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A Grounded Theory Approach on Professional Development of Vocational Teachers

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Abstract:

Professional development of vocational teachers is perceived as an integral part of their professional activity. A lot of research has been conducted which has examined and evaluated the forms and strategies used to enhance vocational teachers' professional development, its performance and effectiveness in different contexts, mostly by applying quantitative research methods. A grounded theory approach was employed to develop a framework of the professional development process from the vocational teachers' perspective. The qualitative research design was based on five semi-structured group interviews with 48 vocational teachers from vocational education and training institutions in Lithuania. The findings show that vocational teachers feel the imperative for their professional development, which is caused by the progress of the technological and labour market, teacher generation change, and motivation. It occurs within the context of complicated financial distributions, careful planning and supervision, by adopting various means and forms for the PD (for example, occupation-related competence development). The learning strategies are influenced by the intervening factors such as the outdated training methods and the lack of continuity of the process. The main result of the PD of vocational teachers is sharing knowledge and helping colleagues.

Keywords: Vocational teachers; professional development; grounded theory

Introduction

Professional development (PD) of teachers in vocational education and training (VET) is recognized as important in the preparation of graduates for the labour market and thus meeting the new demands of economic development (Lloyd & Payne, 2012; Gurskey, 2009; Danasasmita, 2015; Serafini, 2018). The ways, the scope and the effectiveness of this process vary in each country depending on the socio-cultural traditions, policy environment and other contextual factors (Andersson & Köpsén, 2015). In Lithuania, conditions have been created for professional development of VET teachers: the legal framework has been provided, the funds have been allocated. In addition, a few projects devoted to the development of VET teachers' occupational competence were carried out with the support of the EU structural funds. However, the desired results were not achieved – the vocational teachers' competences still need improvement (Žilionis et al., 2013). In recent years, several studies have been published (Serafini, 2018; Andersson & Köpsén, 2015; Bound, 2011; Garet et al., 2001; Brazienė et al., 2014) in which different national initiatives and programmes on the PD of teachers were explored and evaluated focusing on its forms, strategies, and effectiveness in different contexts. As Kennedy (2011) observed, the dominant global discourse promotes instrumental, managerial approaches to the "measurement" of effective professional development. Therefore, the attitudes and understanding of policymakers and educational managers on what the teachers' PD is and how it should take place were presented usually in scholarly articles. This study investigates how current professional development strategies support the improvement of vocational school teachers. Of particular interest is the use of teachers' perception to generate theory for future practice. A better understanding of the teachers' actual thinking and a continuous process of assigning meaning to the perceived and experienced reality subsequently allows a better grasp of the ongoing processes and the causes of failure. Therefore, a grounded theory approach was taken in order to produce a reliable interpretation of teachers' perception by presenting the theory that emerged from their data, rather than imposing the researcher's personal views upon the research setting. The study began with the following research question: How do current educational policy strategies support vocational teachers' professional development?

Literature review

There is a distinct lack of conceptual clarity in the research area of teacher PD (Evans, 2014). Atkins (2018) comments that the terminology itself has seen many iterations: in-service education and training, continuing professional development, training, professional learning, etc. Several authors equate professional development to all kinds of activities that are designed to develop teachers' skills, knowledge, expertise and any other characteristics that enhance their work performance (Caena, 2011; Gulamhussein, 2013; Seyoum, 2012) and that teachers do after initial training (Creemers & Kyriakides, 2013). Andersson et al. (2018) argue that due to the dual professional competence of vocational teachers, they must engage in professional development that involves not only the teaching competence, but also knowledge and skills in their initial occupation. The authors view this as a challenge for VET teachers in any national system. According to Laužackas et al. (2008), the goals of professional development are twofold: professional adaptation and professional growth. Professional adaptation is understood as formal response to changes in qualification requirements, when the contradiction between the increased requirements for the teacher and his/her preparation is resolved. Professional growth enables to move in a horizontal (activities related to professional mastery or excellence) or vertical (activities related to higher professional positions) career by acquiring additional knowledge and skills (Gedvilienė et al., 2010) and updating occupational competence. Hence, professional development, as growth, results in teachers' transformative practice, in specific changes in professional knowledge, skills, attitudes, beliefs or individual endeavours (Rhodes & Beneicke, 2003).

According to recent research (Li & Dervin, 2018; Fullan & Hargreaves, 2012; Postholm, 2012; Whitehouse, 2011; Guskey & Sparks, 2004), the following factors have the strongest and direct impact on the quality of teacher professional development: content characteristics (subject-specific and pedagogical content knowledge); learning design and implementation (types of professional development activities, forms and methods of how the activity is carried out); support and sustainability (sufficient time and duration of professional development, availability of resources, and supportive and engaged leadership in schools and at the system level); collective participation (interaction between teachers during learning sessions, value of practice related discussion, peer support, etc.).

A number of elements of teacher professional development shine out from the literature. One of them is professional development as a continuous process. As Hardy (2010) noticed, professional development is not simply an activity to be completed, but rather a lifelong process of continual self-improvement. Schwille et al. (2007) suggest that teachers' professional development should proceed throughout their active professional life, starting with initial education, continuing with the first independent steps in school and further learning, overcoming the initial challenges of teaching and gaining experience. Professional development as the occurrence of change means that this process brings transformation of existing teachers' practice: a new approach, teaching technique or tool to support classroom practice (Atkins, 2018). Guskey (2009) stresses that change is believed to begin with teacher beliefs and attitudes. However, changes generally involve risk, and sometimes fear. Collinson et al. (2009) note that the risk for members of the education profession is particularly strong. Professional development is also viewed as intricately connected to the specific and broader social settings and circumstances (Atkins, 2018). Middlewood et al. (2005) argue that professional development meets corporate, institutional and individual needs. Understanding the context and the individual teacher is key to understanding their individual orientation to learning (Opfer & Pedder 2011). In other words, the phenomenon 'teacher professional development' is twofold: in a more general meaning, the term is understood as a means for improvement of teaching practice and professional standards (for school improvement); in a narrow, specific sense, it means individual professional learning (Day, 2004). It is argued that there remains a tension between these two aspects of professional development: teachers' learning priorities might differ from those of the school (Daukilas et al., 2016; Day, 2004).

In overall, the process of professional development has been viewed as involving a myriad of dynamic contextual and political variations, tensions, negotiations, and social dilemmas, making it a highly situation specific endeavour (Jones et al., 2018; Thompson & West, 2013).

Context

In Lithuania, the teacher profession is regulated by the state, with legislation defining the qualification requirements for teachers, their training and professional development. A fairly clear and coherent system for professional development of teachers, which consistently extends their initial pedagogical preparation, has been created in the country. In Lithuania, as in many countries, vocational teachers acquire formal teacher qualifications via in-service training in the form of part-time participation in teacher training programmes (Bound, 2011; Daukilas et al., 2016), because they, foremost, are expected to have work experience and to be qualified within their vocational teaching subject (Andersson et al., 2018; Grollmann, 2009). As they proceed through their careers, teachers must develop teaching competence and competence related to a specific work-life vocational practice (Andersson & Köpsén, 2015). According to the Lithuanian legislation, the professional development of all kind of teachers is mandatory, and its duration, possible forms, funding sources are established as well as various methods and forms of professional development, process participants and their functions, responsibilities are described in the Law on education (2011). Vocational training institutions have an obligation to provide conditions for teachers and other persons to participate in the professional training process. The aspiration to ensure harmony between individual, institutional and national needs is emphasised in the *Conception of teachers' professional development* (2012).

Since 1990, national needs, or strategies, for teachers' PD were closely related to the restructurisation of the VET system and went through the key critical junctures such as postcommunist transformation, access to the EU and the global economic crisis of 2008–2009 (Tūtlys et al., 2022). These factors promoted a more holistic attitude towards VET system regarding skill formation and qualifications, and enabled more systemic attention to the professionalisation and qualifications of VET teachers (Winterton et al., 2008). Digitalisation of work processes, competence and professional standard based reforms of VET curricula, development of work-based learning approaches, leadership and effective education of VET students with different educational needs – all theses national strategies increasingly require VET teachers in Lithuania to develop their academic knowledge, professional know-how and competencies (Tūtlys et al., 2022).

Currently, a decentralized system of professional development of teachers functions in Lithuania. This means that, on the one hand, accredited institutions for teacher professional development at local and national levels offers various professional development programmes. On the other hand, decentralisation means that the priorities for improving teachers‘ competences are determined at the school level, after teachers have assessed their individual development needs (Analysis of the educational problem, 2015). Although such a teacher PD system is treated positively, its negative aspects are also identified, especially for VET teachers. It has been observed that when planning teacher training at the school level, the needs of the economic sectors at the national level are often ignored. Institutions offering teacher training courses give priority to pedagogical and general competences, but not occupational. Also it is difficult to involve companies in the teachers‘ occupational competences development at the school level (Žilionis et al., 2013).

At the national level, the ESF-funded project was launched with the aim to create a system that would enable vocational teachers to acquire necessary technological competences, get familiar with the organization of technological processes in business entities, and have knowledge of the latest technological developments (Andriušaitienė, 2014). During the project, about 100 most recent teacher occupational competence improvement programs were prepared in 12 sectors of the economy, more than 600 vocational and college teachers participated learning to work with the modern technological equipment. The project was well-received, but after funding ran out, it was discontinued. The schools themselves take care of developing the occupational competences of teachers by initiating and implementing projects together with foreign partners. The national initiative for VET teachers‘ professional development raised new questions, and the study presented here to examine VET teachers‘ standpoints to PD activities was launched.

Methods

The grounded theory (GT) approach was applied in order to disclose the study aim. Punch (2013) defined the grounded theory approach as a method, an approach, a strategy, while Charmaz (2014) added that grounded theory is focused on inductive strategies for data analysis. In this study, grounded theory is used to analyze semi-structured interviews. The GT is useful for exploring how participants in the research process respond to different conditions and the consequences of their actions (Corbin & Strauss, 1990) and interpret their own reality. The purpose of the GT is thus to generalize explanation of conditions, meanings and significances, as well as procedures that influence people in different situations and areas of their active construction of the world and to offer insight, enhance understanding, and provide a meaningful guide to action (Strauss & Corbin, 1998). Gray emphasized that the inductive process may still have some pre-existing theories or ideas when approaching a problem. Nonetheless, it does not pursue to approve or negate the existing theories, but endeavours to create outlines, stabilities and significances by collecting data (Gray, 2021). In the case of this study, the researcher had an awareness of an area of vocational teachers' professional development that required deeper exploration.

The grounded theory approach has been adopted in recent research (e.g., Perini & Pentassuglia, 2018; Grollmann, 2009; McGavin, 2013; Martino & Lasonen, 2018) to investigate VET teachers‘ concerns and experiences. A few studies based on grounded theory approach explored the professional development of secondary school teachers (Atkins, 2018; Valmori & De Costa, 2016) or higher education teachers (Rapley, 2017). A grounded theory approach was used by Teräs and Kartoğlu (2017) to examine how professional learning takes place in an online professional development programme designed and implemented according to the principles of authentic e-learning, as well as to understand the impact of the authentic learning design on the professional learning experience of the participants. However, no studies were found that examine the professional development of VET teachers from a grounded theory perspective. By employing a grounded theory approach in this study, the endevours were made to consider common trajectories and issues in the professional development process that participants of this study articulated. A comparative and interactive analysis of interview data (axial coding) enabled to enhance the researcher‘s understanding of the process of teachers‘ engagement in their continuous development, and to build a proposed framework of the phenomenon as an interpretation of an underlying structure in the data. Following Bryant (2013), this does not claim to be a criterion of truth, but rather envisage the possibility of changes in practice.

Data collection. The qualitative research design was based on semi-structured group interviews. The interview questions invited the participants to reflect on and describe their experiences of professional development while working at a vocational school. The questions addressed the following: the methods and forms of the CPD, frequency of activities, strengths and weaknesses of the CPD. During the interviews, these aspects were refined and expanded. Data was collected through recorded group interviews. The goal of this qualitative data collection was to capture rich descriptions of the process of the PD that accurately represented the participants' experiences.

Participants. The criterion sampling was used to select the VET schools: big/medium/small, from the city/ countryside. Before paying a visit to the VET educational institutions, the schools' administrators were asked to form separate groups of vocational teachers based on their positions in the school, qualification categories, subjects, age, and work experience. The researchers met with five groups of teachers. The group sizes varied from 8 to 14 members. The total sample size of the research was 48 vocational teachers. All participants of the study had experiences related to continuing professional development, and the research sought to explain the process (Creswell, 2007).

Data analysis. The analysis followed the coding procedures described by Corbin and Strauss (2008). In grounded theory, data collection and analysis are interrelated processes (Corbin & Strauss, 1990): the analysis started with the first interview and guided the next steps in data collection. Such sequential data collection and analysis allowed the researcher to identify related concepts that were explored further in subsequent interviews. After the group interviews were completed, they were transcribed verbatim, the transcripts were read through repeatedly. While analyzing the research data, first, open coding was conducted (Corbin & Strauss, 1990). The overall goal of open coding is to develop a wealth of codes with which to describe the data (Teräs & Kartoğlu, 2017). An effort was made to generate codes that would capture what essentially was going on with regard to professional development. The researcher, guided by the methodological instructions, while performing open coding, wrote a memo in which all ideas that arise while working with the data, about relationships with categories were marked.

The next stage, according to Strauss and Corbin (1990), axial coding is needed to investigate the relationships between concepts and categories that have been developed in the open coding process. To work out the relations between the categories, Strauss and Corbin (1990) suggest examining the data and the codes based on a coding paradigm that focuses on and relates causal conditions, context, intervening conditions, action strategies, and consequences. These perspectives on the data help to detect relations between concepts and categories in order to relate them on a meta level (Khan, 2014). Finally, selective coding shapes the interaction of all categories from axial coding with the chosen core category. The core category describes the central phenomenon around which all the other categories are reviewed and integrated (Strauss & Corbin 1990). As Teräs and Kartoğlu (2017) noticed the central category, must also appear in the data so frequently that, in almost all cases, there will be indicators pointing to that concept. The central category that emerged from the data in this study was "imperative improvement." The result of the process of data collection and analysis is a practical level theory that the researcher creates close to a specific problem or group of people, process or activity (Strauss & Corbin, 1990). The final theory is limited to categories, their properties, and the relationships between categories.

Trustworthiness or truth value of qualitative research and transparency of the conduct of the study are crucial to the usefulness and integrity of the findings (Connelly, 2016). The major research trustworthiness criteria: credibility, dependability, transferability and confirmability were applied for this study (Sikolia et al., 2013).

Credibility. Through the process of data collection and analysis, and the favoured analytical approach of constant comparison within the grounded theory approach, data collected within each participant group was compared and reviewed against that previously collected. Also, memos were written throughout the research process. *Transferability.* The data highlighted that whilst each participant group has its own unique context, the issues faced in relation to the PD of teachers were common across all groups. The quotations used to illustrate the themes within the data were taken from the full range of sources. *Dependability.* Attention was continuously paid to ensure the consistent application of the chosen grounded theory strategy and the collection and analysis of the research data in accordance with methodological requirements. Careful examination of processes of data collection and analysis by colleague, who did not took part in this research, ensured the reliability of the findings. The criterion of *confirmability* shows whether the study could be repeated and similar findings and conclusions could be obtained and whether another researcher who conducts a similar study would confirm the findings of this study. Holton and Walsh (2017) emphasize that the grounded theory cannot be tested in the same way as in the case of other research approaches - it can neither be right nor wrong, neither confirmed nor rejected. However, it can be modified by analyzing it with other theories and scientific data.

Findings

After conducting the first interviews and starting the data analysis, the necessity to be up-to-date was the most important concern of vocational teachers of this study. Through further refining and selective coding „professional development as a constant imperative" (imperative improvement) emerged as a core category and as a key to the challenge to be up-to date constantly. Other sub-categories that emerged from the data were related to the central category, either as causal conditions, contextual conditions, consequences, or strategies, explained in further detail in the following section and presented in Figure 1.

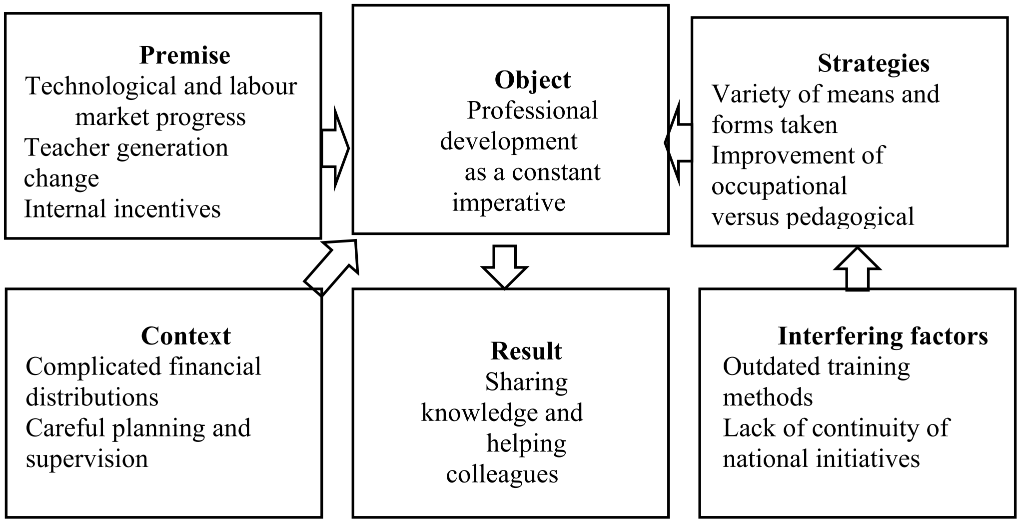

Figure 1. A framework of professional development of vocational teachers

Professional development as a constant imperative

The process of imperative improvement of teachers ("*We must constantly improve ourselves*" R2) is an ongoing and forms an integral part of the VET system. This imperative is so natural and so common to the participants of the research that no one could even imagine that it could be different or non-existent.

This development is affected by both external and internal factors. As far as external factors are concerned, the following instances of technological and labour market progress have forced teachers to change and renew their competences: introduction of new programmes ("*A new fishery programme has been introduced*" R43), re-qualification is required ("*For example, I have a management course this year, and I need to prepare"* R4), installation of new advanced equipment at schools ("*Sectorial training centres possess the equipment; however, there is a lack of teachers who could operate that equipment"* R35), increasing requirements in the labour market ("*High-scale operations have been included in the graduate's speciality*. *These certificates are required for everyone in the construction sector"* R5).

Other important factor is generally related to the turnover of teachers at vocational schools. New teachers are required when new programmes are introduced ("*We have new specialities this year: massage specialists, logistics specialists*" R4) or there is a natural turnover ("*When someone retires, there is a need for a new teacher*" R46). Some schools attract new young teachers, who come to these schools themselves ("*A young female teacher will be employed at our school*" R44), while other schools are looking for new teachers themselves ("*Young teachers are not coming and do not offer themselves up for work. We are looking for new teachers*" R35) or "raise" new teachers from former pupils ("*Some pupils have finished this school, continued their studies and returned to this school for work*" R25). New teachers must quickly grasp the peculiarities of vocational teaching, while those who have come from the business sector and are working as vocational teachers need to acquire pedagogical knowledge ("*College education is enough for a vocational teacher. Additionally, minimal pedagogical-psychological courses are necessary for them.*" R12).

In terms of internal factors, the incentive to improve is more a matter of the teachers' inner need, perhaps driven by the motives for choosing the profession itself ("*The very nature of work* *[at school] is interesting to me. I can realize my ideas here*" R33). Meanwhile, older teachers have a pragmatic motivation ("*We need to learn for these hours*") as the government has established the procedure for the improvement of teachers' qualification. As far as the financial aspect is concerned, qualification improvement is not beneficial ("*If there was a really significant* [salary] *fluctuation then the situation would be completely different*" R16).

Contextually and situationally, improvement of teacher qualification is determined by its funding ("*Now, every course costs, and quite a lot*" R44). All schools have a certain amount of funds for qualification improvement, but these funds are used differently. Larger schools "do not calculate precisely if the competencies need to be improved" ("*If you really need your qualification to be improved, you will go to the director and he/she will definitely find an opportunity*" R4). Meanwhile, other schools "estimate approximately" ("*If we hold seminars at our place and they cost approximately 11 euros, then about 70 euros will be allocated per teacher annually just for his/her training*" R22), whereas others "periodically" consider and calculate. Professional development courses are expensive; therefore, some teachers partially pay for these courses themselves ("*We are looking for a compromise that we would not "waste" money of other teachers"* R26). The teachers also must frequently cover the travel and other expenses ("*You have to pay for your trip and the way home*" R44). Thus, there is not too much money in the study "basket" of teacher qualification; therefore, other professional development funding is being sought.

The funding for the improvement of teacher qualification is related to precise planning and supervision. This function is usually performed by the deputies for education in smaller schools *("I am the administrator and I am also responsible for*" R12), and by the assigned person in larger ones ("*We have a methodologist who is constantly looking for the courses and offers them to us*" R2). That person tries to find out the needs of teachers and is in charge of coordination ("*A survey is conducted first. We identify what we want the most*" R20); that person looks for interesting lecturers, analyses proposals from the training organizations; verifies their status in order to be accredited ("[…] *the institution from which we are buying must be accredited"* R12), organizes public procurements related to training ("*We have to buy every seminar*" R12), follows the daily limit for each teacher's learning ("*They know that this is obligatory for 5 days a year [...] We follow this*" R12), plans the distribution of funds, etc.

