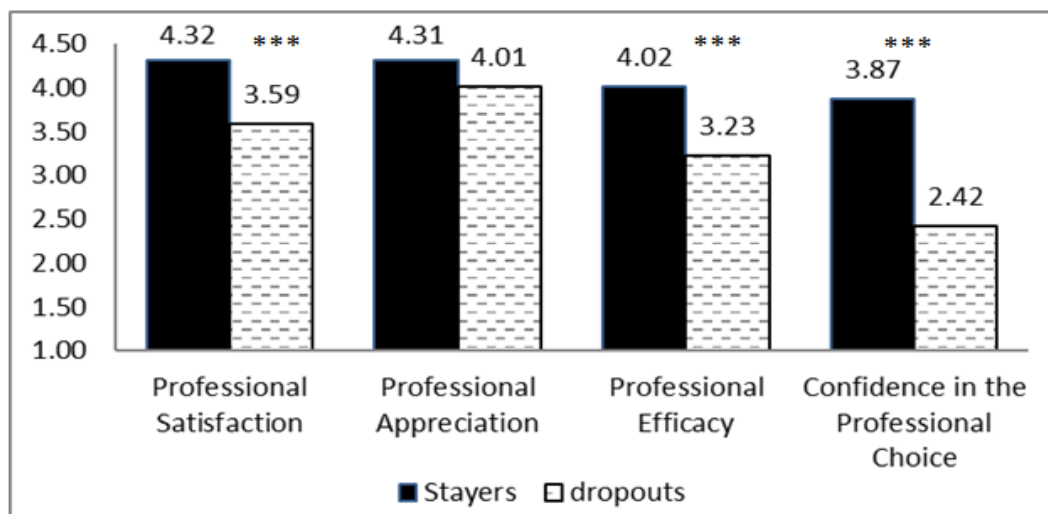


Figure 4. Differences between stayers and dropouts in professional engagement (** Standard deviation range is 0.55-1.45)

Figure 4 shows the differences in professional engagement between stayers and dropouts. Stayers revealed higher levels of professional engagement than did dropouts. These differences reached statistical significance in three parameters: satisfaction ($t = 4.48$, $p < .001$), professional efficacy ($t = 4.61$, $p < .001$) and confidence in the professional choice ($t = 6.60$, $p < .001$). Stayers were highly satisfied with their professional position. They felt proficient and capable to perform professionally as teachers and confident in their career choice. There was no significant difference between the stayers and dropouts in terms of professional appreciation ($t = 1.27$, $p > .05$). Both groups reported feeling appreciated by the school principal and their colleagues.

It is also worth mentioning that cases when teachers do not teach the discipline in which they trained and specialized may also affect the shortage of teachers. As mentioned before, hiring non-qualified teachers is a strategy that school principals use for dealing with teacher shortages or for ensuring that current teaching staff members are assigned an appropriate teaching load [3]. In our study, 16 teachers (13.1%) claimed they were not teaching the discipline in which they specialized, among these, 12 teachers had trained in science education and four had specialized in mathematics education. The results demonstrate that of the participants who dropped out of teaching, 42.3% had taught a discipline other than mathematics or science (for which they had trained), whereas among the participants who remained in the educational system, only 5.2% had taught a discipline other than the one in which they had trained ($\chi^2 = 24.71$, $p = .00$). Teaching the intended discipline for which they trained seems to be a crucial factor in assuring teacher retention, helping to sustain their initial motivation to become teachers and ensuring the development of professional engagement.

4. Discussion and Conclusions

The aim of this study was to discuss the shortage of mathematics and science teachers in the Israeli educational system. According to the literature, this shortage is the outcome of two main reasons: 1. an insufficient number of

candidates who wish to specialize in mathematics and science education, 2. a high rate of teacher attrition in these disciplines. This trend is not unique to the Israeli setting [6,61]. Many mathematics and science classrooms in different educational systems are staffed with teachers who are not qualified to teach these disciplines. While most of the literature on this topic has focused on the magnitude and determinants of this shortage [6], the purpose of this study was to highlight the factors that motivate the decision to become mathematics or science teachers, and the mechanisms that support their engagement to the profession. This perspective is expected to promote an understanding of the aspects that inspire candidates to pursue a career teaching mathematics and science, as well as shed light on the factors that keep teachers engaged in the profession.