Various qualification improvement strategies are applied: teachers attend courses and do internships ("*Teachers are doing a lot of internships abroad: no one can outmatch them there*" R1), invite lecturers to schools ("*We choose and invite lecturers*" R12), organize internal training ("*We organize local training; teachers prepare programmes themselves, [...] we teach each other*" R12), receive distance education and go (together with pupils) to exploration tours in the companies ("*You arrange it with the company personally and then go. You take the pupils and show them everything*" R44) or participate in training courses organized by the companies ("*We cooperate with traders, participate in trainings in the companies*" R6).

The teachers see greater need for and benefit from improvement of vocation-based skills rather than pedagogical ones (*"I think the most effective* [training] *is the kind which is organised in a specific workplace, where a teacher of an occupation can get a sense of both the pace of work and the requirements for the job*" R35). In all of the researched schools, the prevalent view is that the pedagogical training courses are sufficient while the occupational training is especially needed when switching to a modular learning system (*"so that he* [trainer] *would be provided an opportunity to work with modern technology: with welding machines, with state-of-the-art lathes or wood processing"* R35). The teachers were pleased about the completion of the national project for the development of trainers' occupational competences, during which they had improved themselves comprehensively (*"for a month,* [they] *worked, lived and learned in the best hotels* […] *the mechanics worked in Vilnius,* […] *went through all of those areas"* R12). Not everyone who wanted to could undertake traineeships (*"we had signed up to go to several places* […], *and one teacher went"* R36), because the demand was higher than the amount of possibilities to satisfy it. The methods for the improvement of pedagogical and occupational competences are different. As mentioned before, in order to save money and time, pedagogical seminars and other training sessions are usually organised at the schools themselves, after determining the teachers' needs beforehand. Meanwhile, occupational competences are improved abroad, in cooperation with colleges and business partners, by participating in national projects, or by finding specialized training online or in the market.

The outdated training methods and the lack of continuity of training were named as interfering factors of PD. The teachers are particularly dissatisfied with centralized training activities on pedagogical competencies under various projects, including the national ones (*"I took part in such projects, where entrepreneurship training was discussed. So all of those projects had the same lecturers and the same methods [...] I come there, and the lecturer says: "You again". I came because the project's title was completely different"* R4). The teachers hope to gain actual benefit in the form of various methods and practical knowledge, but sometimes they have to face disappointment (*"Everything was known from ages ago, the title is different and it's presented like a new thing* […]*"* R16). As is widely known, distance learning saves money, but even this learning method often does not meet the teachers' expectations (*"Over the last five years, I have attended about 10 such courses. Out of all of them, where I participated, just one was useful, all the others were because those certificates were needed. They're absolutely useless*" R39). Though an opposing view has been expressed by other teachers (*"The Simulith Centre organises* [it] *for us* […] *they truly are great courses* R38). Thus, there are contrasting experiences of participation in projects and courses, but the negative ones shape the opinion that the courses are organised *"in order to earn money"* (R17) while the projects are usually "gaining and laundering money" (*"You launder the money and it's over"* R16). For this reason, schools tend to write the projects themselves or cooperate with other schools in project-based activities. All participants of the study admit that such projects satisfy their needs the most and provide the greatest benefit (*"We choose responsibly, based on the specialization* […] *we choose the organisations we want to visit ourselves, where we see a benefit. Those traineeships are useful"* R8).

Project activities, especially those that are conducted at the national level and dedicated to the improvement of teacher occupational competences or other areas of changing the content of professional education, have a disadvantage: they lack continuity (*"It was a very good project,* […]. *The project ended, everything ended."* R20). Perhaps because of this, many of the good initiatives by the ministry seem so only "on paper" for the teachers (*"So far, the forms of traineeship are planned only in the documents, we do not feel it"* R35).

Teacher training has resulted in the sharing of knowledge and support among colleagues (*"There are conferences, we share it, then we discuss in methodical meetings"* R2). This could be informal conversations or informally organised training for colleagues, e.g. for them to master the potential of IT utilisation (*"We have provided for the possibility to hold 3-day courses, starting from theoretical and practical matters: just certain guidelines, to answer questions, to make work easier"* R11). Less success has been achieved in the practical application of the new methods, during the lessons (*"The methods you hear about – there is no time to apply* […] *you try to teach what is required"* R44).

Discussion

The focus of this qualitative study was on the perceived professional development of VET teachers in the Lithuanian context. This focus is consistent with assumptions of grounded methods used to generate a theory that "evolves from the study of a phenomenon situated in one particular situational context" (Strauss & Corbin, 1990, p.174). This study utilises the experiences and opinions of vocational school teachers in order to generate a grounded theory of the conditions in which teachers' professional development occur.

Vocational teachers perceive professional development more as an external construct, or, as Kennedy (2011) explains – "policy construct". As teachers talked about the preconditions for the PD, they reported external factors such as changes in the business-world or within the organization. The older teachers in particular treated this process as enforced externally, unavoidable, and regulated. This gives the impression of professional development as professional adaptation (Laužasckas et al., 2008) seeking formally to respond to changes. Only a few of teachers spoke about an internal aspiration for improvement. It seems like external norms and regulations are so internalized in the career path that they become matter-of-course, internal, and indisputable for the teachers.

The study participants highlighted sharing of knowledge and helping colleagues as the key result (or outcome) of professional development. Even though the academic literature emphasises that continuous development of teachers influences the pupils' results (Anderson et al, 2018; Guskey, 2009), the existing reality was far from these. The participants pointed out that it is important to teach the pupils what the syllabus demands, and there is simply no time left in the lesson for pedagogical innovations. This simply confirms once again that they treat PD as an external factor, which exists outside of their activities. If we agree with Fullan that actual practice in the three dimensions — in materials, teaching approaches, and beliefs,— is essential (Fullan, 2007, p. 37) to reforming vocational education and training, then we must admit that the teachers' approaches to teaching undergo the most minimal changes.

The VET teachers paves the way for "collaborative learning" (Kennedy, 2011) or the development of "a learning school" (Fullan, 2007). As in many countries, VET teachers take part in several activities that they perceive to be valuable for PD (Köpsén & Andersson, 2018). In Lithuania, they employ various forms and methods of non-formal and informal learning: day trips, learning from one another etc. There has been a noticeable shift in the teachers', especially the older ones, learning needs and requirements for the training itself. They no longer find it sufficient to use the conventional, traditional teaching forms and the repetitive topics. There is ever-growing talk about the necessity for teacher training to involve "mastery of the craft". All the more so because the teachers' attitude towards PD is very practical: they are more appreciative of occupation-based training because it provides them with specific skills and abilities that are required in their professional activities. This is absent from pedagogical training. The qualitative findings presented here confirm that VET teachers in small schools are more likely to learn from each other, while in large schools they are used to buy external training programmes. But overall, a tendency can be observed that there is no dominant form of PD but rather various combinations of PD strategies are used.

Both, the national and the local socio-economic context, affect the process of the professional development of VET teachers. The institutional (local) context, while different in schools that are large and small, in the cities and in the villages, generally is favourable to the process of the PD of vocational teachers. The larger schools, which have more pupils, which also means more financial resources, can allocate more funds to training; the smaller schools have to "calculate it carefully". As schools have an obligation to develop their staff, they do so by clearly planning, monitoring and controlling processes.

The more complicated processes take place in the interactions with the outside or in the national context. The programmes and projects that are funded by government agencies are sporadic and short-lived. This causes teachers to feel uncertain about the continuity of the processes, it even seems to result in hopelessness because they feel particularly dependent on external forces that are beyond their control. Köpsén and Andersson (2018) stress that national policy factors and the relationships with the VET institutions and teachers are important conditions for the potential offered for PD. For example, while analysing vocational teachers' participation in a Swedish national initiative, an increase in participation over the first 2 years was indicated. The initiative was highly appreciated since it recognises vocational teachers' dual professionalism, as it is rare for vocational teachers to be offered opportunities for professional development that suits them and their special needs (Andersson & Köpsén, 2015).

The problem of interaction between the local and the national is also reflected in the perception of PD phenomena. The following quote by Fullan seems like the most accurate description of the emergence of divergent views: "The difficulties in the relationship between external and internal groups are central to the problem and process of meaning. Not only is meaning hard to come by when two different worlds have limited interaction, but misinterpretation, attribution of motives, feelings of being misunderstood, and disillusionment on both sides are almost guaranteed" (Fullan, 2007, p. 100). This is not a minor issue. In the modern pluralistic world, unified, schematised, and authority-based prerequisites of professional development are no longer valid.

Limitations and implications

It should be acknowledged that the aim of this research, to investigate how current educational strategies support the development of vocational staff professional development, was best approached through qualitative means. Only the experiences and knowledge of practising teachers could shed light on the processes, successes and complications associated with PD. Therefore, this study, being an entirely qualitative, is subjective and open to interpretation.

In terms of the generalisability of the research, the results of this study may not be applicable to all vocational teachers because of the limited number of participants found within interviewed groups. However, it should be recognized, that the schools within this study are not significantly unique from others across the country. Specifically, an effort was made to select the most typical schools in different regions of the country. The use of semi-structured interviews to collect data limited the amount of in-depth exploration that individual interviews could have provided. If participants had sensitive or threatening input, they may have been hesitant to share their perspective with their peers in a group setting. In future studies, the use of individual interviews may elicit more in-depth information from the interview content. Additionally, further research into various issues of professional development of VET teachers would therefore be in place.

Conclusions

In relation to the research question that investigated the VET teachers' professional development experiences reinforced by educational policy strategies, a framework to advance an understanding of the underlying mechanisms of teachers' engagement in maintaining their proficiency was developed. It was done in accordance with the grounded theory parameters that influence the process of continuing professional development.

There are three key features in the professional development of VET teachers that may inform educational policy strategies development and implementation. First, within the theoretical framework that was developed in this study, the VET teachers feel a permanent imperative for their professional development. Mostly, external forces, the most important of which are social and economic changes, determine this imperative. Second, in order to change outdated and ineffective teaching methods, vocational teachers are offered the same traditional and ineffective learning and training strategies. Overall, though centralised national programmes have been perceived as the most useful avenue of teachers' professional development, for the most part, they are not able to meet the needs and interest of vocational teachers because of their short-term nature. Third, the professional development of VET teachers' could be characterized as collaborative learning, since the process of PD results in sharing knowledge and helping colleagues.

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Conflicts of interest. **Please select one of the following statements (and delete the other one):**

The author of this paper certifies that she has NO affiliations with or involvement in any organization or entity with any financial or non-financial interest (such as honoraria; educational grants; membership, employment; affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

The Impact of Artificial Intelligence on Higher Education: An Empirical Study

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Abstract:

Artificial intelligence (AI) has been a topic of growing interest and investigation in various fields, including higher education. This research article explores the impact of AI on higher education by examining its effects on teaching and learning, assessment, ethics, required skills, and future careers. The aim of this study is to analyse the influence of AI on higher education, investigate its impact on the teaching and learning process, examine its effect on assessment and grading, and predict its influence on graduates' future careers. To accomplish this, the study employs a qualitative approach based on a survey of the higher education audience. The results of this study demonstrate the crucial role of AI in the future of higher education. The findings highlight the effectiveness and efficiency of AI in equipping graduates with new skills for their future careers. They also emphasise the importance of considering the ethical implications of AI. The study reveals that higher education institutions need to integrate AI more extensively in their programs to prepare graduates for the future workforce.

AI has the potential to revolutionize education by personalizing teaching methods to suit individual student needs, providing prompt feedback, and automating administrative tasks. It can also assist in grading and assessment, freeing educators to focus on developing curriculum and providing quality instruction. The study findings suggest that AI has a positive impact on the learning experience by facilitating the acquisition of new knowledge and skills. This research provides insights into the potential of AI to transform higher education and contribute to the development of new skills for graduates. It has important implications for educators, policy-makers, and other stakeholders in the higher education sector. The study findings suggest that AI should be more extensively integrated into higher education curricula, and that institutions need to consider the ethical implications of AI in the development and implementation of their programs. By doing so, they can better prepare graduates for the demands of the future workforce.

Keywords: AI; Higher education; impact; learning & teaching

1. Introduction:

Artificial intelligence (AI) is a vast branch of computer science concerned with developing intelligent computers capable of doing tasks that typically need human intelligence. Siri, Alexa, self-driving cars, Robo-advisors, talking bots, and email spam filters are examples of AI (Stanford Encyclopaedia of Philosophy, 2020). AI is the world's new trend as it has proved more efficient in many fields, mainly during the COVID-19 pandemic (Vaishya et al., 2020). AI helped fight the virus and globally rescued jobs and educational systems (UNESCO, 2020). Thus, it is vital to shedding light on how AI will impact one of the essential areas of life, higher education. This research article studies how AI impacts higher education based on previous studies and participants' experiences, views, and predictions.

2. Literature review

Currently, AI has become a vital part of the virtual world. Unquestionably, AI plays an important role in general education and higher education (Edtech, 2020). For example, the efficient uses of filtering emails, advertising, applications, YouTube, and virtual assistants such as Google, digital libraries, Google Scholar, and other digital research engines in any higher institution worldwide (García-Vélez et al., 2021). However, AIoth is weak and robust, according to Ma & Siau (2018). In other words, Ma and Siau (2018) label AI as fragile when it is limited to small, restricted, and structured tasks such as collecting data. The latter researesearchersAI as sharp and robust when performing most or all cognitive tasks are typically human (Beight & Reddell, 2005). Although AI plays a vital role currently, the researchers mentioned above consider AI a threat to human civilisation and support their argument with what experts in the field think about AI, such as Bill Gates, Elon Musk and Stephen Hawking (Ma & Siau, 2018). Undeniably, what is mentioned above about AI is vital. Still, at the same time, it is questionable for any critical-thinking reader as any further investigation remains possible, and the truth is never absolute. So, how would AI impact the learning and teaching processes?

2.1 AI impact on the learning and teaching process

Dealing with the impact of AI on learning and teaching in higher education, it is evident that AI will impact higher education in many ways and mainly in two focal areas: enrollment and curriculum (Taneri, 2020). For instance, Ma and Siau (2018) maintain that AI will speed consistency and accuracy in curriculum and registration. Furthermore, according to Ma and Siau (2018), human sciences and liberal arts majors will become more popular because these areas of study are less vulnerable to the field of AI than other areas, such as accounting and finance (Ma & Siau, 2018).

Although this study is essential for a load of information on the influence of AI on higher education, it can be criticised for not tackling the issue genuinely, as the impact is much more profound. Indeed, focusing on the learning and teaching process, no one would doubt that AI is replacing the lecturer or tutor in many ways, such as blended learning and e-learning. The presence of an e-learning lecturer is limited as the learner interacts with a virtual classroom, whether on Blackboard, Moodle, Turnitin or any other platform (Jlu & Laurie A, 2018). Equally, Professor Roland T Chin from Hong Kong Baptist University (2018) believes that AI is meant to revolutionise how we learn, teach, work, live, make decisions, and be ready for the AI era. Therefore, AI is not only about its superficial effect, but about radical changes in the teaching and learning process in depth (Chin, 2018).

What reinforces this idea conditionally is the argument from Princeton's Head of Computer Science, Jennifer Rexford. She surmises that AI is efficient in learning and teaching if others learn: “Learning how people learn will hopefully help us and others think more broadly about retraining down the road” (Rexford, 2018). Hence, according to Jennifer, the efficiency of AI is provisional, as understanding learning styles is the only key to success. Alike, Jabar and Yousif (2011) argue that the learning process in this world is becoming more interactive and engaging, according to recent researchers, because e-learning provides the learner with artistic and pedagogical features as well as incorporates and deals with countless types of content which react effectively to the students’ needs (Jabar and Yousif, 2011).

The absence of striking examples of how AI impacts the learner’s daily life can be a limitation of the approach of Jabar and Yousif, highlighted below in the Education and Unit Study. For example, AI provides deep learning and teaching processes to get higher performance from both the tutor and the tutee. For example, adopting hypermedia for a writing class facilitates mistakes and reduces time consumption. For example, before discovering AI, it took ages for a teacher to assess and grade papers and check for plagiarism. Thanks to AI, checking for academic integrity and language issues takes minutes or less. Indeed, using artificial intelligence, a lecturer submits the work to Turnitin, Grammarly, or other software. In minimal time, it can provide constructive feedback based on the results generated by the software used.

Although AI is perfect in covering language and academic integrity issues, semantic, pragmatic, and cognitive levels, in many cases, require the intervention of the human mind to perform the last touch (Mellul, 2018). Nevertheless, AI offers various learners links about the topics required by the subject matter and eases and inspires both learner and tutor by addressing different learning styles such as autonomous learning, visual learning, e-learning, audio-visual learning, and deep learning. Equally, AI enables the tutor to select and apply the learning method taxonomy that the learner needs and highlights the areas of improvement to be focused on (Jabar and Yousif, 2011). Meanwhile, AI reinforces independent learning as the learner becomes autonomous and free to access input anytime and anywhere. Finally, according to Richer (1985), AI positively influences education by providing intelligent computer-assisted instruction that facilitates learning intuition and provides expert systems to diagnose and assess learning outcomes (Richer, 1985). It is undoubtedly clear that AI adds a lot to the learning and teaching process, so what about assessments and grading?

2.2 Impact of AI on the assessment and classification process

AI does not impact only the learning and teaching process but also the assessing and grading process. For instance, AI checks assignments and research projects through software such as Turnitin against billions of resources in no time. Consequently, similarities are easily generated to judge whether the learner plagiarised. Similarly, online rubrics and grading forms are added to assignments with criteria and scales, and final grades are automatically added to the submitted work without any hassle (Mahana et al., 2012). Furthermore, AI offers interactive ways of providing constructive feedback to the learner, easy access in a relaxed manner anytime and anywhere, with more privacy and autonomy. Additionally, the instructor can write or record feedback to facilitate and improve learning from errors.

Also, referring to a study by Stanford University, AI is applied to evaluate students’ responses and create a computer model that endorses rules inferred from the tutor's grading decisions. What is specific about AI is that it improves learning instead of making a final authoritative decision. In addition, it reflects more transparency, trust, and quality control (Stanford University, 2019). In the same context, Tovia Smith, in her article “More states opting to Robo-Grade’ Student Essays by computer,” argues that rob-graders (robots used for grading students’ papers) are increasingly used to grade students’ essays mainly in Utah, Ohio and soon Massachusetts to follow (Brad Rose Consulting, 2019). Similarly, a research professor at Colorado University named Peter Foltz says they have AI techniques that can judge up to 100 features and that grading essay is highly accurate (Brad Rose Consulting, 2019). In short, artificial intelligence is playing a more prominent role in the evaluation and classification of higher education in the United States of America.

Though the above studies are valuable from different perspectives in addressing the role of AI in grading and assessing the learner and facilitating the role of the instructor, a critical thinker would not fail to pose the following questions: What about bias in marking reports? Who would guarantee that AI is fair and objective? What about the human side of the learning process and assessment? Will AI consider the psychology of learner grading or assessing a paper?

2.3 AI Impact on Future Careers of Graduates

AI affects the world of education, but it also seems restricted to this area and follows the learner even after graduation. For instance, according to Wang and Siau (2017), AI will impact the future job market of required skillsets. It will replace many other studies that involve routine tasks and structures that are easy to automate instead of unstructured disciplines that require complex cognitive interference (Wang & Siau, 2017). AI or computer assessment is not limited to grading papers but can be the gateway to a future career. For instance, a human may not read CVs but be screened by an algorithm specialised in candidate shortlisting. As an example, in an article by the Economist entitled “How algorithms may decide your career: getting a job means getting past the computer”, it is reported that the largest firms are now using computer programs or algorithms to select candidates with an applicant tracking system (ATS) which can reject up to 75% of candidates. The above policy pushed applicants to use keywords to maximise screening interests (Brad Rose Consulting, 2019).

Vodafone and Intel are not satisfied with shortlisting CVs but instead use a computer-driven visual interviews service called “HireVue” to further select candidates. In this process, AI analyses facial expressions and language patterns and decides to pass or fail the applicant (Brad Rose Consulting, 2019). According to a study by Frey & Osborne (2013), the number of jobs at risk that will be computerised and include advances in robotics and machine learning is roughly 47% of US total employment (Frey & Osborne, 2013). Likewise, Dizikes (2020) refers to research conducted by Daron Acemoglu and Pascual Resrego from MIT University that each added robot replaces 5.6 workers, almost equal to six people (Dizikes, 2020).

Similarly, similar research conducted by Ma & Siau (2018) of Oxford University argues that within the next 20 years, around 47% of jobs in the United States of America and almost 54% in Europe are at risk due to AI (Ma & Siau, 2018). Additionally, the latter researchers at Oxford University forecast that AI will write high-school essays by 2026, write best-selling books by 2049, translate languages by 2024 and perform surgeries by 2053. Chin (2018) from Hong Kong University argues that there are overlooked AI examples or less obvious ones such such as translation machines that enable you to speak to anyone with any language instantaneously. Chin (2018) added that JPMorgan Chase and Co use a learning machine that deals with loan agreement processes and saves 360 000 hours of work by accountants and lawyers (Chin, 2018).

Although all the values stated above about how AI is creeping into the career world, Ma and Siau (2018) criticise these aspects arguing that when it comes to soft skills such as empathy, communication, collaboration, innovation, critical thinking, problem solving, and leadership, AI is not as robust as human cognitive ability (Ma & Siau, 2018). Both researchers reinforce their views by suggesting that higher institutions should provide soft and hard skills such as maths, IT, and engineering while training students. They think AI may not be capable of affording these skills for future business careers (Ma & Siau, 2018). Although computer-driven screening is believed to avoid biases in the traditional recruitment process, AI is not bias-free. That algorithm can favour candidates with time and money to continually re-tool their resumes (Brad Rose Consulting, 2019).

To end the conflict with a culminating result, Chin (2018) argues that citizens of the new world order require new skills. These skills should include interpersonal skills such as adaptability, critical thinking, conflict resolution capabilities, and other cognitive skills. Steve Jobs thinks, 'It is technology married with the liberal arts, married with the humanities that yields us the results that make our heart sing' (Henn et al., 2005). How would higher education impact AI? Undoubtedly, the world is getting more innovative, and AI has rehabilitated our world by putting natural languages and data by enabling Siri, Netflix, Facebook, Google, Alexa, Amazon, and many other platforms as part of our daily life (Oblinger, 2018). However, the question arises: How will higher education affect AI? This research paper will address these issues from the two focal points of ethics and cognition as answers to these issues.

2.4 Cognitive and ethical impacts of higher education on AI

Dealing with ethics in AI is a lecturer in learning science and innovation at the Institute of Educational Technology in the UK. Holmes (2018), discussing the impact of AI on education, raised the importance of adopting ethics in AI education. The same lecturer argues that whether we like it or not, AI is being deployed in higher institutions worldwide and significantly impacts the future of higher education. Similarly, he adds that by 2024 the global AIED market will be worth 4.5 billion pounds. Companies such as Google, Facebook, and Amazon invest millions of dollars in developing AI in education (Drabwell, 2018).

However, Holmes (2018) believes that 'adaptive' or 'personalised' ethical learning systems are not entirely taken into account. He also stressed that there is a 'moral vacuum' without guidelines, policies, regulations, or research done to stress the specific ethical issues raised by AI in education (Holmes, 2018). The question is not a question of data for him, but instead is an issue of morality and that is why he asks: *“How can we be sure that the data are accurate, who owns and controls the data, and how is student privacy maintained?”* According to Holmes (2018), AIED ethics should not be reduced to questioning data and controlling the potential of bias that is incorporated in AIED computational approaches, algorithms, and the decisions taken by the AI’s deep neural networks that are not quickly inspected and that he describes as “known unknowns” (Holmes, 2018).*” Whether anyone likes it or not, AI has quietly entered the university* *campus, but little attention has been paid to ethics. To give just one example, what happens if a student is subjected to a limited set of algorithms that impact negatively and incorrectly on their assessments?"* What is inferred from this study is that higher education should give more importance to the ethical part while teaching AI.

To address the ethical issue of AI, and as an example, Open University in the UK conducted workshops involving researchers around the world on AIED in 2018 at the AI in Education International Conference. Participants considered the importance of doing empirical work to address systematic biases in learning machine models and create impenetrable algorithm black boxes and AI ethics-driven courses. Therefore, Open University started using "Chatbots", an internet-based program designed to simulate conversation with users. Communicates through text messages through websites, applications, or instant messengers to support students and staff (Drabwell, 2018). Likewise, higher education institutions should think of security and privacy issues. When it comes to AI, these burning issues, despite the rosy promises of AI humans, have to address this ethical issue, with intelligent systems monitoring our faces 24 hours a day with only a few elements of our private life remaining untouched. Are there legal frameworks, policies, or ethical codes to control the brutality of AI? Moreover, we should consider robot cops and their ability to kill and hold them without human ethics.

AI raises many social issues that are more complex than technological ones, such as ethics, privacy, and inequality, which entails that we need STEM and technology graduates and graduates who are deeply grounded in humanities and arts. With liberal arts education, intellectual and ethical growth will be an opportunity that integrates compassion, civic-minded citizens, responsibility, and ethics.

2.5 Cognitive impact of higher education on AI

Thinking cognitively, AI has made it a present-day reality that imitates humans in many functions such as language translation, medical diagnostics, and decision making. If humans interact, analyse, deduce, think logically, and reason contextually, AI performs these actions artificially based on powerful computers, high-speed internet connections, algorithms and extensive real-time data (Chin, 2018).

However, unlike humans' AI performs fixed and domain-specific tasks with unmatched learning speed, extensive data, excellent efficiency and unlimited computing capacity. On the contrary, humans learn flexibly, pose, and solve issues creatively, think critically, and innovate adaptively (Chin, 2018). Despite the above facts about humans, AI, deep learning, and ample data supply, AI has surpassed average human performance in manufacturing automation and face recognition. For example, it is expected to perform enormous tasks (Chin, 2018). Professor Ronald T Chin relates a story of two robots trained to communicate at a sophisticated level. They were found later speaking to each other in a language they had developed, which spooked the scientist and caused him to shut down the project. Therefore, AI may not be as cooperative as expected (Chin, 2018). Here lies the question, what have higher education institutions done to monitor and control the cognitive wilderness of AI? The issue is not creating a sophisticated language that humans would not grasp, but more than that. Even more astonishing is that their idea of embedding AI in human intelligence is forthcoming. Scientists think of hardwiring human brains to implant a neuro-electronic chip into human heads, enabling communication via voice or texts through the cloud to brain signals that connect the internet (Chin, 2018).

Recently in 2017 and in many TV talk shows around the world, a humanoid robot named Sophia developed in Hong Kong dazzled audiences by officially joining a recent United Nations Summit as a panelist to address issues of inequality and said: *"The future is already here. It is not very evenly distributed. If we are smarter and focused on win-win results, AI could help to efficiently distribute the existing resources of the world, such as food and energy"* (Guardian News, 2017). Again, where is the role of the higher institution in creating a boundary for empowering the AI with highly sophisticated cognitive skills that transgress the human mind and frees itself from the human aspect as the robot killer and robot cop and perhaps much more? Against this tremendous growth in the AI world, one should not forget that progress has been made by improving people and not improving machines, as the science fiction author Tchaikovsky (2018) argues. In short, this statement empowers humans over AI because any cognitive intelligence AI owns, first of all, is inherited or programmed by a human mind that can ultimately control this potential (Chin, 2018).

3. Situation of the problem

The twenty-first century has posed many challenges to the new world order. The influence of AI on higher education and the impact of higher education on AI are two crucial areas, among many others, worth studying (United Nations, 2018). Thus, the research questions of this article are: What is the impact of AI on higher education? Alternatively, how is higher education going to impact AI?

Aims of the study

[1] To study the impact of AI on higher education.
[2] Investigate the impact of AI on the learning and teaching process.
[3] To study AI impact on the assessments and grading process
[4] To predict the impact of AI on future careers of graduates

4. Method

This research paper uses objectivism as a philosophy, as the data collected are based on perceptions, feelings, and experiences. Objectivism entails realism, and ontologically, it considers social entities as physical ones making the world independently (Saunders et al., 2009). Therefore, this article uses the qualitative method to investigate the topic raised. The qualitative approach focuses on collecting data from people's experiences, views, and feelings dealing with AI in higher education and life in general (Hammersley, 2012). A qualitative survey was used to ensure the quality and authenticity of the data collected. The survey comprises ten questions aligned with the research paper topic forwarded to participants via Office 365 Form (Treharne & Riggs, 2015). The survey targeted an audience made of higher education students (50), academic staff (34), decision-makers and managers (8). The audience comprises international academic staff, students, managers, and decision-makers with different cultural and educational backgrounds. Overall, 92 participants responded that they are both men (62) and women (30) aged between 20 and 60 years and are current students and academic staff from different institutions. The survey link was shared on Facebook with selected colleagues and alums students who have a background in higher education and AI to ensure the validity of data collected from different countries during the academic year 2020-21. The first question was created to ensure that participants belong to the higher education field. If not, then he/she is eliminated automatically. The survey targeted participants worldwide via a link forwarded via emails, Facebook, and WhatsApp to ease participants' contribution (Liang & Zhu, 2017).

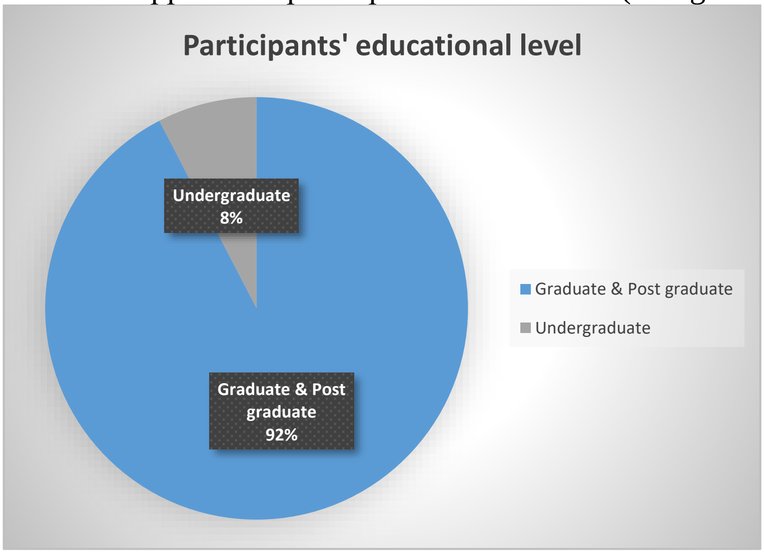

Figure 1. *Participants' educational level*

4.1 Material

Data collection was based on primary and secondary data. The preliminary data was collected through a qualitative survey and secondary data was collected by investigating previous studies. The secondary data used mainly academic resources from the Web of Science, Scopus, ERIC and Emerald, and limited grey literature.

4.2 Data analysis

Data analysis is deconstructing data and breaking down data collected into categories and codes. Then, interpretation by giving a sense of and understanding of the principles generated and exploring theories would help explain relationships. Finally, reconstruct data by systematically recreating and repackaging the significant themes and codes (Sergeant, 2012).

5. Findings

The results collected through the survey reveal that AI will significantly impact higher education in many areas, such as learning and teaching methods, assessing and grading, skills required for future work, and future graduate careers.

5.1 AI impact on the learning and teaching process

First, concerning the idea that AI affects higher education, the results reveal that most agree with 73 "Yes" that AI affects higher education. However, 17 participants think 'Maybe' and only 2 say 'No' AI will not impact higher education.

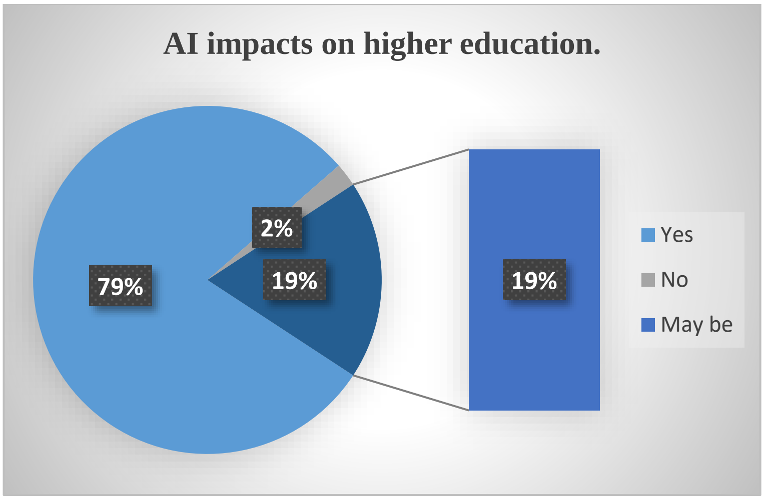

Figure 2. *Impact of AI on higher education*

AI uses better learning styles and teaching methods in higher education than humans. The responses reveal that 40 participants strongly agree, 14 agree that AI uses better learning styles and teaching methods than humans, compared to 19 participants who disagree, 6 strongly disagree, and 23 are neutral.

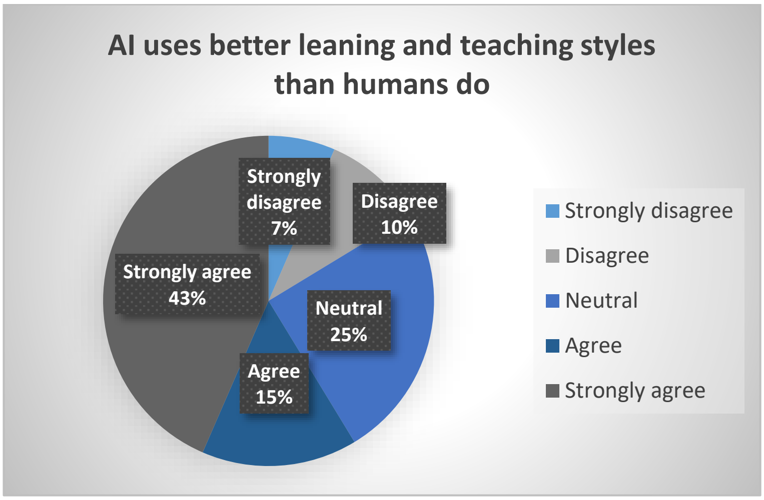

Figure 3. *AI uses better learning and teaching styles than humans.*

5.2 Impact of AI on the assessment and classification process

Concerning the effects of AI on assessments and classification, the vast majority of participants, 64, strongly agree that AI is more effective, accurate, and objective in evaluating and grading complex and straightforward tasks than humans. However, 19 participants were neutral, 2 strongly disagreed, and 7 disagreed.

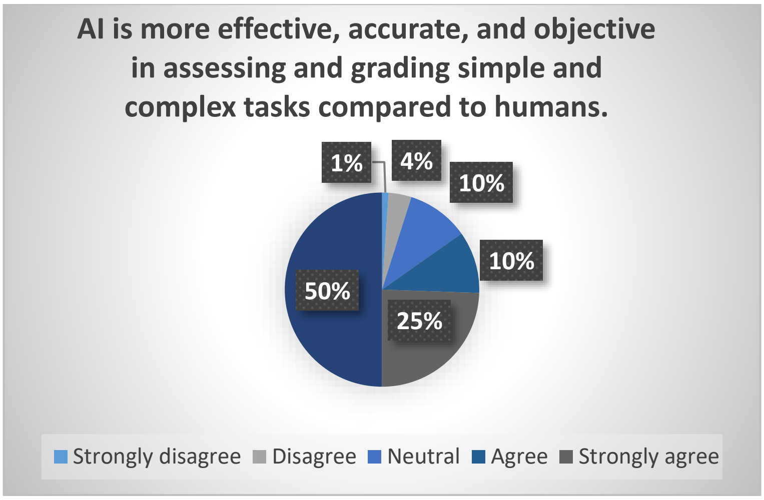

Figure 4. *AI impact on assessment and grading process*

5.3 AI Impact on Future Careers of Graduates

Regarding the fact, how will AI impact the future career of higher education students? Findings reveal that 50 participants think the impact will be positive, and 3 think the effect will be negative. However, 39 believe that the effect will be negative and positive, with no participants saying there will be no impact.

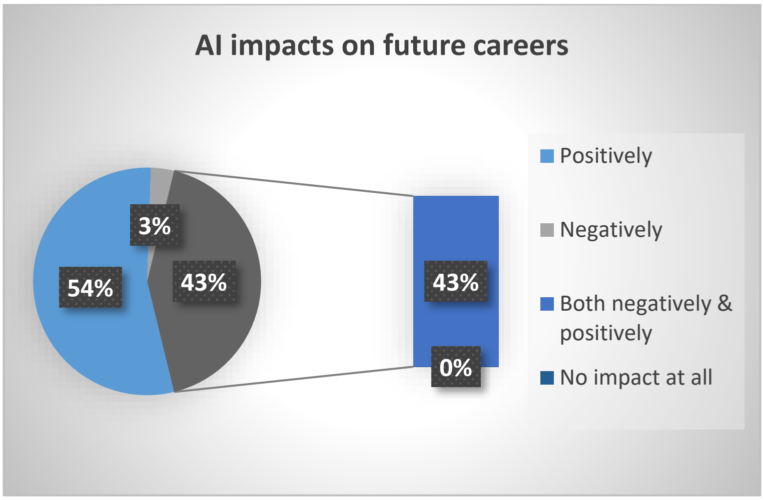

Figure 5. *Impact of AI on future careers*

Likewise, results reveal that 76 think "Yes" we need to teach students new skills to meet future career requirements dictated by AI, only 2 participants think "no", and 14 think "Maybe".

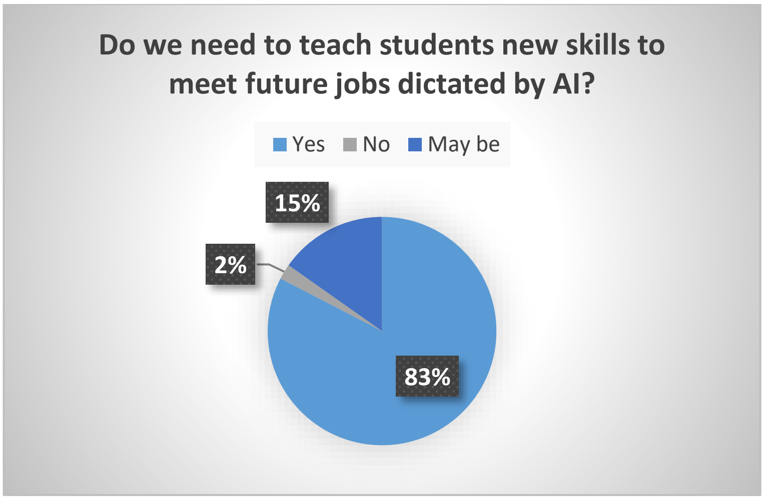

Figure 6. *Teaching new skills to meet the requirements of AI*

Correspondingly, 21 participants preferred to be interviewed by human rather than robots, of 71 liked robot interviewers, as explained by the following figure.

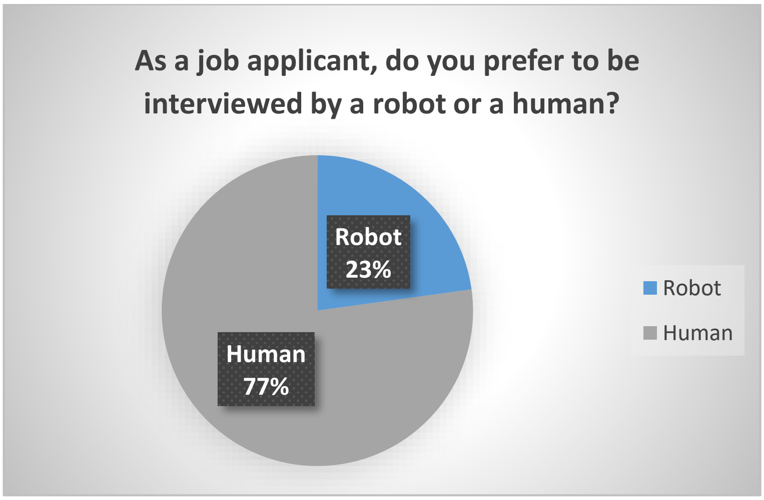

Figure 7. *Prefers to be interviewed by a robot or a human.*

The results reveal that 50 participants think shortlisting should be done manually compared to 42 who believe it should be AI.

Figure 8. *Candidate shortlisting manual or via AI*

5.4 Cognitive and ethical impacts of higher education on AI

Concerning the impact of higher education on AI from the ethical and cognitive levels, 45 participants think higher education impacts the ethical, cognitive, and human sides. Overall, humanity comes second with 19 votes, cognitive ability with 17 votes, and ethics with 11 votes.

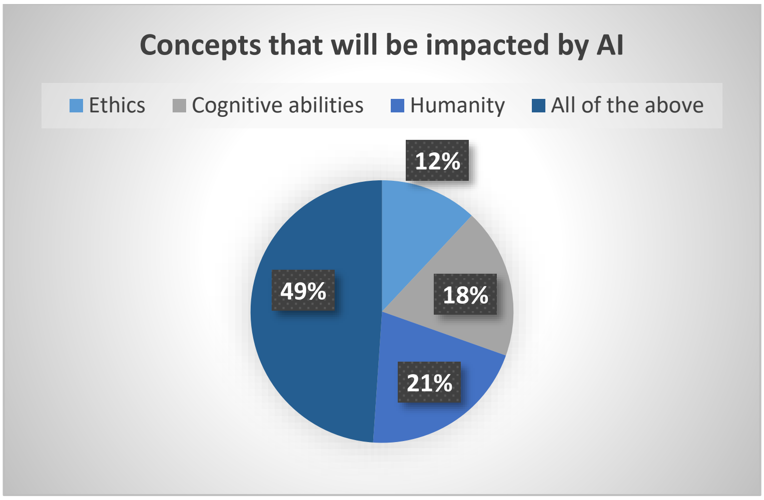

Figure 9. *Cognitive and ethical impacts of higher education on AI*

Similarly, vis-à-vis the robotisation of academic staff, the majority did not accept replacing academic staff with robots in higher education, as 27 strongly disagreed, and 22 disagreed. Whereas 7 strongly agreed, 20 agreed, and 16 were neutral.