The results indicate that teaching-career decisions are strongly associated with intrinsic motivations and personal tendencies. Many of the participants, all of whom initially chose to become mathematics and science teachers, did so as a result of idealistic motives, involving a sense of a mission, the desire to work with children and to educate the young generation, and the expectation to experience professional fulfilment and develop special interests and proficiency in the field of mathematics or science. Moreover, these motivations typically predicted positive professional engagement. As the study findings demonstrate, a high level of internal motivation increases satisfaction, sense of appreciation, professional efficacy and confidence in the career decision.

Do career decisions among mathematics and science teachers relate also to extrinsic motivations? Our results indicate that, in fact, the occupational conditions and the career opportunities are marginal considerations in the decision to become a teacher. Nevertheless, occupational conditions and the career opportunities affect also professional engagement to a limited extent. Hence, these findings do not mean that extrinsic motivations are entirely unimportant for teachers. According to the 'principal-agent' theory, for teachers (agents) who are motivated by intrinsic incentives, the positive contribution of the extrinsic motivations is limited [62]. These teachers are motivated by altruistic values aiming to promote students' education, morale and welfare. They usually

follow their mission with little regard for the occupational conditions. However, as teachers, they are required to perform multiple roles and are responsible for a range of outcomes, some of which are easily measurable, e.g., students' academic achievements and cognitive development, and some are less tangible, such as the acquisition of skills that manifest in adult life, as well as the inculcation of values, behaviours and attitudes. Given these important tasks, it would make sense to guarantee certain external incentives as a way of ensuring the effectiveness and quality of teaching, even if these incentives are not the main consideration driving teachers' motivation or engagement. Indeed, former studies have shown that low occupational conditions have a harming effect on the professional efficiency, and more specifically, low salary conditions enhance the likelihood to quit a teaching career [17,31,50]. Consequently, a balance between an altruistic approach and decent rewards is likely to have a positive effect on teacher retention.

The mathematics and science teachers participating in the study who opted to stay in the educational system reported higher levels of intrinsic motivations than did their colleagues who decided to drop out of the profession. They also expressed higher levels of professional engagement. They felt more satisfied, had a greater sense of professional efficacy and were more confident about their career choice. The only component that did not differentiate between the groups was a sense of appreciation. This finding is probably related to the fact that the majority of the participants were experienced teachers, who already had a well-developed social network that provided them with the professional support they needed.

Following Herzberg et al. [26] and Deci & Ryan [27,28], the results suggest that retention among mathematics and science teachers may be classified through a pyramid of needs (Figure 5). This pyramid has three layers. The first layer, the base of the pyramid, is formed by profound intrinsic motivations that correspond to personal needs. Intrinsic motivation provides teachers an authentic meaning for their efforts. It generates fulfilment and empowerment, as well as professional ethics and personal development. Addressing these needs has the potential to promote deeply enriching educational experiences and encourages teachers to take on new social initiatives.



Figure 5. Pyramid of Needs –Teacher Retention

The second, intermediate layer involves the extrinsic motivations – the occupational needs. Decent occupational conditions are needed as a security net, to ensure the continuous development of a caring, enriching and meaningful approach to the educational endeavour. In Israel, the teaching position offers various job benefits and rewards, such as long vacations, the option of part time work, job security and decent social conditions. Most teachers are employed by the state and usually receive tenure after 3 years; afterwards they are protected and cannot be easily dismissed. These benefits compensate for their relatively low salary, especially at the beginning stages of their career. It is worth mentioning that new educational reforms have made a massive change in teachers' occupational conditions, including improvements in their income structure.

The third layer, the top of the pyramid, encompasses the aspects of professional engagement - professional identity needs. Professional engagement is a psychological response that encourages feelings of commitment and belonging, combined with satisfaction, professional efficacy, a sense of being appreciated and confidence in one's career choice. Reaching this point has a positive effect on retention.

Reducing the shortage of mathematics and science teachers calls for broadly recognizing the importance of teachers' ambitions and attitudes. Taking these aspects into account may serve to increase enrolment in --and improve the quality of-- teacher-training programs. It can also be used by school principals to design and construct a meaningful school environment, one that supports teachers' needs, and ensures that only qualified teachers are assigned to mathematics and science classes. Proficient teachers have the know-how to apply positive instruction methods, thus providing students with the opportunity to engage in meaningful learning and to experience success in these fields of study. In the long-term, such an experience could motivate them to study mathematics and science at an advanced level, and to become candidates for teaching positions.

4.1. Limitation of the Study

It is acknowledged that this study is based on a small and non-representative sample, collected from one college. This limitation does not allow us to examine differences within subsectors or geographic regions.

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