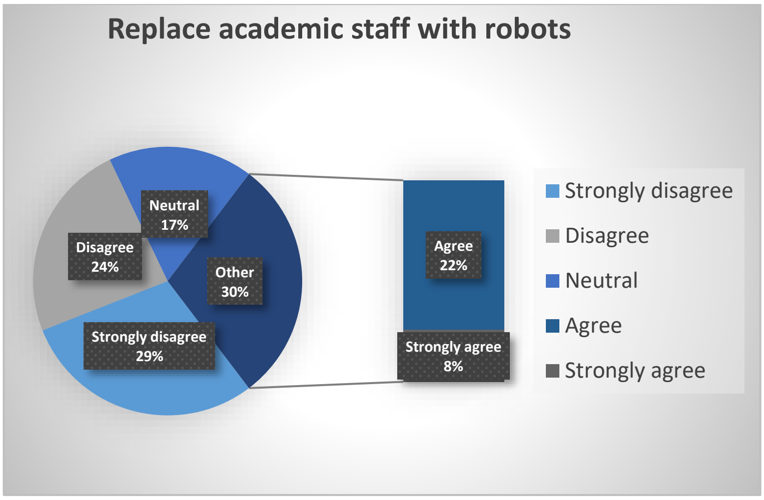

***Figure 10**. Replaces academic staff with robots*

6. Discussion

6.1 AI impact on the learning and teaching process

The impact of AI on higher education is made clear as 79% of the participants think "Yes" compared to 19% who think "Maybe" and only 2 % who contradict the idea by saying "No". These results support what was discussed earlier in the literature review (Rexford, 2018) in reinforcing the idea that AI will significantly impact the future of higher education (Tuomi et al., 2018). Likewise, regarding the efficiency of AI in learning and teaching, a big part of the participants believe that AI is more efficient than humans: 43 % strongly agree, and 15% agree with this idea, in contrast with 7% who strongly disagree, 10% who disagree, and 25 % are neutral. Again the results agree strongly with Brad Rose's thoughts (Brad Rose Consulting, 2019) and discussed earlier in Mahana, Johns and Apte (2012).

6.2 Impact of AI on the assessment and classification process

Similarly, regarding AI's efficiency, accuracy, and objectivity in assessing learners, results reveal that the majority agree with this point, as 25% strongly agree and 50% agree, compared to 10% strongly disagree, 4% disagree, and 1 % who are neutral. The findings agree with Brad Rose's (2019) perceptions about AI's efficiency in grading and accuracy (Brad Rose Consulting, 2019). The results agree with what Brad Rose Consulting (2019) believes and Chin (2018) believes.

6.3 AI Impact on Future Careers of Graduates

The last point concerns the impact of AI on students' future careers. The findings say that those who think it will negatively impact future careers of students are as follows: 54 % believe it will positively impact them. In comparison, 43% believe positively and negatively, and 3% think that AI will negatively impact future careers. Therefore, the findings agree again with what was discussed in the literature review by Global Business Outlook (2018) and Chin (2018). Additionally, regarding the recruitment recruitment recruitment recruitment process using AI, the the the the findings reveal that the majority of the majority of the majority of the majority of the most substantial prefer a manual method with a percentage of 54%, compared to a minority choosing an artificially intelligent approach with a percentage of 3%, and this is an example that justifyes their choice: *"I prefer to be assessed by a human because a human can understand what you mean more than a robot. For example, in exams, students can write an answer that makes sense but is not available in the book so that the robot can mark that as a wrong answer, but the human will mark it as a right answer. '*

The latter results contradict what was discussed in the literature review, as researchers think that automation will be used in interviewing and shortlisting candidates (Wang & Siau, 2017) and (Global Business Outlook, 2018). Similarly, 77% of participants prefer a human to 23 % who fancy robots being interviewed by robots or humans. This finding is not reflected deeply in Frey and Osborne's (2013 think) and is used nowadays by Vodafone and other organisations, as mentioned earlier in the literature review.

Finally, concerning the necessity to learn new skills to meet the requirements of the AI era, the the the the the findings reveal that 83% of the the the the the participants think 'Yes'. In comparison, 15% assume "Maybe", and only 2% feel "No." Therefore, the results agree strongly with what was discussed in the literature review that higher education institutions should prepare learners for the new world order of AI (Frey and Osborne, 2013).

6.4 Cognitive and ethical impacts of higher education on AI

Regarding the impact of higher education on AI ethically, humanly and cognitively, 49% of the participants think higher education should impact the human, cognitive and ethical aspects. However, 21% of the contributors believe in the human element compared to 18% who favour cognitive abilities as a second priority, and only 12% thought ethically. The findings reveal a significant concern with all aspects together, which is in harmony with what was raised earlier in the literature review in that AI should go hand in hand with ethics, as Chin (2018) (Chin, 2018) argues when he talked about liberal arts, humanity and AI combination. Not only Chin (2018) raised this point but also Guardian News (2017) and the example of human-robot talking about equality in the world, as well as Holmes (2018) as he focused a lot on putting ethical rules for AI.

7. Recommendations:

Based on the findings and issues raised in this research paper, the researcher recommends that applying AI in higher education is a requirement for all higher institutions. However, AI appliance suggests that academic staff should be well trained in using AI to equip learners with the required skills to face future care challenges. Similarly, the researcher recommends highlighting ethics and humanity first when teaching AI, as it threatens humankind without these values. Furthermore, privacy and dignity should be respected and protected by regulations and international laws, as AI can be used without limitations and violate human freedom. Finally, higher education institutions should control AI, make it serve and not destroy and dehumanise humankind.

8. Conclusion

This research paper investigated the impact of AI on higher education. Therefore, it stressed AI's human, ethical and cognitive impacts on the future of humanity in general and students and their future careers. Consequently, AI affects the learning and teaching process. For instance, a large part of the participants believe that AI is more efficient than humans when it comes to learning and teaching: 43% strongly agree and 15% agree with this idea, in contrast with 7% who strongly disagree and 10% who disagree, and 25% are neutral. The latter finding goes hand in hand with the literature review findings suggested by (Chin, 2018; Ma and Siau, 2018; and Jabar and Yousif, 2011).

Similarly, regarding AI's efficiency, accuracy, and objectivity in assessing learners, results reveal that the majority agree with this point as 25% strongly agree, 50% agree compared to, 10% strongly disagree, 4% disagree, and 1% are neutral. Findings meet with the argument of (Mahana et al. 2012; Stanford University, 2019; and Brad Rose consulting 2019). Additionally, regarding the process of recruiting using AI, findings reveal that the most substantial majority prefer a manual method with a percentage of 54% as contrasted to a minority choosing an artificially intelligent approach with a percentage of 3%, and this is an example justifying their choice: "I prefer to be assessed by a human because a human can understand what you mean more than a robot. Therefore, the results agree strongly with what was discussed in the literature review that higher education institutions should prepare learners for the new world order of AI (Frey and Osborne, 2013; Oxford University, 2019). Finally, academic professionals should be well trained in artificial intelligence to provide learners with the necessary skills to handle future care concerns. When teaching AI, academics should emphasise ethics and humanity first, as AI is a threat to humanity without these ideals. Higher education institutions should also maintain control over AI, ensuring that it serves rather than dehumanises humanity.

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Undesirable Student Behaviours and the Proposed Solutions Within the Context of Discipline Model Based on Reality Therapy in Classroom Management: A Case Study in Turkey

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Abstract:

This paper focuses on investigating undesirable student behaviours in classroom management at the stage of middle schools of Turkey and proposed solutions within the context of Reality Therapy. The specific objectives of the research focuses on identifying the application of Reality Therapy Discipline Model to solve problems in the class, according to teachers' points of views and the researcher's observations. The study relies on the method of case study and the phenomenological approach, which centers on the noted phenomenon, as well as the in-depth information that is not yet known (Yıldırım & Şimşek, 2013). The study group of the research consisted of 20 branch teachers who were voluntarily chosen and had worked in the middle schools of Ministry of National Education in Turkey, within the school year of 2019-2020. Before the data were collected, the participants were informed about the content of the research and data confidentiality and voluntary consent forms were signed. In this research, the teacher information form was joined to the interview form, the teacher interview form, the observation form, and the research diary, which were used as the instruments to collect the data. Content analysis method was used to analyse the data collected by means of the interviews with teachers, the research diary, and the observations made in two teachers' classroom environment. Expert opinions guided the transition from the draft to the final version of the interview form used in the study. A pilot interview was made with two teachers, who were not in the study group. The findings obtained indicated that the teachers did not accurately use all the steps of Reality Therapy Model to solve the discipline problems. It was determined that they used some steps of the model. The teachers first used the solution that should be applied in the end according to Reality Therapy Model, and those who chose to talk to the students at first initiated other steps before they developed a plan to solve serious problems, whose solutions needed to be made outside the class. In accordance with findings, to contribute to the field, some suggestions have been made.

Keywords: Reality Therapy, discipline model, undesirable student behaviours, classroom management

Introduction

In today's education system, model teachers need two major qualifications: the skill of highly developed classroom management and curricular mastery. Another required qualification is the ability to prevent undesirable student behaviours and other discipline problems which occurs in the process of teaching (Erdem, 2012). Efficient classroom management increases students' terminal behaviours and reduces undesirable behaviours (Yıldız, 2011). In relation to this issue, the discipline models that the teachers have adopted and used in classroom management vary. In student-centred classroom management, positive discipline model comes to the forefront (Güven & Cevher, 2005). In such a discipline model, the development of the students' positive behaviours in class is also expected. "Teachers are responsible for creating a discipline environment that is appropriate to the classroom in order to realize the aims, objectives, and intended learning outcomes of the education. If an appropriate discipline environment is not created in the classroom, realizing the aims, objectives, and intended learning outcomes of education will be difficult and nearly impossible" (Erdem, 2012, p.90). Teachers have to keep their classes in order by monitoring the events and reacting as quickly as possible when certain behaviours threaten the order in the class. This is in addition to the fact that they form an efficient management system like a conductor who directs the orchestra (Evertson & Harris, 1992; Weber, 1986). According to Ada and Çetin (2006), a lot of problems evolve within the educational institution, which obstructs the fulfilment of its aims. Teachers and school administrators try to maintain discipline in order to solve the problems that have occurred. The aim of maintaining discipline is to provide security for personnel and students and build an efficient environment for learning (Ada & Çetin, 2006; Çobanoğlu, 2021).

According to literature review, researches conducted are mostly related with the undesirable behaviours in the classroom and the reasons for these undesirable behaviours. Sadık and Öz (2015) conducted a study on middle school teachers and students, it was seen that teachers and students perceived discipline problems as behaviours which negatively influenced teaching and relationships. In the research results, the teachers mostly emphasized family, peer influence, the change in the social structure and culture, media, and students' qualities in relation to discipline problems. Dağlı and Baysal (2011) conducted a research on teachers working in middle schools, it was determined that "students' talking without permission", "making unnecessary complaints about each other", and "talking to each other about the topics that were irrelevant to the course" were three discipline problems that they encountered most in the class. Another important point related to teachers' coping with discipline problems is the precautions that are taken while problems have not occurred yet. In relation to this point, Güven and Akdağ (2002) studied students' perceptions about middle school teachers' classroom management activities, it was concluded that teachers generally explained the rules of their lessons at the beginning of school year.

There are various discipline models which teachers can use in classroom environment in terms of classroom management. Atıcı (2014) classified these discipline models according to the level of teacher's control. One of the models based on teacher control at a medium-level is Reality Therapy. The pioneer of Reality Therapy is Glasser. Glasser (1986) expressed that most of the students were satisfied with poor-quality activities and studies, and they were even satisfied with the fact that they did not participate in any activities and the studies at the school. However, he opined that an environment should be created to meet the students' needs and they should be oriented about the activities and studies in this environment.

Based on literature review, various researches employed different variables such as culture, seniority differences, and the stages of education to identify teachers' classroom management skills and the discipline models used (Gage, Scott, Hirn & MacSuga-Gage, 2018; Gaias et al., 2019; Wolff, Jarodzka & Boshuizen, 2020; Lazarides et al., 2020; Voss et al., 2017). Furthermore, it was determined that the discipline models which the teachers used influenced the efficiency of teaching and academic success (Chamundeswari, 2013; Soheili et al., 2015; Rusk, 2016). In some researches, it was also concluded that the discipline model, which was used, influenced the students' commitment to the school (Lee, 2008; Wang, 2010; Yang, 2015). However, in the literature, there are very few researches conducted on the use of specific discipline model in the classroom. On the other hand, the fact that dealing with undesirable student behaviours in the classroom is investigated deeply by means of a qualitative method is important in increasing the efficiency of education and training process. Therefore, in this research, the use of Reality Therapy, which is one of the discipline models based on teacher control at a medium level, in middle schools in Turkey has been studied. Nonetheless, since this research has a versatile content within the context of the reasons, prevention, and solution of undesirable student behaviours in the class, it is expected that it will contribute to the field of classroom management. Furthermore, the fact that Glasser's Reality Therapy Model, including student and teacher control, is deeply investigated by means of a qualitative research method is important in filling a gap in the literature. It is expected that the findings of the research can provide important insights into the studies on curriculum development and teacher training. Thus, the teaching process, which is designed to prevent undesirable student behaviours, will directly influence students' level of learning and educational attainments.

The general aim of this research is to determine the branch teachers' application of Reality Therapy Discipline Model to the discipline problems in the classrooms of middle schools. Based on this general aim, the answers to the sub-problems below are sought:

- What is the teachers' application level of Reality Therapy Discipline Model in the classroom?
- What are the behaviours that have been observed in terms of teachers' using Reality Therapy Discipline Model?

Methods

Research Model

The general aim of this research is to determine the branch teachers' application of Reality Therapy Discipline Model to the discipline problems in the classrooms of middle schools. The research was designed according to qualitative research methods. The study relies on the method of case study and the phenomenological approach, which centers on the noted phenomenon, as well as the in-depth information that is not yet known (Yıldırım & Şimşek, 2013). Within this context, semi-structured interview with teachers were conducted. Thereafter, two teachers and their students, who were in the sample and were determined by means of purposeful sampling, were observed in the classroom environment and their behaviours were analysed comprehensively in terms of the stages of Reality Therapy Discipline Model. The branch teachers whose weekly course hours were the most were used as a criterion to select the teachers. A case study is a method where one case or cases are examined longitudinally and what happens in natural setting is examined (Subaşı & Okumuş, 2017). Similarly, in this research, the use of Reality Therapy Model for the discipline problems in the classroom was also analysed in its natural setting. The person who conducted the case study entered the natural setting where the research was done, accompanied the study group, and focused on the case or cases that was to be investigated. The researcher collected the data from the natural setting and tried to reflect personal perspectives and the participants' perspectives (Gall et al., 1999; Büyüköztürk et al., 2014). The stages of Reality Therapy was determined as criteria for classroom observations, which enabled the resarcher to generate a personal research diary. Also, teachers' and students' viewpoints were used in order to reflect the participants' perspectives.

Study Group

As in-depth data were collected while the study group of the research was determined, maximum variation sampling method was used. The study group of the research consisted of 20 branch teachers who were voluntarily chosen and had worked in the middle schools of Ministry of National Education in Turkey, within the school year of 2019-2020. The interviews were conducted with these teachers. Research data were collected in September, November and December, which was in the fall semester of 2019-2020.

Data Collection

McMillan (2004) stated that two or more data collection methods had to be used in order to describe the situation with depth and enable the research to be conducted appropriately, in terms of the aim of the research, while the case studies were being carried out. Consequently, the data were collected via observations of classroom and interviews with the teachers through open-ended question forms. Furthermore, the data of research diary, which the researcher kept while making observations about the classroom, were also used within the scope of the research. Before the data were collected, the participants were informed about the content of the research and data confidentiality. Thus, voluntary consent forms were prepared. For the first stage, which was designed phenomenologically, the interviews with 20 teachers were conducted through open-ended question forms and each of these interviews, which lasted for 20 minutes, was transcribed by the researcher. In the second stage, which was designed as a case study, the researcher observed two teachers' classrooms and each of these observations lasted for 12 hours.

Research Instruments (Instruments For Data Collection)

In this research, the teacher information form was joined to the interview form, the teacher interview form, the observation form, and the research diary, which were used as the instruments to collect the data.

Teacher Interview Form

Semi Structured Teacher Interview Form was prepared by the researcher. There were 15 questions in a question pool that were produced by means of the form. In relation to the interview form, expert opinion was obtained from two associate professors, who worked at the department of education curriculum and instruction and who studied the discipline problems in the classroom. First, the number of questions was reduced to 10 due to the expert opinions. Second, a pilot interview was made with two teachers, who were not in the study group. The data collected from the pilot interviews were evaluated alongside experts and the questions whose answers were similar were combined. Subsequently, the final form of teacher interview form was created, which included 8 open-ended questions.

Observation Form

The researcher prepared the observation form by using the literature in order to facilitate taking notes during the observations made in the classroom environment and to record the observed behaviours related to Reality Therapy in orderly manner. In the observation form, there was descriptive information in relation to grade level, seniority, alma mater, gender, and the date of the week in which observation was made. In the observation form, there was detailed information related to the cases that would be observed, including explanation and examples of these cases. Expert opinion was obtained from two domain experts to create the final form of the observation form.

Data Analysis

According to Meriam (2013), data analysis was used to answer the research questions and reveal the meaning of the data. Content analysis method was used to analyse the data collected by means of the interviews with the teachers, the research diary, and the observations made in two teachers' classroom environment. The basic practice done in content analysis involves gathering the specific concepts and themes that resemble each other and interpret them by organizing them in a way that can be understood by the reader (Yıldırım & Şimşek, 2006). The data collected were recorded and transcribed into the computer, while the raw data collected from the interviews, research diary, and observation forms were categorized and analysed. When citing what the participants said, the letter "T" and the numbers assigned to participants such as "T-1, T-2" were used. To ensure the reliability of the analysis conducted, the codes and themes that were produced from the data of interviews and observations were given to two domain experts and the consistency between the analysis of two coders were analysed. According to the coder reliability formula described in Miles and Huberman (1994), the agreement between the coders were determined as 75 percent. It is accepted that reliable result was obtained when this percentage was higher than 70 (Miles & Huberman, 1994).

Results

In this chapter, the findings in relation to the cases where teachers used Reality Therapy Discipline Model in order to deal with undesirable student behaviours in the classroom are presented.

The Findings that Indicate the Data Collected from the Interviews with the Teachers

The Teachers' Viewpoints on the Behaviours Described as Discipline Problems in the Classroom

The findings related to the behaviours in the classroom, which the participant teachers described as discipline problems, are shown in Table 1.

Table 1. *The Behaviours which the Participants Described as Discipline Problems*

Subthemes	Codes	Frequency
	Injuring each other physically	4
	Disrespecting the teacher	2
Violent behaviours	Exercising psychological abuse to each other	1
	Swearing at each other	
	Making rude gestures at each other	1
	Vandalizing the properties of class and their	1
	friends	1
Total	6	10

Individual behaviours	Answering questions without taking permission to speak Not listening to the teacher while lecturing Leaving the classroom without permission	2 1 1
Total	3	4
The behaviours interrupting the flow of the lesson	Speaking without permission Talking to other students without permission Exhibiting behaviours distracting students Making noise by shouting Eating and drinking during the lesson Coming to the lesson without any preparations	9 7 4 3 1 1
Total	6	25
Behaviours disrupting the classroom order	The students' changing places without permission Not keeping the classroom clean Coming to the class late	5 1 1
Total	3	7
The behaviours resulting from reasons outside the classroom	The students' parents' entering the classroom within the course time	1
Total	1	1

It was determined that the behaviours which the participants defined as discipline problems were mostly seen under the theme of "The Behaviours Interrupting the Flow of the Lesson" (f=25). Speaking without permission (f=9), talking to other students without permission (f=7), and the students' changing places without permission were discipline problems that were mostly indicated by the participants. The observations and reasons which the participants provided in relation to the discipline problems are described below.

"The students sometimes walk inside the class; they can exhibit behaviours that influence the flow of the lesson. Sometimes, the students can't concentrate on the lesson when they are distracted" (T-12).

The participant teachers described these student behaviours as discipline problems and the findings that indicate the reasons for describing these student behaviours as discipline problems are presented in Table 2 below.

Table 2. *The Reasons for Describing These Behaviours as Discipline Problems*

Subtheme	**Codes**	**Frequency**
The reasons influencing the teacher	Making the teacher inefficient in the class Distracting the teacher's attention Creating difficulty in classroom management	3 2 2

Total	3	7
The reasons influencing the students	Disrupting the general order of the classroom	2
	Harming other students	1
	Creating chaos in the classroom	1
Total	3	4
The reasons influencing teaching-learning process	Interrupting the flow of the lesson	3
	Decreasing the efficiency of the lesson	3
	Distracting other students' attention	2
Total	3	8

According to Table 2, the reasons the participant teachers describe these behaviours as discipline problems are mostly seen under the theme of "the reasons influencing teaching-learning process" (f=8). Additionally, making the teacher inefficient in the class (f=3), interrupting the flow of the lesson (f=3), and decreasing the efficiency of the lesson (f=3) were the reasons which the participants indicated the most.

The Findings that Indicate the Reasons for the Behaviours Described as Discipline Problems

The findings related to the participant teachers' viewpoints on the reasons underlying the student behaviours described as discipline problems are presented in Table 3.

Table 3. *Possible Reasons for Student Behaviours Described as Discipline Problems*

Subtheme	**Codes**	**Frequency**
The reasons stemming from the teacher	Being unable to make the students adopt the rules	4
	Non-existence of sanctions following the behaviours	2
	The teacher's inexperience in classroom management	1
Total	3	7
The reasons stemming from the students	Being unable to adapt to the classroom	4
	The students idea based on "everything should be mine"	2
	Inadequate development of empathy	
	Unwillingness to accept responsibility for the results of their behaviours	2
	The students' being distracted easily	1
	Insufficient development of the students' listening skills	
	Negative attitudes towards the school and the teacher	1
		1

		1
Total	7	12
The reasons stemming from the parents	Parents' doing everything which students want	7
Total	1	7
The reasons stemming from teaching process	Students' losing interest in the lesson quickly Students' finding the course subjects boring Length of the course	4 2 1
Total	3	7

According to Table 3, the teachers perceived that the reasons for the student behaviours described as discipline problems were mostly based on the reasons indicated under the theme of "reasons stemming from the students" (f=12). The teachers also emphasized that parents' doing everything which students wanted (f=7) caused the discipline problems to occur in the classroom. Some of the participants' viewpoints on the possible reasons of student behaviours described as discipline problems are provided below:

> *"It can be mostly selfishness, the idea based on 'everything should be mine'. Additionally, the parents spoil their children while raising them, they do whatever they want. Therefore, a generation without rules have been growing up" (T-6).*
>
> *"They behave like that as the teacher doesn't have the power of sanction related to the behaviour" (T-7).*

The Findings Related to the Solutions Used for the Discipline Problems

The solutions which the participant teachers used to cope with the discipline problems are presented in Table 4.

Table 4. *The Solutions Used For Discipline Problems*

Subtheme	Codes	Frequency
Reactive solutions	Warning verbally Inflicting punishment Orienting them to school counselling service Changing the students' places Ignoring the behaviour Writing an official report related to student and his/her behaviour	5 2 2 1 1 1
Total	6	12
	Making the lesson more enjoyable Using educational games in the course Determining the classroom rules with	4 4

	the students	
Preventive solutions	Attaching importance to peer interaction in the classroom	2
	Becoming a role model with their behaviours for students	2
	Taking short breaks in the course	1
	Using different teaching methods	
		1
		1
Total	7	15
Developmental solutions	Attaching importance to empathizing and making students empathize	3
	Individual and collective interview with the students	3
	Giving responsibility to the students	
	Providing an opportunity for students to solve their own problems	1
	Becoming a guide for the solution of the problems	1
		1
Total	5	9

According to Table 4, the teachers indicated that they mostly used the solutions which existed under the theme of "preventive solutions" to address the students' behaviours described as discipline problems (f=15). It was determined that warning the student verbally (f=5), making the lesson more enjoyable (f=4), and using educational games in the course (f=4) were the solutions which the teachers employed to solve the discipline problems. The viewpoints on the solutions which some of the participants used to cope with the discipline problems are described below:

> *"I divide the course hour into two parts without letting it last for a whole course hour" (T-5).*
>
> *"First, I listen to the student. I expect him/her to solve the problem after he/she understands the problem. If he/she can't solve the problem, I advise him/her. Finally, I phone the student's parent when I am with the student" (T-18).*

The Findings Related to the Cases whose Solutions Reflect Outside the Classroom

The solutions, which the participant teachers followed respectively for the cases outside the classroom, are presented in Table 5.

Table 5. *Solutions Followed Respectively for the Cases outside the Classroom*

Solutions Followed Respectively	**Frequency**
Meeting with the parent→ Informing the school counselling service	5
Meeting with the student→Meeting with the parent	
Meeting with the student→Meeting with the parent→Informing the counselling service	1
Meeting with the student→ Informing the counselling service	1
Meeting with the parent→Visiting home	
Meeting with a parent	1
Informing the counselling service	
	1
	1
	1

7	11

According to Table 5, there were 9 teachers who experienced the problems whose solutions were outside the classroom. The solutions which these teachers followed respectively included meeting with the parent and informing the school counselling service (f=5). Some of the participants' viewpoints on the solutions which they used for the problems outside the class are described below:

> "When it *happened, I talked to the family, I talked to the school counsellor. One of my students was taking his/her classmates' properties to his/her own house. First, I talked to the family. Then I and the family talked to the school counsellor together" (T-7).*

The Problems which the Teacher had Difficulty in Solving and Coping with and their Reasons

The findings related to the reasons for the discipline problems which they had difficulty in coping with are presented in Table 6.

Table 6. *The Reasons for the Discipline Problems that could not be solved*

Subtheme	Codes	Frequency
The reasons resulting from parents' attitudes and behaviours	The parents' inconsistency in their behaviours	4
	The parents' not accepting the undesirable student behaviours	4
	The parents taking over the students' responsibilities	1
Total	3	9
The reasons resulting from the attitudes and behaviours of school management	The lack of cooperation and communication between the school management and the teacher	4
Total	1	4
The reasons resulting from the students	The students' lack of intrinsic motivation	1
	The students' negative attitudes towards the school	1
Total	2	2
The reasons resulting from school counselling service	The lack of cooperation and communication between the school counselling service and the teacher	4
Total	1	4
The reasons resulting from the curriculum	The complication and difficulty of the subjects	1
Total	1	1

According to Table 6, the teachers perceived that the reasons for the discipline problems which could not be solved were mostly caused by the parents' attitudes and behaviours (f=9). The parents' not accepting the undesirable student behaviours (f=4) and their inconsistency in their behaviours (f=4) were the reasons that were mostly expressed in relation to this theme.

Classroom Rules

The teachers, who were interviewed, were asked questions about their methods for establishing classroom rules, the number of classroom rules, and how they made the students adopt the rules. 15 of the teachers stated that they determined the rules with the students, 3 of the teachers stated that they established classroom rules related to the cases creating confusion, and 2 of the teachers stated that they set the classroom rules themselves at the beginning of school year. The findings that indicated the teachers' viewpoints on how they made the students adopt these classroom rules are presented in Table 7.

Table 7. *The Methods Used to Make the Students Adopt the Classroom Rules*

Subtheme	Codes	Frequency
Using rewards and punishments	Punishing the students who did not obey the rules	6
Total	1	6
Raising awareness by drawing attention	Putting up the classroom rules on the bulletin boards	3
	Posting the classroom rules at the classroom door	2
	Making the students write the classroom rules on the board	1
Total	3	6
Using teaching methods	Teaching the classroom rules by gamifying	3
	Using drama method	2
Total	2	5
Using effective communication skills	Avoiding the use of "You" language and judging	3
Total	1	3

According to Table 7, the teachers mostly used the methods of using rewards and punishments (f=6) and raising awareness by drawing attention (f=6) to make the students adopt the classroom rules. Punishing the students who did not obey the rules (f=6), putting up the classroom rules on the bulletin boards (f=3), avoiding the use of "You" language and judging (f=3), and teaching the classroom rules by gamifying (f=3) were the methods that were chosen by the teachers the most.

The Role of the Environment in Coping with the Discipline Problems

The findings collected from the participant teachers' viewpoints on their expectations from the environment and the people to cope with the discipline problems are presented in Table 8.

Table 8. *The Expectations from the Environment and the People to Cope with the Discipline Problems*

Subtheme	Codes	Frequency
Expectations from the parents	Respecting the teachers' decisions and cooperating with the teacher	9
	Being made aware of pre-school education	2
	Giving children responsibility within the family	2
	Valuing the children within the family	2
	Setting the rules within the family and the family members' obedience to these rules	2
Total	5	17
Expectations from the school counselling service	Respecting the teachers' decisions and cooperating with the teacher	2
Total	1	2
Expectations from the teacher	Imposing sanctions against undesirable behaviours	8
	Cooperating with the parents School management and school counselling service	3
	Being consistent and determined in their behaviours	2
Total	3	13
Expectations from the school management	Respecting the teachers' decisions and cooperating with the teacher	3
	Supporting the communication between the parent and the teacher	1
Total	2	4

According to Table 8, it was determined that the teachers had the most expectations from the parents in terms of coping with the discipline problems. (f=17). The teachers who had expectations from the school counselling service and school management also indicated their viewpoints on the attitudes and behaviours which they should display. The teachers mostly expected the parents to respect their decisions and cooperate with them (f=9). Furthermore, they stated that the teachers should impose sanctions against undesirable behaviours which were displayed in the classroom (f=8). Some of the teachers' viewpoints are described below:

> *"The student who is sent to disciplinary board should be punished so that the undesirable behaviour won't happen again and this punishment will set an example for other students. Because the student has been warned several times before this punishment; at last he is sent to the disciplinary board. If the parents really value their children, they should accept the punishment and support the teacher. Because none of the teachers blame their students without a reason and cause their students to be punished unnecessarily" (T-2).*

The Findings Obtained from the Observations in the Classroom

The findings determined by means of the analysis of the qualitative data, which were obtained from the observations in the classroom, were presented according to the order of the steps in Glasser's Reality Therapy Model. In addition, the findings were supported by reporting the sample case and events related to each item as they happened without changing them.

Step 1 (Communication)

The findings obtained from the analysis were provided below. T-1 asked the students questions about the kind of rule that should be established when a situation that required a rule to be established occurred. Related to this, an anecdote recorded in the research diary is provided below:

> *"After lesson started, 7 or 8 minutes passed and then a student came to the class. The teacher and the students were demotivated. The student apologized to the teacher and the teacher asked the student why he was late. The student said that there were long queues at the school canteen and it came to his turn when the bell rang. The teacher told the student that he could be hungry as it was morning; therefore he could be right for this reason, but teacher and his classmates in the classroom were distracted due to his entering the class. The teacher turned to look at the class and told them that they had to find a solution to this problem."*

T-1 and T-2 indicated that they enabled the students to use the right to vote for the election of the class president. T-2 added that the discipline problems increased when the right to choose was totally given to the students. Consequently, it was concluded that both teachers gave the students the right to choose but the students were limited in using their rights to choose. It was seen that T-1 mostly used "I language" while communicating with the students. Nevertheless, "You language" was involuntarily used when intensities of the discipline problems continuously increased. It was also observed that the students could generally express themselves freely in T-1's classes and were treated fairly in every sense. T-2 was more serious than T-1, and fun activities such as humour were hardly ever used. Additionally, the other students made jokes and used humour on their own. Consequently, T-2 also evaluated the groups through the project papers assigned to the students previously. It was determined that T-2 sometimes used both "I language" and "You language". It was further observed that the students communicated by taking permission to talk and freely asked the teachers whatever heightened their curiosity.

Step 2

Most of the students in T-1's classroom were interested in the lesson. However, some of the students lost their interest in the lesson for a short while. When the students' interest in the lesson decreased, T-1 tried to make the lesson alive and dynamic by means of different and comic examples. When a problem occurred in the classroom, T-1 first made the student define the problem and then expounded the problem in a more constructive term.

Related to this:

"The student whose pen point was broken started using the pen that belonged to his friend sitting next to him without asking permission. The student who owned the pen got really angry at this situation and an argument broke out. T-1 first asked what happened. Both of the students defined the problem according to their own perspectives. Then, T-1 defined the problem by expressing what was understood"

In T-2's lesson, it was observed that the students were more distracted and they were interested in the things that were irrelevant to the lesson. With regard to this, T-2 tried the methods of using interactive whiteboard, activity, etc. in order to draw the students' attention to the lesson. Thes methods, however, did not achieve the desired results. Thereafter, T-2 gave the students verbal warnings such as "sit down", "listen to the lesson" when a problem occurred. Nevertheless, these warnings provided solutions momentarily. When T-2 continued lecturing, the chats between the students started at an extremely high level. In relation to the undesirable behaviour during the lessons, T-2 asked the students "Is your behaviour right?". Then, the students defined and interpreted their behaviours in reply to this question.

According to the observation findings collected, both teachers made the student define the problem. However, they did not use this solution for every discipline problem and they sometimes reacted to these problems by involuntarily shouting at the students.

Step 3

T-1 talked to the students when a problem occurred in the classroom. The teacher specifically addressed the students who made trouble in the classroom to identify the reasons for the chaos. Nonetheless, the solutions to the problem were provided by the teacher. When a student posed a discipline problem, T-2 approached the students with a stern warning. The teacher listened to the student's self-defense, but repeated the warning. When the same problem occurred, a statement was taken down. This event that happened in T-2's class is described below:

"The student, who changed his/her place in the class and who didn't get permission from T-2 while changing his/her place, tried to make the students speak. T-2 didn't ask the student why he behaved like that and warned him/her by saying "go and sit at your desk". However, the students continued displaying the same behaviour. Therefore, T-2 took a statement down. Then, the student cried and left the classroom by slamming the door.

With regard to step 3, T-1 and T-2 exhibited behaviours which were appropriate to Reality Therapy. In some cases, they used traditional teaching methods by shouting and warning the students. However, the students were not given opportunity to evaluate their behaviours, which were discipline problems.

Step 4 and 5

T-1 behaved according to a frame of plan so as to solve the problem. However, the steps of this plan did not overlap the steps of Reality Therapy exactly. T-1 gave the students a chance to solve the discipline problem that occurred in the classroom. They were asked what they could do based on this issue. For example, T-1 asked the students what they should do to prevent undesirable behaviours of coming late to class and eating and drinking something at the time of the lesson. When the students did not answer, the teacher proferred a solution. On the other hand, T-2 did not behave according to a specific plan but produced spontaneous solutions to the discipline problems occurring in the class. T-2 identified the reason for the undesirable behaviour by asking the students "who caused the problem", "Why are you displaying this behaviour?". Therefore, it was observed that T-1 and T-2 did not behave according to a specific plan in order to cope with the discipline problems and they differed in using the methods to cope with the discipline problems.

Step 6 and 7

T-1 checked the students' studies to observe their answers to the questions that were written on the board by walking in the classroom. By means of observations, T-1 saw the mistakes that the students made in solving the problems and intervened immediately. The students who solved the questions correctly were given rewards such as "well-done, high marks", and the students who gave wrong answers were punished. However, the students who displayed undesirable behaviours, which were defined as discipline problems, were given sanctions such as waiting in front of the board, sitting at the back of the class, solving extra questions, and taking a statement down.

Related to these items, T-2 helped the students who were called to the board while they were solving the questions, but the teacher did not directly tell the answer to the problem. The teacher asked questions which provided cues to solve the question. Also, the teacher used reinforcements such as "well-done, good" for the students who answered the questions correctly. Accordingly, T-2 imposed sanctions against students who created discipline problems such as making them stand for a few minutes, changing their places and making them sit at a desk, which was different from the desk next to their best friends. When a student continued creating a discipline problem insistently, the teacher made the students sign student behaviour contract.

Thus, it is possible to say that the appropriateness of the behaviours of T-1 and T-2 to the steps of Reality Therapy is at a medium level. Based on the findings obtained from the observations, it can be concluded that the data collected from the interviews were reliable.

Conclusion, Discussion, And Suggestions

The teachers, who were interviewed generally, described the behaviours preventing the teaching process as discipline problems. Although the behaviours which were described as discipline problems by the teachers interviewed were different, the reasons for which they were indicated as discipline problems were similar. According to some researches (Çapri et al., 2010; Dağlı & Baysal, 2011; Demir, 2013; Sadık & Öz, 2015; Uğurlu et al., 2015), similar results were determined. The teachers generally defined the behaviours preventing the teaching and learning activities as the discipline problems. To cope with the complication of the class and the variety of events in the class poses huge challenges and difficulties to classroom management (Wolff, Jarodzka & Boshuizen, 2020). Therefore, it is possible to evaluate the behaviours which the teachers regarded as discipline problems within the scope of "need for power and need for freedom", which are two of the unsatisfied needs in Glasser's Reality Therapy. According to Glasser, if a person feels unhappy, it means that at least, one of this person's basic needs is not satisfied (Glasser, 2005; stated by Türkdoğan & Duru, 2012). Accordingly, creating a classroom environment which meets the students' needs can be one of the efficient ways to cope with the discipline problems.

It is possible that the students' behaviours based on the teaching process and the features of discipline problems created in the classroom by the students can be related to the quality learning of Reality Therapy Discipline Model. The quality curriculum emphasizes that deep learning of a small number of subjects should be preferred to superficial learning of a very large number of subjects (Atıcı, 2014). Within this context, the subjects which will be taught should be discussed by getting the students' opinions. This will enable the students not to lose their interest in the lesson. Similarly, in Djigic and Stojiljkovic (2011)'s research, it was concluded that teachers' classroom management styles were significant variables for efficient teaching.

It was also determined that teachers generally used preventive solutions to the discipline problems and applied a set of tactics to prevent the discipline problems from occurring. By considering the tactics used to solve the discipline problems, it is possible to say that some of the teachers used the steps of Glasser's Reality Therapy Model, which were related to undesirable behaviours. However, the solutions which these teachers used did not have the same order as the steps of Reality Therapy Model (The order of solutions which the teachers used was not the same as the order of the steps of Reality Therapy Model). Furthermore, there was no sufficient number of teachers who gave the students an opportunity to notice their behaviour and reflect on such behaviour. This situation that occurred required the determination of the reasons underlying it.

According to Glasser's Reality Therapy Model, meeting with the parents is used when the students do not raise awareness of their behaviour and when the solution plan does not work. If the behaviour continues even after the teacher's meeting with the parent, professional help will be provided to the students. Considering this principle of the model, it was seen that teachers first used the solution that should be applied in the end and teachers who talked to the students at first initiated other steps before they developed a plan for the solution.

In terms of Glasser's Reality Therapy Model, it can be said that teachers' enabling the students to take responsibility for their own behaviours by using the student-centered behaviours is an accurate and efficient method. This is because the student's being aware of the results of his/her behaviours and being responsible for these behaviours are the suggestions belonging to Reality Therapy. However, according to this model, it is possible to say that developing alternative methods to solve undesirable behaviours is preferred to using rewards and punishments.

According to Reality Therapy Model, classroom rules are necessary and teachers and students must establish these rules together (Aksoy, 2001). Within this context, it can be stated that most of the teachers who participated in the research appropriately established the classroom rules in terms of Reality Therapy Model and they used different methods to enable the students to obey the rules. Additionally, this situation can be accepted as an indication that the students participated in the classroom activities and decision making process related to the classroom. Thus, it can be evaluated that the teachers' that made students participate in establishing rules and their uage of "I " language to communicate with the students are appropriate to the communication step of Reality Therapy Model. According to Glasser's Reality Therapy Discipline Model, help should be provided by the school counsellor and the parents when the teacher's help is no longer sufficient. Accordingly, it is possible to say that teachers' having expectations from the environment or people is an appropriate attitude. However, it should not be ignored that the teacher should get help from the environment or the people when the steps existing in Reality Therapy have been completed and there are still problems that can not be solved.

It was determined that the teachers, in whose classrooms the observations were made, used different tactics to maintain the discipline in the class. One of the teachers performed teaching in a way that was appropriate to the constructive approach and tried to use some steps of Reality Therapy. Nonetheless, the teacher did not know that the steps used were appropriate to Reality Therapy. The other teacher performed teaching more traditionally and displayed behaviours that were less appropriate to Reality Therapy Model. The fact that the teachers' seniority was low caused their level of occupational burnout to be at a low level and enabled them to be more energetic and interested in dealing with the discipline problems in the classroom, even if they used different methods. The fact that the classes where the teacher taught had few problems or a lot of problems may have caused these results. In accordance with these findings, to contribute to the field, it can be suggested that:

- The researches in relation to investigating the relationship between the teachers' level of occupational burnout and the models that they use to cope with the discipline problems can be conducted.
- The teachers can be provided a performance oriented in-service training which teaches and explains to teachers all the models to cope with the discipline problems.

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The Effect of the Building Blocks Education Program on Turkish Preschool Children's Recognition of Geometrical Shapes

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Abstract:

This study examined the effect of the Building Blocks mathematical education program on 4-year-old Turkish preschool children's recognition level of geometrical shapes. A pretest-posttest control group experimental design was employed. The sample group was composed of randomly selected 39 preschool children (of whom 21 were in the experimental group, and 18 in the control group). A geometric shapes recognition test was used for data collection. Results indicated meaningful differences in the mean scores of the triangle and rectangle shapes in favor of the experimental group. When the children's responses to the geometric shapes recognition test were examined in detail, it was observed that in the post-test the children in the experimental group, as compared to the ones in the control group, were more inclined to define geometrical shapes with their qualitative features rather than visual features.

Keywords: Curriculum, geometric shapes, mathematics, preschool

Introduction

Early mathematics achievement is the strongest predictor of children's mathematics achievement in later school life (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Claessens & Engel, 2013; Duncan et al., 2007; Fuson, Clements, & Sarama, 2015; Jordan, Glutting, & Ramineni, 2010; Nguyen, et al., 2016; Watts, Duncan, Siegler, & Davis-Kean, 2014). The National Council of Teachers of Mathematics (NCTM) and the National Association for the Education of Young Children (NAEYC), two internationally recognized organizations in the field of early childhood, also report that providing high quality, challenging and accessible mathematics education for children aged 3-6 is of vital importance for their future mathematics learning (NAEYC, 2002).
Geometry and spatial reasoning are important and fundamental parts of mathematics learning in early childhood education (NCTM, 2006). These two areas also support number and arithmetic related concepts and skills (Arcavi, 2003; Gunderson, Ramirez, Beilock, & Levine, 2012).

However, geometry and spatial thinking are usually neglected or take up only a small portion of curricula (Hawes, LeFevre, Xu, & Bruce, 2015; Sarama & Clements, 2009). Clements (2004) reports that although the NCTM standards try to distance teachers from basic number sense in mathematics, most teachers still focus the curriculum on number skills. Similarly, there are studies emphasizing that early mathematics education should focus on basic skills such as spatial skills beyond number knowledge (Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014). On the other hand, Ginsburg, Lee, and Boyd (2008) report that early childhood educators receive insufficient training to teach mathematics, they rarely teach mathematics, they do not believe that mathematics is important, or they are afraid to teach it. Verdine, Golinkoff, Hirsh-Pasek, and Newcombe (2014) emphasize the need to train teachers on the best methods for teaching geometry and spatial concepts.

Children need to acquire these skills from an early age to acquire both STEM careers (Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2014) and the 21st century skills. It is reported that individuals who have a solid foundation in these concepts are generally more interested in STEM related disciplines - science and mathematics - and are more likely to obtain high-quality advanced degrees (Newcombe, 2010).

International studies show that there is a weakness in students' geometry achievement (Mullis et al. 1997). The same is true for Turkish students. Recent national (e.g., Ministry of National Education [MoNE], 2019; Monitoring and Evaluating of Academic Skills [ABIDE], 2018) as well as international evaluation programs (e.g., Programme for International Student Assessment [PISA], 2018; Trends in International Mathematics and Science) Study [TIMSS], 2019) indicate that Turkey is behind the OECD average in the field of mathematics. There has been an increasing awareness of the importance of mathematics throughout the world. Educators and business leaders express that they are very concerned about the success of students in mathematics because individuals with more complex skills are needed than in the past. In response, early intervention programs based on scientific studies are developed to increase the mathematical success of young children. One of these is Building Blocks, a research-based early intervention program developed and tested by Clements and Sarama (Clements & Sarama, 2007a). Hofer, Farran, and Cummings (2013) evaluated the effectiveness of the Building Blocks and report that this program has positive effects on children's geometry-related skills. Likewise, Canadian researchers Hawes, Moss, Caswell, Naqvi, and MacKinnon (2017) state that the early intervention programs such as the Building Blocks can be used by educators to increase children's geometric and spatial skills in line with the demands of the 21st century. Indeed, adapting and spreading research-based tools throughout an education system can buttress improvement efforts (National Council of Teachers of Mathematics [NCTM], 2013). Therefore, it is thought that adapting and testing the Building Blocks in Turkey will lead to more efficient results and will save a great deal of time and effort. Therefore, the aim of this study is to analyze the effect of the Building Blocks early math education program in a Turkish preschool, with specific interest in children's geometry outcomes.

With this overarching aim in mind, we address the following research questions:

(1) To what extent are there post-test differences in *shape recognition* between the children in Building Blocks classroom and their peers in business-as-usual classroom?
(2) To what extent are there post-test differences in *shape type* scores between the children in Building Blocks classroom and their peers in business-as-usual classroom?
(3) To what extent are there post-test differences in *shape classification* scores between the children in Building Blocks classroom and their peers in business-as-usual classroom?

(4) What are the criteria children employ to differentiate between the shapes (triangles, rectangles, squares, and circles)? Are there differences between groups?

Method

ResearchDesign

This study used a cluster randomized trial design to evaluate the effectiveness of the Building Blocks early math education program, with specific interest in children's geometry outcomes. One preschool in the district of the Directorate of National Education of Mentese in the province of Mugla, Turkey was randomly selected to serve as the study site. Two classrooms out of eight were randomly selected within this preschool and were randomly assigned one of two conditions using a randomized block design: one classroom was given the intervention (the BB curriculum) and the other (control) classroom received no intervention (business-as-usual math teaching) over the same period (30 weeks). The two groups underwent the same tests at the beginning (pre-test) and at the end (post-test) of this period (Karasar, 2020). Table 1 depicts the timing of the pre-test, the Building Blocks program implementation, and post-test.

Table 1. Symbolic view of research design

		Pre-test		Post-test
G_E	R	$O_{1.1}$	X	$O_{1.2}$
G_C	R	$O_{2.1}$		$O_{2.2}$

Note: **G_E:** the experimental group**, G_C:** the control group, **R:** the subjects were randomly assigned to the group, **$O_{1.1}$ and $O_{1.2}$:** the experimental group's pre- and post-test measurements, **$O_{2.1}$ and $O_{2.2}$:** the control group's pre- and post-test measurements, **X:** the independent variables (experimental variables) implemented on the experimental groups.

- **Participants**

Pre-school classrooms

The sampling process was composed of two steps. First, a preschool in the district of the Directorate of National Education of Mentese in the province of Mugla, Turkey was randomly selected to serve as the study site. Second, two classrooms were randomly selected within this preschool and were randomly assigned one of two conditions: (a) Building Block (BB) + business-as-usual math teaching condition, in which children received both the BB program and the math objectives of the regular pre-school education program (b) Business-as-usual math teaching classroom, in which children did not receive the BB program intervention. The children in both conditions continued to receive regular math instructions as a part of the pre-school education curriculum.

Teachers

The teachers of the selected classrooms are Early Childhood Education program graduates, and both have more than ten years of professional experience (Building Blocks, 16.9 years; control, 17.2 years of experience).

Children

There were twenty-three children whose parents volunteered to participate in the study in each classroom (forty-six total). Two inclusion criteria were used to guide the selection of children:

those children who (a) had not participated in another intervention program that supported the development of mathematics skills and who (b) were typically developed. Seven children were excluded from the study: one was with severe cognitive delay, and six others were withdrawn from the school for various reasons. Therefore, the research continued with thirty-nine typically developing children, twenty-one of which were in the experimental classroom and eighteen were in the control classroom. The mean age of the children in the experimental group was 4.4, and the mean age of the children in the control group was 4.3. The gender distribution for the experimental and control classrooms are displayed in Table 2.

Table 2. Demographic characteristics of the children in the Building Blocks (experimental) and business-as-usual (control) classroom

	Classroom		**n**
Gender	Experimental	Female	12
		Male	9
	Control	Female	9
		Male	9

Intervention

The Building Blocks (BB) Program

The Building Blocks curriculum (Clements & Sarama, 2007a) is an early childhood mathematics program developed for preschool children. It covers topics including numbers, operations, and geometry. Throughout this study, the Building Blocks Program materials such as the Teacher's Edition, the Teacher's Resource Guide, Assessments and Manipulative Sets were used. In the Teacher's Edition (Clements & Sarama, 2007b), there are thirty weekly plans. Each unit includes whole and small group activities, a hands-on math center activity, home connection feature (i.e., parent letter), and sequence of math topics to cover throughout the academic year. Since there are no computers available in most of the Turkish preschool classrooms (Babayigit, 2014; Orcan-Kacan & Kimzan, 2017) (including the experimental and control group classrooms of this study), the on-computer activity sets of the Building Blocks were not used in this study.

The process of translating and adapting the Building Blocks Education Program into Turkish

First, the BB curriculum materials were translated into Turkish and then back translated for accuracy and quality. An expert in English and Turkish languages compared the equivalence of the original and translated BB text. The researchers also examined the English and Turkish texts through the lens of content experts in mathematics education. Then, the original and translated materials were shared with early math education experts to comment on the appropriateness of the BB content for Turkish culture. In line with the experts' suggestions, some revisions were made to make it more clear for Turkish users. This version was deemed as the final version for pilot implementation.

A pilot study of the BB program was carried out with 22 children for five days in a randomly selected preschool in the Mentese district of Mugla. The findings of the pilot implementation suggested that the BB program was age-appropriate, culturally relevant, comprehensible by the children (both in term of language and content) and it was ready for larger-scale implementation.

Implementation of the Building Blocks Curriculum

The first author observed Clements and Sarama's Building Blocks (BB) program at the University at Buffalo in the Early Math Laboratory for two years. During this period, she also observed implementation of the BB curriculum in classrooms at the Early Childhood Research Center every day for six months. The second and third authors also had the opportunity to observe the whole BB Education Program and its applications at http://triad-research.du.edu.

The researchers had face-to-face meetings with the BB and control classroom teachers from September 18 to October 6, 2017, providing them with information about the study. The BB teacher received further information about the aim, content, and implementation of the BB program. Also, a newsletter describing the BB program and its intended benefits for children was sent home to the families.

The experimental group's (BB classroom) teacher was trained by the first author prior to the implementation. She also had face-to-face meetings with the researchers to discuss BB materials every week. The business-as-usual (control) teacher implemented the Turkish National Preschool Curriculum. The BB program was implemented from October 9, 2017 to May 18, 2018 (for 30 weeks).

Fidelity of implementation

The teacher prepared the classroom in accordance with the BB curriculum with the guidance of the researchers before the start of the academic year. The whole group and hands on math center BB activities were implemented every day; the small group BB activities were implemented on Wednesdays and Fridays for 30 weeks. The research team members conducted one fidelity observations each week. The BB teacher was scored on how accurately she implemented the BB program on a 3-point scale. The fidelity score for the intervention was .98 Also, every Friday afternoons, the researchers briefed the teacher about the forthcoming week's BB activities.

Data Collection

Data collection included pre-test (September 25, 2017, and October 06, 2017) and post-test (between May 21, 2018, and June 02, 2018) performance on measures designed to assess children's shape recognition knowledge. Also, some basic demographic information about the children were collected during pre-test period.

- **General Information Form**

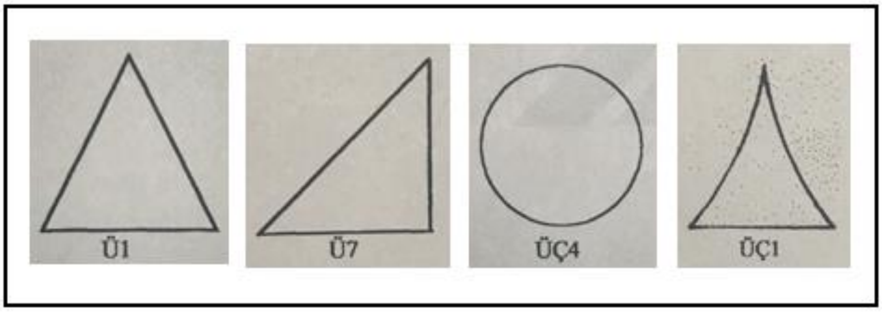
This form was used to collect demographic information, including children's genders and age.

- **Geometrical Shapes Recognition Test (GSRT)**

The Geometrical Shapes Recognition Test (GSRT), developed by Aslan (2004), is composed of four dimensions that assess knowledge of triangles, squares, circles, and rectangles. Each geometrical shape was presented to children on a paper (12 shapes in total), and they are asked to mark which shapes are the corresponding shape (e.g., triangle) and which shapes are not. If the child chooses the correct one, his/her answer is coded as "1" and if not, it is coded as "0". The GSRT also includes an Interview Form to record child's response for each shape when s/he was asked why s/he thinks so (e.g., Why do you think this one is a triangle?)

Each question in the GSRT included typical and non-typical examples of each shape. Non-typical examples were related to test the location, flatness, distortion, size, and edge variables of the shapes. Exemplary shapes also included obvious and non-obvious distractors. The obvious distractors are typical examples of other shapes than the tested one. The non-obvious distractors consist of shapes that do not fit the geometric definition of the tested shape (see Figure 1). The number of questions in each type and classification are given in Table 4 (additional information can be found in Aslan, 2004).

Figure 1. Sample item from triangle recognition test



U1: Typical example, U7: Non-typical example; UC4: Obvious distraction, UC1: Non-obvious distraction

Table 3. The number of questions in each type and classification in the GSRT

		Triangle	Rectangle	Square	Circle
Type of shape	**Typical example**	1	1	1	2
	Non-typical example	6	4	3	3
	Obvious distraction	2	4	6	4
	Non-obvious distraction	3	3	2	3
Classification of the shapes	**Distortion**	3	-	-	-
	Location	3	3	2	-
	Flatness	3	2	-	-
	Size	-	2	2	3
	Location-size	-	-	2	-
	Edge width	-	-	-	3
	Edge width-size	-	-	-	3

Aslan (2004) reported the discrimination index of each item in the GSRT was below .15 and item difficulties ranged between .31 and .99. In this study, reliability scores for the pre-test (KR-21) were computed as .75 for the triangle recognition test, .71 for the rectangle, .77 for the square, and .72 for the circle. The reliability values were slightly higher than .70 acceptable cut-off value (Buyukozturk, 2020).

- **Data Collection**

The data was collected during the 2017-2018 school year. The pre-tests were administered between September 25, 2017, and October 6, 2017. Implementation of the BB program began in October 2017 and ended in May 2018. Post-test administration began May 21, 2018 and ended on

June 2, 2018.

Data Analysis

Firstly, independent t-tests were used to test if the experiment and the control group's performance on the GSRT were equal. All independent t-tests were non-significant, (t values from -.84 to .052 and for all comparisons, p> .05). We specified mixed ANOVAs to examine the extent to which BB students' scores were higher relative to their peers in the control group. We checked the normality and sphericity assumptions of the dependent variable, the GSRT score. Kurtosis and skewness values of both test scores ranged between -1 and +1, suggesting a normal distribution. The quantitative data were analyzed in the SPSS 22.0 package program.

In addition, descriptive methods (e.g., frequencies) were used to examine the answers given by the children to the questions about how they define the geometric shapes in the GSTR. To establish inter-coder reliability, another researcher (who is a specialist in the field of early math education) also coded the replies provided by the children for the geometrical shapes recognition test. The inter-coder reliability was found by calculating Cohen's Kappa reliability correlation coefficient. The correlation coefficient was calculated as 0.85. This score indicates a high rate of reliability between the two coders. The children's responses were grouped visually and qualitatively. The responses that do not fall into these two groups like "I know this (I pondered, I guessed)" and "I do not know" were presented as separate categories in the relevant tables.

Results

The aim of this study was to analyze the effect of the Building Blocks mathematical education program in a Turkish preschool, with specific interest in children's geometry outcomes. The following analysis shows that the BB program participation has strengthened geometrical shapes recognition in Turkish preschool children ($\bar{x}$= 50 months).

- **Findings for the Geometrical Shapes Recognition Test and its Sub-Tests**

To find out if there was a meaningful difference between the mean scores of the experimental and control group children's levels of recognizing geometrical shapes (levels of recognizing triangles, rectangles, squares, circles) before the Building Blocks Education Program was implemented. As seen in Table 4, at the pre-test children's mean scores in the experimental and the control groups were close to each other.

Table 4. Descriptive statistics for the pre- and post-tests of the experiment and the control groups

		Pre-test		**Post-test**	
The Shapes Test	**Groups**	**M (SD)**	**Skewness (kurtosis)**	**M (SD)**	**Skewness (kurtosis)**
Triangle	**Control**	7.22 (1.56)	-.15(.55)	7.66 (1.53)	-.68(.22)
	Experiment	7.42 (1.80)	-.45(.69)	10.09 (1.58)	-.27(.17)
Rectangle	**Control**	7.05 (2.58)	-.35(-.38)	9.16 (1.38)	-.33(-.02)
	Experiment	7.57 (2.40)	-.04(-.84)	11.38 (1.35)	.41(.19)
Square	**Control**	8.33 (3.11)	-.61(-.76)	9.50 (1.38)	.32(.39)

	Experiment	8.38 (2.58)	-.04(-.97)	11.19 (.93)	-.79(-.52)
Circle	**Control**	8.22 (2.88)	-.07(-.31)	11.00 (1.06)	-.58(.27)
	Experiment	9.04 (3.15)	-.57(-.32)	11.90 (1.53)	. -41(-.80)

To test *the research question 1*, the effect of the programs on children recognition of the geometrical shapes, we applied a mixed ANOVA tests to the data (See Table 5). The mixed ANOVA tests revealed that there were statistically significant effects of the treatments, time, and the interaction of treatment*time in the triangulation test. The main effect of the treatment ($F(1,37) = 15.65$, $p < .001$, $r = .54$) was significant indicated that the experiment and control groups statistically differed. The main effect of time was significant ($F(1,37) = 15.07$, $p < .001$, $r = .54$), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The interaction effect of treatment*time was statistically significant ($F(1,37) = 7.59$, $p < .001$, $r = .42$). This result showed that the students' scores on pre- and post-tests were statistically different across the treatment groups.

The mixed ANOVA tests revealed that there were statistically significant effects of the treatments, time, and the interaction of treatment*time in the rectangular test. The main effect of the treatment ($F(1,37) = 6.50$, $p < .001$, $r = .38$) was significant indicated that the experiment and control groups statistically differed. The main effect of time was significant ($F(1,37) = 6.50$, $p < .001$, $r = .79$), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The interaction effect of treatment*time was statistically significant ($F(1,37) = 5.68$, $p < .001$, $r = .36$). This result showed that the students' scores on pre- and post-tests were statistically different across the treatment groups.

Table 5. Results of mixed ANOVAs

The Shapes	**Groups**	**SOS**	**F**	**r**
	Group	34.87	15.65	.54
Triangle	**Time**	45.48	15.07	.54
	Time*group	22.92	7.59	.42
	Error	111.70		
	Group	34.67	6.50	.38
Rectangle	**Time**	166.70	63.53	.79
	Time*group	14.91	5.68	.36
	Error	97.09		
	Group	13.72	2.51	.25
Square	**Time**	78.77	20.22	.59
	Time*group	12.21	3.13	.27

	Error	144.17		
	Group	13.59	2.39	.24
Circle	**Time**	156.92	38.07	.71
	Time*group	.01	.01	.01
	Error	152.54		

The mixed ANOVA tests revealed that there were statistically significant effects of the time, but the effects of treatment and the interaction of treatment*time were not in the square test. The main effect of time was significant (F (1,37) = 20.22, p <.001, r= .59), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The main effect of the treatment (F (1,37) = 2.51, p =.12, r= .25) and treatment*time (F (1,37) = 3.13, p =.08, r= .27) were not significant indicated that the experiment and control groups statistically did not differ.

The mixed ANOVA tests revealed that there were statistically significant effects of the time, but the effects of treatment and the interaction of treatment*time were not in circle test. The main effect of time was significant (F (1,37) = 38.07, p <.001, r= .71), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The main effect of the treatment (F (1,37) = 2.39, p =.13, r= .24) and treatment*time (F (1,37) = 0.01, p =.98, r= .01) were not significant indicated that the experiment and control groups statistically did not differ.

To test *the research question 2*, we compared the students at the experimental and control groups responses based on the shape types (typical example, non-typical example, obvious distraction and non-obvious distraction). Descriptive statistics for the experimental and control groups were displayed in the Table 6. The results of mixed ANOVAs showed that some interaction effects were statistically significant for shape types but other were not. In triangle, the interaction effect of treatment*time for non-obvious distraction was statistically significant (F (1,37) = 4.25, p <.001, r= .32), indicating that the experimental group statistically significantly increased their post score than the control group did.

In rectangle, the interaction effect of treatment*time for non-obvious distraction was statistically significant (F (1,37) = 17.77, p <.001, r= .56), indicating that the experimental group statistically significantly increased their post score than the control group did. In square, the interaction effect of treatment*time for non-typical distraction was statistically significant (F (1,37) = 5.11, p <.001, r= .34), indicating that the experimental group statistically significantly increased their post score than the control group did.

Table 6. Descriptive statistic for the triangle, rectangle, square and circle recognition test based on the shape type

			Pre-test **M (SD)**	**Post-test** **M (SD)**	**Pre-test** **M (SD)**	**Post-test** **M (SD)**
T r	**Sets an Example**	**Typical Example**	.86 (.36)	1.00 (.0)	.83 (.38)	1.00

iangle		**Non-Typical Example**	3.29 (2.10)	5.24 (1.13)	3.56(1.72)	4.05 (1.73)
	Doesn't Set an Example	**Obvious Distraction**	1.64 (.73)	1.95 (.22)	1.44 (.92)	2.00 (.0)
		Non-Obvious Distraction	1.66 (1.15)	1.90 (.89)	1.39 (1.14)	.61 (.61)
Rectangle	**Sets an Example**	**Typical Example**	.76 (.36)	1.00 (.0)	.67 (.48)	.94 (.23)
		Non-Typical Example	2.67 (1.39)	3.71 (.72)	2.33 (1.45)	3.61 (.78)
	Doesn't Set an Example	**Obvious Distraction**	2.61 (1.32)	4.00 (.0)	12.44 (1.72)	3.67 (.59)
		Non-Obvious Distraction	1.52 (1.36)	2.67 (.73)	1.67 (1.37)	.94 (1.10)
Square	**Sets an Example**	**Typical Example**	.76 (.43)	1.00 (.0)	.83 (.38)	1.00 (.0)
		Non-Typical Example	1.90 (1.13)	2.52 (.75)	2.27 (.95)	1.88 (1.02)
	Doesn't Set an Example	**Obvious Distraction**	4.42 (1.77)	5.90 (.30)	3.77 (2.18)	5.33 (.83)
		Non-Obvious Distraction	1.28 (.78)	1.76 (.62)	1.44 (.85)	1.33 (.76)
Circle	**Sets an Example**	**Typical Example**	1.52 (.87)	2.00 (.0)	1.44 (.92)	2.00 (.0)
		Non-Typical Example	2.24 (1.22)	3.00 (.0)	2.11 (1.18)	2.83 (.51)
	Doesn't Set an Example	**Obvious Distraction**	3.05 (1.39)	3.95 (.21)	2.78 (1.48)	3.79 (.42)
		Non-Obvious Distraction	2.23 (.13)	2.95 (.21)	1.89 (1.18)	2.44 (.78)

The students at the experimental and control groups responses based on their classification (triangle: distortion, location, and flatness; rectangle: location, flatness, and size; square: location, size, and location + size; circle: size, edge width and edge width + size) were compared (*the research question 3*). Descriptive statistics for the experimental and control groups were displayed in the Table 7. The results of mixed ANOVAs showed that all interaction effects were not statistically significant for shape classification.

Table 7. Descriptive statistics for in the triangle, rectangle, square and circle recognition test based on their classification

		Experimental		Control	
		Pre-test	**Post-test**	**Pre-test**	**Post-test**
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Triangle	**Distortion**	1.81 (.93)	2.81 (.40)	1.94 (.93)	2.28 (.67)
	Location	2.52 (.92)	3.00 (.0)	2.61 (.98)	2.89 (.47)
	Flatness	1.52 (1.03)	2.43 (.81)	1.50 (.85)	1.89 (.93)
Rectangle	**Location**	2.19 (1.21)	2.90 (.43)	2.22 (1.26)	2.94 (.23)
	Flatness	1.29 (.72)	1.90 (.30)	1.05 (.80)	1.77 (.54)
	Size	1.05 (.80)	1.72 (.57)	1.48 (.87)	1.90 (.30)
Square	**Location**	1.57 (.68)	1.81 (.40)	1.67 (.68)	1.72 (.46)
	Size	1.33 (.73)	1.95 (.21)	1.56 (.70)	1.66 (.48)
	Location+ Size	1.28 (.71)	1.76 (.43)	1.56 (.61)	.150 (.51)
Circle	**Size**	2.23 (1.30)	3.00 (.0)	2.11 (1.27)	2.89 (.32)
	Edge Width	2.28 (1.23)	3.00 (.0)	2.17 (1.30)	3.00 (.0)
	Edge Width + Size	2.28 (1.23)	3.00 (.0)	2.16 (1.38)	2.94 (.23)

When the children's definitions of the shapes in the triangle and rectangle recognition test were examined closely, it was found that while the visual expressions decreased, the qualitative expressions increased in the post-tests in both the experimental and control groups. However, the increase was found to be higher in the experimental group. They emphasized the number and features of edges and vertices more. Although the qualitative responses for square and circle shapes also increased in the post-test, they still focused more on the visual features of shapes even after the BB program implementation.

Discussion

The pre-test scores of the experimental and control group children's levels of the geometrical shapes recognition indicate that there was no statistical difference between the two groups. Therefore, it can be argued that before the implementation of the BB both groups' levels of recognizing geometrical shapes were close to each other. In addition, measurements taken before the BB program was implemented show that children had higher averages in square and circle shapes than in triangle and rectangular shapes. The high averages obtained in square and circle shapes are similar to the results of the study conducted by Clements, Swaminathan, Hannibal and Sarama (1999).

A comparison of the shape types in the answers provided by the students in the pre- and post-tests reveals that there is a significant difference in favor of the experimental group in the non-obvious distractions of the triangle shape. The non-obvious distractions in the triangle recognition test are triangle shapes with inwardly or outwardly curved sides. It was observed that the control group students were not well-informed about their edge features and thus were inclined to regard these shapes with curved sides as triangles. Kesicioglu, Alisinanoglu and Tuncer (2011) in their descriptive study where they used the same assessment tool also found that in the triangle recognition test among the shapes that the obvious distraction shapes group was the one the students made frequent mistakes. The fact that the experimental group students scored higher with these shapes indicates that the Building Blocks education program had a significant effect on the experimental group students' ability to identify the triangle's edge features. Additionally, the fact that the children in the experimental group used the qualitative expressions related to the edge properties of the shapes more in the posttest while defining the shapes in the triangle recognition test, also supports this result. The responses given by the children in both the experimental and control groups in the triangle recognition test show that the most repeated response in the pre-test was "looks like it" (i.e., "It looks like a triangle."), which was a visual response, however, it was the "number of edges" in the posttest, which was a qualitative response. In Aslan's study (2004), it was also found that the most common answer in the triangle test in the 3-4-year-old group was "looks like it", and "stating the number of vertices" in the 6-year-old group. Considering that the study group of this research consists of children aged 4 years, the pre-test results in both studies support each other. However, the post-test responses of the 4-year-olds in the current study are similar to the responses provided by 6-year-olds in Aslan' study (2004). Therefore, it can be deduced that the BB program intervention had a positive effect of on the children in the experimental group.

In the square recognition test, there was a significant difference in favor of the experimental group in the non-typical examples. This group of shapes consisted of three square shapes of which one was 45 degrees rotated, another one decreased in size at 1/3 rate, and the last one was both rotated and decreased in size. The experimental group students were more successful than the control group in identifying these shapes as squares. Similarly, in Kesicioglu, Alisinanoglu and Tuncer (2011)'s study, it was observed that in the square recognition test one of the shapes that the students most frequently misidentified was the both rotated and size-reduced shape of the typical square. The results obtained in this study demonstrate that teaching the experimental group students different shape features like location, flatness, and size had a positive effect on their achievements. Thus, it was noticed that the control group students had problems in identifying the square shape when its size and location changed. The reason for this might be that in the control group while teaching the square shape the teachers usually concentrated on the typical examples. Moreover, the answers given by the children for the shapes in the square recognition test show that while "I know / I don't know" type of answers in the experimental group decreased significantly in the post-test, these types of answers were still present in the control group's post-test responses. All these results indicate that the implemented BB program had a positive effect on the children's definitions of the square shape through its qualitative features.

There was no significant difference in any of the shape types in the circle recognition test. In the circle recognition tests both experimental and control groups increased their scores similarly. Clements (1999) noted that pre-school children predominantly correctly identified the circle shape, and that only very few children of that age group made mistakes with the circle shape. Also, other studies concluded that among geometrical shapes children scored the highest in identifying the circle shape (Kesicioglu, Alisinanoglu & Tuncer 2011; Maričić & Stamatovic, 2017). Likewise, in this study, both groups of students increased their scores in the circle recognition tests and there was no significant difference between the groups. Therefore, it can be argued that the provided BB education did not have any effect on experimental group's ability to recognize the circle shape. When the children's responses in the circle recognition test were examined, it was seen that although the visual responses increased slightly, the qualitative responses increased significantly in the post-test for the experimental group.

Another result obtained in the circle shape is that, from the pretest to the posttest, "resembling an object" type of responses (i.e., "Looks like a ball.") increased slightly in both the experimental and control groups unlike other shapes. When the children's answers were examined, it was seen that most of the children tend to explain the shape by likening an object in the pre-test because a child of this age can recognize shapes and their names but cannot understand the relationships and connections between shapes. Also, the child's reasoning is general and undifferentiated, therefore, the child identifies geometric shapes with objects that have the same properties (Maričić & Stamatović, 2017). While there was a significant decrease in these types of responses given for the triangle, rectangle, and square shapes in the post-test for the experimental group, it was observed that there was a slight increase in the circle recognition test. The reason for this can be explained by the fact that when defining the circle shape, children cannot focus clearly on the edge and vertex features as in other shapes, and they tend to explain the shape by its similarity to a real-life object, just like what they did before the intervention.

Conclusion

Several studies demonstrate that mathematical skills acquired in early childhood has a positive effect on children's future success in school and mathematics (Claessens & Engel, 2013, Duncan et al., 2007, Fuson, Clements & Sarama, 2015, Watts, Duncan, Siegler & Davis-Kean, 2014). Also, recent studies emphasize that there is a positive correlation between children's spatial skills and mathematics knowledge in early childhood years (Rittle-Johnson, Zippert, & Boice, 2019). The findings of this study also support the importance of quality mathematical education programs.

Overall, it can be argued that the GSRT results reveal that the Building Blocks Education Program, which was implemented on the experimental group, were largely effective on 4-year-old children's ability to recognize and identify geometrical shapes. On the other hand, although the control group children, who did not undergo any special education program, also increased their levels of recognizing some geometrical shapes by the end of the 30-week period. It is interesting to note that this increase generally occurred with the typical examples of geometrical shapes.

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Conflicts of interest

The authors of this paper certify that they have NO affiliations with or involvement in any organization or entity with any financial or non-financial interest (such as honoraria; educational grants; membership, employment; affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

The Evolution of Students' Mental Models and Metaphors towards the Atomic Concept*

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Abstract:

It could be argued that the main goal of the teaching process is to create accurate projections of scientific models in the minds of individuals. In this context, it could be argued that it is important to determine the change and development of the mental models that individuals create for events/phenomena and related metaphors in this process.

This paper seeks to reveal how the mental models and metaphors of students with similar sociodemographic characteristics have evolved throughout the teaching process from secondary school to the undergraduate level. In the present study, the cross-sectional survey model, which is one of the descriptive research methods, was used. While the population of the study consists of students and pre-service teachers who receive formal education in public schools located in the South East Anatolia region in the 2019-2020 academic year, the sample consists of 720 students in total selected in equal numbers from every grade level with similar socio-demographic characteristics (60 students selected from the 5th-grade to the 4th-year students of the undergraduate degree). The data collection tool used in the study was a four-tier conceptual understanding test created by the researcher, who also tested its validity and reliability. The data were subjected to descriptive statistics, content analysis, and the Chi-square test.

The results reveal that the students have highly different definitions and metaphors for the concept of the atom with their mental models generally evolving up to the Rutherford atomic model and failing to reach a higher model.

It is recommended in future studies that researchers follow the process longitudinally and investigate the reasons why students' mental models fail to evolve into higher atomic models.

Keywords: Science Education, Atom, Mental Model, Metaphor

* This study was conducted on a different sample, independent of the previous study conducted by the researcher, and presented as an oral presentation at the *International Conference on Education in Mathematics, Science & Technology* (ICEMST 2017).

1. Introduction

From a modelling perspective, Science Education can be defined as a process aimed at creating accurate projections of scientific models formed in basic disciplines such as physics, chemistry, biology, and astronomy in students' minds (Norman et al. 1983). In simpler terms, science education can be defined as the process of transforming scientific models in related disciplines into mental models (Teller, 1994). In this respect, it can be argued that effective and efficient science teaching requires the definitions of not only the scientific models in the related disciplines and the mental models corresponding to the students but also the monitoring of their development and that success can only be achieved if the harmony between the two models is identified (Norman at al. 1983; Schwarz & White, 2005).

Considering the scientific models taught as part of science teaching, it is suggested that such models generally describe abstract phenomena/events, but can be presented to students through representations (Coll & Treagust, 2001; Gilbert, 2004), and in this respect, they are more challenging compared to the models in other disciplines in creating accurate mental projections (Harrison & Treagust, 1998). On the other hand, bearing in mind that mental models are subjective cognitive constructs that can differ from scientific models in constructing mental models not only because of the individual characteristics of those who construct but also because of external factors such as social environment, instructor, and teaching materials (Harrison & Treagust, 1998), the importance of monitoring the compatibility of mental models with the scientific model becomes more evident throughout the science teaching process.

In addition, it could be argued that mental models, which refer to the meaningful and coordinated whole of the information constructed in the mind, exist not only cognitively but also emotionally and in terms of psychomotor. In this respect, to fully understand the mental models that students have for any phenomenon/event, the data for these three dimensions should be collected and handled holistically. In this context, metaphors can be drawn upon to understand how mental models of individuals are created emotionally. It is reported in various studies that metaphors can be used to determine individual thoughts and feelings toward a certain concept (Fainsilber & Ortony, 1987; Lubart & Getz, 1997; Lakoff, & Johnson, 1980).

The literature review reveals that studies have long been carried out to identify mental models and the level of models. It is understood that current studies are generally aimed at identifying mental models and model levels, provided that they are limited to the cognitive dimension of the target group at a certain age level for basic concepts such as "*atom, cell, reaction, planet*" (Ayvacı et al, 2016; Coll & Treagust, 2001; Vosniadou & Brewer, 1992).

Studies specific to *the concept of the atom* have shown that the age groups from primary school to the undergraduate level are handled separately, and remarkable results are achieved in terms of the cognitive dimension and depending on the developmental characteristics and knowledge levels of the age groups (Adbo & Taber, 2009; Allred & Bretz, 2019; Akyol, 2009; Alkan, 2022; Baji & Haeusler, 2021; Bilir & Karaçam, 2021; Çökelez & Yalçın, 2012; Derman, at al, 2019; Kaya, 2018; Muştu & Ucer, 2018; Muştu, 2021: Özgür, 2007; Sarıdaş & Ünsal, 2020;). On the other hand, the literature does not include a comprehensive study that holistically scrutinizes the mental models of such age groups related to the concept of the atom and compares such models in terms of various dimensions apart from the cognitive dimension. In this context, this study is expected to make a significant contribution to the literature as it is aimed at determining the mental models of students from secondary school to undergraduate level, the metaphors they created for the concept of the atom, and the progress in such phenomena throughout education.

In this context, the present study seeks to determine how the mental models and metaphors of students with similar sociodemographic characteristics have evolved throughout education from secondary school to the undergraduate level.

In parallel with the relevant purpose, the following research questions were addressed:

1) What are the definitions and visual representations of the concept of the atom according to the grade and school level of the student groups?
2) What types of *metaphors* are created by the student groups for the concept of the atom according to grade level and school level?
3) To which scientific model do the mental models of the student groups for the concept of the atom correspond?
4) Is there a significant difference between the mental models of the student groups for the concept of the atom according to the education level?

2. Method

2.1 Design

Seeking to determine the evolution of the mental models and metaphors for the concept of the atom created by students with similar sociodemographic characteristics throughout the teaching process from secondary school to the undergraduate level, the present study quintessentially is based on the "cross-sectional survey model", which is listed among descriptive research method. It can be claimed that the relevant research model is suitable for measurements made at once on samples with different characteristics and large numbers (Büyüköztürk et al., 2010).
The sample of the study was shaped as follows appropriately and in compliance with the relevant selected method.

2.2 Sample

The researcher drew upon the selective sampling method in the study. The population consists of students and pre-service teachers receiving formal education in public schools located in the South East Anatolia region in the 2019-2020 academic year, and the sample consists of 720 students in total selected in equal numbers from every grade level with similar socio-demographic characteristics (60 students selected from the 5th-grade to the 4th-year students of the undergraduate degree). The students and pre-service teachers included in the sample were picked from among students with similar sociodemographic characteristics with the following selection criteria: Parents' educational status, economic income, and no history of receiving supportive education outside of school. In this direction, the sample included students who grew up in a family with secondary and high school education and without any supportive academic education outside of school (private lessons, private tutoring education, etc.). Secondary school students were picked from the 5th, 6th, 7th, and 8th grades of a public school while high school students were picked from the 9th, 10th, 11th, and 12th-grades of the numerical sciences department of an Anatolian high school and pre-service teachers from the 1st, 2nd, 3r, and 4th grades studying in the science teaching program of 3 different state universities. Pre-service science teachers were included in the sample as they are the first educators to guide students in constructing the concept of the atom.

The goal of using the relevant sampling method is to bring the research closer to the longitudinal research model. This helped determine how the mental models and metaphors of the students for the concept of the atom evolve throughout the teaching process and statistically compare the relevant phenomena in terms of education levels. Similarly, this sampling method helped perform an effective and efficient longitudinal study, which could only be carried out with a 12-year follow-up period, in a short time.

The research process for the relevant sample proceeded as follows.

2.3 Research Process

At the onset of the research process, a theoretical framework was drawn through a literature review along with a four-tier conceptual understanding test developed by the researcher based on the framework and a sample determined in parallel with the purpose of the research. Once the necessary permissions were obtained, the authorized administrators and advisor teachers in public schools were interviewed and given information about the purpose and process and which characteristics are needed for students to be included in the sample. Thus, in consultation with the advisor teachers, the researcher determined the intended characteristics and number of students for each grade level among the students studying in branches different from the relevant grade levels on a voluntary basis. To avoid any disruption in the teaching process, students selected from different branches were taken to the same advisory class, and the application process was performed on different days for each grade level under the supervision of the advisor teacher and the researcher. The researcher informed the students about the content of the study, distributed the measurement tools, and asked them to answer the relevant questions in a sufficient time (35 minutes). The students were not interrupted throughout the application. And finally, the measurement tools were retaken to terminate the application.

The characteristics of the measurement tool used in the research are detailed below.

2.3 Measurement Tool and Its Characteristics

A four-tier conceptual understanding test was developed by the researcher in line with the theoretical framework and the measurement tool development process. In the first stage, 4 questions were formed in line with the theoretical framework along with necessary instructions. Then, 4 faculty members working in the related field were consulted for their opinions on field, language, structure, and face validity. Once positive expert opinions were obtained, a pilot scheme was performed with the participation of 1 teacher and 3 students from each grade level and the validity of the measurement tool for each grade level was ensured. Thus, the tool took its final form. The items in the measurement tool created at the end of the process are respectively as follows:

- How would you describe *the concept of the atom* in your own sentences*?*
- Considering the *atomic* structure, can you write its properties?
- Can you draw the shape that occurs in your mind when you hear *the concept of the atom?*
- I think the atom looks like …………………. because …………………………………. .

The analysis process of the data obtained via the relevant measurement tool is as follows.

2.3 Data Analysis Process

Descriptive statistics, qualitative-quantitative content analysis, and Chi-square test were applied to the data obtained via the measurement tool. While analysing the data, first, two science educators specialized in their fields performed a qualitative content analysis simultaneously and independently of each other. As part of the analysis process, the experts examined the statements written for each item (1^{st}, 2^{nd}, and 4^{th}) and created codes and themes. Then, they analysed the responses to the 1st and 2nd questions and the images in the 3^{rd} question to identify which scientific model is compatible with the mental model of the student (Dalton, Thomson, Rutherford, Bohr, Modern Theory and Quantum Atom Models, as cited in Şahin and Founder 2005, were taken as a reference).

The evolution of atomic models can be summarized as follows.Dalton atomic model can be considered as the simplest model. It forms the basis of today's models. According to this model, the atom is defined as a filled sphere. Thomson atomic model; In addition to the dalton model, the charges (+,-) showing an even distribution in the filled sphere are revealed. Rutherford introduced the concept of nucleus and stated that negative charges are around this nucleus. The Bohr Atom model took the atom out of the classical understanding and brought it into a modern framework. Bohr stated that electrons are in certain orbits (circular) and move with opposite spin. Modern Theory put forward the concept of Orbital and put forward the concept that electrons are located in different orbitals according to their energy level and orbitals are not orbitals. According to this theory, orbitals are defined as regions where electrons are most likely to be found (Şahin ve Kurucu,2005).

At the end of the process, the Kappa value, which indicates the agreement between experts, was calculated as 0.75 (good level). The scientific model determined by experts for each student was numbered from 1 to 6 (Dalton Atom model: 1, Thomson Atom model: 2, Rutherford Atom model: 3, Bohr Atom model: 4, Modern Theory Atomic model: 5, and Quantum Atom model: 6) and converted into categorical data. The Chi-square test was applied to the obtained data via the SPSS 23.0 package program to identify the levels of differentiation between the groups.

The findings obtained from the analysis are detailed below.

3. Findings

The findings that emerged as a result of the analysis process are given in line with the problem statements and the order of the students' education level. In this way, it is aimed to organize the data according to the education level of the students and to interpret the differentiation patterns according to the education level more effectively.

In this context, the findings regarding the definitions of the concept of the atom and the shapes drawn by the student groups according to the level of education are presented below.

Table 1. Findings regarding the definitions of secondary school students for the concept of the atom

Definitions/Grade Level	5th-grade		6th-grade		7th-grade		8th-grade		Total	
	f	%	f	%	f	%	f	%	f	%
The smallest unit of a matter	11	18	20	33	33	55	44	73	108	45
Indivisible smallest matter	13	22	10	16	15	25	9	16	47	11
Matter too small to be observed	2	3	10	16	6	10	4	6	22	9
Sphere with stored energy	15	25	5	8	6	10	3	5	29	12
Bomb-making material	13	22	11	18	-	-	-	-	24	10
Very small fireball made of gases	6	10	4	7	-	-	-	-	10	4
Total	60	100	60	100	60	100	60	100	240	100

Table 1 reveals that 45% of secondary school students make use of the scientific definition in the books while 55% make wrong definitions using their own sentences. It is understood that as the grade level increases, the tendency to make scientific definitions increases, but the students tend to avoid using their own sentences and resort to the definition in the books. On the other hand, it can be suggested that the vast majority of 5th and 6th-grade students define the atom as a bomb or a sphere carrying energy.

Table 2. Findings regarding the shapes drawn by secondary school students for the concept of the atom

Shapes/Grade Level	5th-grade		6th-grade		7th-grade		8th-grade		Total	
	f	%	f	%	f	%	f	%	f	%
The atomic model with S-P orbitals	9	15	3	5	8	14	4	7	24	10

The atomic model with S orbitals	-	-	-	-	20	33	6	10	26	11
Interconnected spheres	-	-	4	8	5	8	15	25	24	10
Hollow sphere	9	15	16	25	12	20	13	21	50	21
Solid sphere	8	15	12	20	10	17	10	17	40	17
Solid cube	11	18	3	5	-	-	-	-	14	6
Fireball	16	25	15	25	2	3	3	5	36	15
Amorphous structures	7	12	7	12	3	5	9	15	26	11
Total	60	100	60	100	60	100	60	100	240	100

Table 2 reveals that 31% of secondary school students draw scientific shapes, 38% draw hollow or solid spherical structures, 15% draw fireballs, 11% draw amorphous structures, and 6% draw cubic structures. It is understood that as the grade level increases, they tend to draw scientific figures. On the other hand, it can be suggested that this tendency decreases as there is an increase in the grade level in which 25% of the 5th and 6th-grade students draw the atom as a fireball. Finally, 10% of the students in all grade levels describe the atom using amorphous (meaningless) drawings. The definitions of high school students about the concept of the atom and the findings regarding the shapes they draw are presented in Table 3 and Table 4.

Table 3. Findings regarding the definitions of high school students for the concept of the atom

Definitions/Grade Level	**9th-grade**		**10t-grade**		**11th-grade**		**12th-grade**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
The smallest unit of matter	34	57	23	38	17	29	19	31	93	39
The particle that chemically has all the properties of an element	18	30	5	8	23	38	13	21	59	24
Sphere with a nucleus made up of protons and neutrons around which electrons revolve	-	-	3	5	7	12	14	24	24	10
The round shape inside a matter			8	13	3	5	6	10	17	7
The smallest indivisible matter with energy at its centre	5	8	14	24	5	8	4	7	28	12
Matter used in making weapons that are too small to be seen	3	5	7	12	5	8	4	7	19	8
Total	60	100	60	100	60	100	60	100	240	100

Table 3 reveals that 39% of high school students make a scientific definition based on books, 24% make a scientific definition in their own words, and 47% make a wrong definition. It can be suggested that some students make definitions by using subatomic particles at a rate that varies in direct proportion to the grade level, although the students are wrong in this sense. On the other hand, it is understood that 20% of the students at this level of education tend to make definitions related to energy or weapons. Finally, it is observed that the students' use of subatomic particles in their own words to make correct scientific definitions and use of subatomic particles for a definition first occurs at this level of education.

Table 4. Findings regarding the shapes drawn by high school students for the concept of the atom

Shapes/Grade Level	**9th-grade**		**10th-grade**		**11th-grade**		**12th-grade**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
The atomic model with S Orbitals	9	15	7	12	12	20	21	36	49	21
The atomic model with S-P Orbitals	9	15	6	10	9	15	6	10	30	12
Interconnected spheres	-	-	5	8	-	-	6	10	11	4
Sphere full of charge	5	8	3	5	5	8	4	7	17	8
Sphere with dots inside	15	25	5	8	7	12	5	8	32	13

Hollow sphere	10	16	8	14	9	15	3	5	30	12
Solid sphere	4	7	9	15	8	13	3	5	24	10
Fireball	4	7	10	16	6	10	10	16	30	12
Amorphous structures	4	7	7	12	4	7	2	3	17	8
Total	60	100	60	100	60	100	60	100	240	100

Table 4 reveals that 25% of high school students draw the atom with scientific models, 43% with hollow, solid spheres, or spheres full of charge, 12% with a fireball, and 8% with amorphous structures. It can be suggested that the number of students who draw scientific models increases in direct proportion to the grade level, the number of students who draw spherical structures decreases inversely with the grade level, albeit at a low rate, and the number of students who draw fireballs and amorphous structures does not change with the grade level. Finally, it can be observed that the tendency to draw shapes by using charges (plus+, minus-) first occurred at this level of education. The definitions of the pre-service teachers regarding the concept of the atom and the findings about the shapes they drew are presented in Table 5 and Table 6.

Table 5. Findings regarding the definitions of pre-service teachers for the concept of the atom

Definitions/Grade Level	**Undergraduate 1**		**Undergraduate 2**		**Undergraduate 3**		**Undergraduate 4**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
The smallest unit of matter	35	58	40	67	26	44	28	47	129	54
The smallest unit of matter that has physical and chemical properties	1	2	2	3	8	13	2	3	13	6
A system with a nucleus made up of protons and neutrons, in which electrons revolve in their orbits	5	8	12	20	2	3	20	33	39	16
A system that operates with a centre (core) focus	3	5	-	-	3	5	-	-	6	2
The beginning of the formation phase of a matter	4	7	3	5	5	8	3	5	15	7
The core of the indivisible matter	7	12	-	-	16	27	7	12	30	12
Hard sphere with charges inside	5	8	3	5	-	-	-	-	8	3
Total	60	100	60	100	60	100	60	100	240	100

Table 5 reveals that 54% of the pre-service teachers make a scientific definition based on books, 24% of them make a scientific definition in their own words, and 22% of them make a wrong definition. On the other hand, for the first time in this teaching level, the students use the existence of neutrons to define the atom and tend to define the atom as a dynamic system. Considering the differences at the grade level, it is understood that the tendency to make scientific and accurate definitions increases in direct proportion to the grade level.

Table 6. Findings regarding the shapes drawn by the pre-service teachers for the concept of the atom

Shapes/Grade Level	**Undergraduate 1**		**Undergraduate 2**		**Undergraduate 3**		**Undergraduate 4**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**

The atomic model with S-P Orbitals	10	17	6	10	11	18	12	20	39	16
The atomic model with S Orbitals	19	32	30	50	25	41	9	28	91	37
Interconnected spheres	3	5	3	5	-	-	3	5	9	4
Solid sphere	16	26	13	22	9	16	11	18	49	21
Hollow sphere	11	18	8	13	4	7	7	12	30	12
Sphere full of charge	1	2	-	-	11	18	10	17	22	10
Total	60	100	60	100	60	100	60	100	240	100

Table 6 reveals that 47% of the pre-service teachers use scientific models and 43% use solid/hollow spheres or spheres with positive/negative charges to represent the atom. It is striking that as the grade level increases, the use of scientific models decreases and the tendency to represent the atom using a charged spherical structure increases. On the other hand, it is understood that unusual representations such as amorphous structures and fireballs are not observed at this level of education.

The findings regarding the metaphors created by the students for the concept of the atom according to the level of education are as follows.

Table 7. Findings regarding the secondary school students' metaphors for the concept of the atom

Metaphors/Grade Level	**5th-grade**		**6th-grade**		**7th-grade**		**8th-grade**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Planet (Sun, Earth)	2	3	4	7	5	8	5	8	16	6
Solar system					6	10	8	13	14	5
Cell	11	18	3	5	4	7	2	3	20	8
Black Spot	6	10	6	10	10	17	7	12	29	13
Soccer ball or marble	7	12	16	27	16	27	11	19	50	21
Daisy	3	5	3	5	2	3	2	3	10	5
Watermelon			3	5	8	13	10	17	21	9
Bomb	20	34	11	18			4	7	35	15
Meteor	6	10	5	8	3	5	5	8	19	7
Volcano			5	8	3	5	2	3	10	5
Stone or rock	5	8	4	7	3	5	4	7	16	6
Total	60	100	60	100	60	100	60	100	240	100

Table 7 reveals that considering this level of education, students make use of 11 different metaphorical concepts in total. It is understood that 11% of secondary school students liken the atom to the planet or solar system, 8% to the cell, 47% to soccer ball, marble, and black spot, 5% to daisy, 9% to watermelon, 27% to a dangerous structure such as a bomb, meteor, and volcano, and 6% to a stone or rock. As the grade level of the students increases, the planet model analogy for the atom increases, the soccer ball or black spot analogy is used by a significant portion of the students at every grade level, the analogy of a dangerous structure such as a bomb, meteor, and volcano and a cell is quite high in the low-level grades, and this figure decreases as the grade level increases. On the other hand, it is also understood that the analogy of daisy and watermelon increases in direct proportion to the grade level, and some of the students at each grade level liken the atom to structures such as stone and rock.

Table 8. Findings regarding high school students' metaphors for the "concept of atom”

Metaphors/Grade Level	**9th-grade**		**10th-grade**		**11th-grade**		**12th-grade**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**

Solar System	7	12	7	12	6	10	6	10	26	11
Saturn	6	10	-	-	10	17	7	12	23	10
Grape cake	5	8	7	12	5	8	4	7	21	9
Fruit (apple, watermelon)	6	10	5	8	3	5	5	8	19	7
Grit	11	18	10	16	9	15	12	20	42	18
Soccer ball or marble	14	23	17	29	10	17	16	27	57	24
Bomb	4	7	9	15	5	8	2	3	20	8
Meteor	7	12	5	8	12	20	8	13	32	13
Total	60	100	60	100	60	100	60	100	240	100

Table 8 reveals that the high school students make use of a total of 8 different metaphorical concepts for the atom. Accordingly, 11% of the students liken the atom to the solar system, 10% to Saturn, 7% to fruit, 9% to grape cake, 24% to soccer ball or marble, 8% to bomb, and 13% to meteor. In total, the students used metaphors associated with scientific models such as the solar system, Saturn, fruit, and grape cake by 37% without any increase or decrease based on the grade level. They also made use of metaphorical concepts that could not be associated with scientific models such as grit, soccer ball, bomb, and meteor by 63%. On the other hand, it is observed that at this level of education, 21% of the students liken the atom to structures that may pose a danger such as meteors or bombs.

Table 9. Findings regarding pre-service teachers' metaphors for the "concept of atom"

Metaphors/Grade Level	Undergraduate 1		Undergraduate 2		Undergraduate 3		Undergraduate 4		Total	
	f	%	f	%	f	%	f	%	f	%
Solar System	9	15	8	13	7	12	13	22	37	16
Universe	7	12	6	10	5	8	8	13	26	10
Saturn	4	7	2	3	4	7	3	5	13	5
Earth	9	15	6	10	5	8	-	-	20	8
Cell	5	8	9	15	7	12	7	12	28	12
Fruit (apple, pomegranate, watermelon, etc.)	3	5	10	17	6	10	10	17	29	13
Grape cake	4	7	2	3	11	18	-	-	17	7
Soccer ball or marble	11	18	10	17	11	18	11	18	43	18
Grit	8	13	7	12	4	7	8	13	27	11
Total	60	100	60	100	60	100	60	100	240	100

Table 9 reveals that the pre-service teachers use 9 different metaphorical concepts in total. Accordingly, 16% of them liken the atom to the solar system, 10% to the universe, 5% to Saturn, 8% to the earth, 12% to the cell, 13% to the fruit, 7% to grape cake, 18% to a soccer ball or marble, and 11% to grit. It is understood that the metaphors created by the pre-service teachers are mostly concepts that could be associated with scientific atomic models while concepts that may pose a danger such as meteors or bombs are not preferred.

Table 10 includes the findings regarding the scientific models in which the students' mental models for the concept of the atom are compatible based on the level of education. Since the mental model compatible with the quantum atom model could not be achieved, the relevant model was not included in the findings section.

Table 10. Findings on scientific models that are compatible with secondary school students' mental models for the concept of the atom

Scientific Atomic	5th-grade	6th-grade	7th-grade	8t-grade	Total

Models/Grade Level	**f**	%	**f**	%	**f**	%	**f**	%	**f**	%
Dalton Atomic Model	53	88	51	85	43	72	46	77	193	81
Thomson Atomic Model	3	5	6	10	6	10	5	8	20	8
Rutherford Atomic Model	3	5	-		6	10	5	8	14	6
Bohr Atomic Model	1	2	3	5	5	8	4	7	13	5
Modern Atomic Theory	-		-		-	-	-	-	-	-
Total	60	100	60	100	60	100	60	100	240	100

Table 10 reveals that the mental models of the secondary school students included in the sample for the concept of the atom are compatible with the Dalton Atom Model (81%), Thomson Atomic Model (8%), Rutherford Atomic Model (6%), and Bohr Atomic Model (5%) and that at this level of education, no mental models compatible with the Modern Atomic Theory are created. The findings for the grade level also reveal that 75% of the students in all grade levels have a mental model compatible with the Dalton Atomic Model, and as the grade level increases, so does the rate of students' atomic models that are compatible with more advanced scientific models. In this context, considering the historical development process of atomic models, it is observed that students' mental models are compatible with more advanced scientific models in direct proportion to their grade level and show a positive change.

Table 11. Findings on scientific models that are compatible with high school students' mental models for the concept of the atom

Scientific Atomic Models/Grade Level	**9th-grade**		**10th-grade**		**11th-grade**		**12th-grade**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Dalton Atomic Model	27	45	36	60	23	38	27	45	113	**47**
Thomson Atomic Model	11	18	12	20	19	32	10	16	52	**21**
Rutherford Atomic Model	16	27	8	13	11	18	13	22	48	**20**
Bohr Atomic Model	6	10	4	7	7	12	9	15	26	**10**
Modern Atomic Theory	-		-		-	-	1	2	1	1
Total	60	100	60	100	60	100	60	100	240	100

Table 11 reveals that the mental models of high school students for the concept of the atom are compatible with Dalton (47%), Thomson (21%), Rutherford (20%), Bohr (10%), and Modern Atomic Theory (1%). Grade-level-based findings also reveal that most of the mental models of 9th and 10th-grade students are compatible with the Dalton atomic model and that this rate decreases as the grade level increases while the rate of compatibility with more advanced atomic models increases. In addition, it is understood that mental models compatible with the modern atomic model are created among 12th-grade students, albeit at a low rate.

Table 12. Findings on scientific models that are compatible with pre-service teachers' mental models for the concept of the atom

Scientific Atomic Models/Grade Level	**Undergraduate 1**		**Undergraduate 2**		**Undergraduate 3**		**Undergraduate 4**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Dalton Atomic Model	20	33	20	33	9	15	14	23	63	26
Thomson Atomic Model	12	20	7	12	21	35	18	30	58	25
Rutherford Atomic Model	16	27	27	45	15	25	13	22	71	29
Bohr Atomic Model	11	18	5	8	15	25	15	25	46	19
Modern Atomic Theory	1	2	1	2	-	-	-	-	2	1

Total	60	100	60	100	60	100	60	100	240	100

Table 12 reveals that 26% of the pre-service teachers' mental models for the concept of the atom are compatible with Dalton, 25% with Thomson, 29% with Rutherford, 19% with Bohr, and 1% with the Modern Atomic Model. Grade-level –based findings also reveal that the mental models of the pre-service teachers increase in direct proportion to the grade level, and the compatibility with the modern atomic theory is at a very low rate only in the 1st and 2nd years of undergraduate education. Finally, it is understood that compatibility intensifies in decreasing proportions from the Dalton and Thomson models to the Rutherford and Bohr models.

Table 13 includes the findings of the Chi-square test performed to determine the statistical differentiation level of the scientific models that are compatible with scientific atomic models based on the level of education.

Table 13. Findings of the Chi-square test performed to determine the relationship between the student groups' levels of education and the compatibility of their mental models with scientific models

Type of School	Scientific Atomic Models						X^2	sd	p
	Dalton	**Thomson**	**Rutherford**	**Bohr**	**Modern**	**Total**			
Secondary School	%59,5	%11,7	%12,9	%16	0	%100	247,46	8	0.000
High School	%24,1	%22,2	%31,3	%21,3	%1,1	%100			
University	%11,9	%22,4	%38,4	%25,6	%1,8	%100			

$p<.05$

Table 13 reveals that 59.5% of secondary school students' mental models are compatible with Dalton, 11.7% with Thomson, 12.9% with Rutherford, and 16% with Bohr Atomic Model. Similarly, the mental models of high school students are observed to be compatible with Dalton (24.1%), Thomson (22.2%), Rutherford (31.3%), Bohr (21.3%), and the Modern Atomic Model (1.1%). Finally, the mental models of the pre-service teachers are observed to be compatible with Dalton (11.9%), Thomson (22.4%), Rutherford (38.4%), Bohr (25.6%), and the Modern Atomic Model (1.8%). Considering the level of significance [($X^2(8)=0,393$)], it can be argued that a significant difference emerges in terms of the compatibility of the students' mental models with the scientific models based on the level of education. In other words, a significant relationship emerges between students' levels of education and the compatibility of their mental models with scientific models.

The comparison of the findings with previous studies in the literature is presented below.

4. Discussion

Designed to unearth how the mental models and metaphors for the concept of the atoms created by students with similar sociodemographic characteristics have evolved throughout the teaching process from secondary school to the undergraduate level, this study reveals some significant findings.

The findings reveal that the majority of secondary school students misidentify the concept of the atom using their own sentences at the beginning of their education, and as the grade level increases, the rate of correct and book-based definitions increases. Similarly, a majority of the students initially define the atom as a dangerous object that carries energy, which is a tendency that declines in further stages of education (Table 1). Approximately 1/3 of the students make use of scientific shapes to describe the atom and the tendency to use scientific shapes increases depending on the grade level. While students initially liken an atom to a fireball, such tendency declines in further stages of education (Table 2). Some studies also reveal similar findings showing that the majority of students misidentify the atom, compare it to a bomb, and make epistemologically similar definitions to historical processes (Baji, & Haeusler, 2021; Muştu & Ucer, 2018; Özgür, 2007). The findings regarding the metaphorical approach of secondary school students to the concept of the atom indicate that they make use of 11 different metaphorical concepts including spherical structures such as soccer balls or marbles, black spots, planets or solar systems, dangerous structures such as bombs, meteors or volcanoes, and stones or rocks (Table 7). Alkan reports that the students of the level of education mainly draw upon the solar system as a metaphorical concept for the concept of the atom. Finally, most of the mental models created by the students for the concept of the atom are observed to be compatible with the Dalton Model and change partially toward Thomson, Rutherford, and Bohr Models, respectively, depending on the increase in the grade level while such models fail to be compatible with the Modern Atomic Theory (Table 10). Along the same lines, Çökelez & Yalçın reported some findings in this respect in a study conducted in 2012.

In this context, it could be argued that at the onset of the secondary education level, a mental model for the concept of the atom is not developed by some of the students, while the model developed by other students is compatible with the Dalton Atom Model contrary to expectations. Similarly, a vast majority of the students emotionally perceive the atom as a dangerous phenomenon that carries energy at the beginning and gradually experience a decline in such tendency.

The definitions made by high school students for the concept of the atom reveal that the rate of correct definitions increases considerably in direct proportion to the grade level and the students can make correct definitions using their own sentences and use subatomic particles for the first time at the secondary education level. On the other hand, a majority of the students wrongly define the atom with some of them defining it as a dangerous matter (Table 3).

The shapes drawn at this level of education demonstrate that although the rate of drawing scientific shapes increases at the secondary school level, a significant part of them draw non-scientific shapes with some of them drawing amorphous structures and shapes described as dangerous. As in the definition, it is striking that subatomic particles are used in the drawings for the first time at this level (Table 4).

Another finding is that high school students make use of 8 different metaphorical concepts for the concept of the atom, most of which could not be associated with scientific models, and that the use of metaphors such as bombs and meteors continues. On the other hand, more sympathetic concepts such as daisies are also preferred (Table 8). High school students are observed to develop mental models that are compatible with the Dalton Atomic Model at the beginning and compatibility with the Thomson and Rutherford Atomic Models increases as the grade level increases. Although compatibility with the Bohr Atomic Model increases at a limited level in direct proportion to the grade level, the development of a mental model compatible with the Modern Atomic Theory is quite limited (Table 11). Some studies report that high school students generally have a mental model compatible with the Bohr Atomic Model (Adbo & Taber, 2009; Kaya, 2018; Sarıdaş & Ünsal, 2020).

It could be argued that the atomic models of high school students are still at the level of the Dalton Model at the beginning with some students still perceiving the atom as a dangerous phenomenon emotionally. This tendency is observed to change positively in direct proportion to the grade level with mental models evolving into more advanced scientific models and mainly continues to be concentrated in Thomson and Rutherford Models while there is no evolution into modern and higher atomic models.

The findings regarding pre-service teachers reveal that a majority of them define the atom scientifically, based on books, and as a mobile system for the first time with misconceptions continuing at this level as well (Table 5). Derman et al (2019) reported that pre-service teachers make a great number of individual definitions. The shapes drawn indicate that a majority of the pre-service teachers draw shapes in harmony with scientific models and avoid extraordinary drawings such as amorphous structures and fireballs. On the other hand, highly charged spherical shapes are also drawn (Table 6). Bilir and Karaçam (2021) reported that pre-service teachers have a mental model compatible with the particle model. The findings indicate that the pre-service teachers used 9 different metaphorical concepts that are largely compatible with scientific models and unassociated with dangerous structures. Although the mental models of pre-service teachers for the concept of the atom are at a lower rate than high school students at the beginning of their undergraduate education, they are significantly compatible with the Dalton Model and evolve into the Bohr Atomic Model while a low-level evolution emerges for the Modern Atomic Model (Table 12). Allred & Bretz (2019) report similar findings while Akyol (2009) reports that the mental models of pre-service teachers are mostly compatible with the Rutherford Model. Along the same lines, Muştu (2021) reports that pre-service teachers are highly open to developing concept maps for the atom.

A majority of undergraduate students still have simple mental models at the beginning of education and continue to do so, albeit at a lower rate, however; the mental models could evolve to the Bohr Atom Model with negative affective approaches disappearing subsequently.

Finally, a significant relationship emerged between the level of education and the compatibility of students' mental models with scientific models (Table 13). Accordingly, it could be argued that the level of education significantly affects the mental models for the concept of the atom.

5. Conclusion

In summary, secondary school students develop mental models compatible with the Dalton Atomic Model, which is contrary to expectations and such tendency generally evolves to a construct compatible with the Bohr Atomic Model in further stages. Similarly, students generally begin to develop mental models for the concept with a structure such as a solid sphere or black spot by evolving into spheres containing spaces and charges at the high school level, while undergraduate students make use of mobile systems and charges moving in orbits independent of the nucleus. On the other hand, students perceive the atom as a dangerous phenomenon emotionally at the secondary school level and continue to do so, albeit at a diminishing pace, even until the end of high school level and such tendency ends at the undergraduate level. One may also notice that students have important misconceptions in their mental models of the atom at almost every level during their education in terms of conceptual and visual structures, and such misconceptions continue at the undergraduate level.

Finally, based on the findings the following recommendations are given for a huge contribution to the literature:

- Although the concept of the atom is taught to the students in accordance with the Modern Atomic Theory, an explanation should be provided for the reasons why their mental models begin to form in accordance with the Dalton Atomic Model.

- Researchers are recommended to unearth the reasons why students do not reach Modern and Quantum Atomic Theories during the teaching process.
- Researchers are recommended to reveal the reasons why students perceive atoms as dangerous emotionally at the beginning of the teaching process.
- Researchers are recommended to eliminate the misconceptions of pre-service teachers in undergraduate education and to design sample applications for the correct construction of the atomic concept and test the effects.

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