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Review

# Enhancing pre-K-12 student learning outcomes: The need for synergies of policy-makers, school administrators and parents

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**Building strong synergy among policy-makers, school administrators, teachers and parents in the execution of their roles is very important to improve student learning outcomes. It helps to lay a firm educational foundation for children from Pre-K-12 and facilitates life-long learning in order to assist learners to acquire knowledge, skills, values and attitudes that empower them to contribute to sustainable development. As a remedy to deteriorating student learning outcomes (exemplified in Liberia), this paper examines and discusses synergic alignment of education stakeholders' roles towards the primary goal of better learning outcomes for students from pre-primary through high school, focusing on the need for combined efforts. It highlights why synergic alignment matters in spite of their traditionally ascribed roles and pinpoints some challenges and benefits of building synergy among stakeholders. Finally, this article offers suggestions aimed at improving student performance, particularly in developing countries through collaborative partnership. It sees synergy in group roles as one of the most effective solutions to cultivating better student learning outcomes and condemns children's education as the sole responsibility of school workers (administrators and teachers). It was concluded that the survivability of social institutions and continuity of human existence hinges on synergy built to support children's learning.**

**Key words:** Pre-K students, learning outcomes, synergic alignment, education stakeholders.

## INTRODUCTION

Policy-makers, school administrators, teachers and parents are at the centre of Pre-K to 12<sup>th</sup> education. They are believed to be core stakeholders in the education

sector with collective responsibility for students' learning and development (Epstein and Sheldon, 2006). According to Jimenez and Sawada (1999), learners'

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educational outcomes are products of their interactions in the schooling process. Pre-primary through high school education is seen as the first necessary step to put children on the right path to becoming knowledgeable. It helps to make them become skilful individuals and ensure they fulfil their full potential in the future (Fasina, 2011). Particularly for early years, Hopkins et al. (2014) and Knaus (2015) observed it is key to children's success later in life. It is through high quality learning experiences at either home or pre-school setting the development of children can be boosted. Thus, it acts as 'protective' factors (Sylva et al., 2011). Experiences children encounter significantly contribute to economic development and growth (Sahlberg, 2006). Besides, it is associated with better cognitive skills in reading, mathematics and science (Pholphirul, 2017), and improvement in social skills (Nokali et al., 2010). But the contrary may have serious negative consequences on children (Moore et al., 2014).

Educators around the world are interested in better solutions to promote effective schools for improved learning outcomes (Jimenez and Sawada, 1999) as education systems, especially in sub-Saharan Africa are faced with vast challenges (Jones, 2016). For instance, as country emerging from a decade plus civil war, Liberia faces countless constraints including implementing its free and compulsory basic education policy (Waydon et al., 2016), covering grades 1-9. Consequently, raising the quality of education to facilitate student success is a matter of concern for education stakeholders (Singh et al., 2015; Jones, 2016; Adolffson and Alvunger, 2017). Stakeholders are interested in necessary ways that improve students' learning and development (Singh et al., 2015), amidst increased enrolment at various levels in view of global policy instruments to provide education opportunities for all (UNESCO, 2017).

As part of efforts to deal with poor learning outcome challenges (Nishimura et al., 2009; Jones, 2016; Waydon et al., 2016), particularly in Liberia, this review article looks at one aspect that blends all synergies toward the ultimate goal of better student learning results from Pre-K-12. It focuses on the need for combined efforts of policy-makers, school administrators, teachers and parents to facilitate the much desirable transformative education. Swartz and Triscari (2011) noted that collaborative partnership concentrates on the interplay of education stakeholders and all their many aspects. In fact, building synergy supports social constructivist approach to learning, emphasizing that social context of learning and the idea that knowledge is mutually built and constructed (Santrock, 2011). Santrock (2011) believe involvement with others creates opportunities for students to evaluate and refine their comprehension. This can be created both at home and school with stakeholders working together collaboratively.

There is a glaring need for concerted efforts to deal with various challenges facing the education sector

because through working hand in hand, individuals can harmonize for the good of the whole capabilities, thus providing various opportunities for student success (Andrews and Abawi, 2017). Andrews and Abawi (2017) noted that collaborative partnership helps to promote shared individual strengths, as well as build capacity in areas of challenge. However, how synergy of education stakeholders can be aligned and fostered has been sparsely considered in the literature; consequently, very strong sense of isolationism and individualism is still widespread (Mifsud, 2015; Silva et al., 2017). Exploring this aspect is critical and it cannot be over-stated in remedying the current situation of somehow poor learning outcomes of students. It is important because synergy among influential role groups can directly and indirectly result to academic and personal success (Epstein and Sheldon, 2006) and competitiveness can be stimulated and improved by fostering cooperation and interaction at three levels in education: schools, teachers and students (Sahlberg, 2006). According to Mifsud (2015), the main aims of collaboration include the sharing of professional expertise, the enrichment of learning opportunities for students and the breaking down of barriers between the schools and individuals.

Masino and Niño-Zarazúa (2016) identified bottom-up and top-down participatory and community management strategies, via decentralisation reforms, and with involvement of communities in the school system management as one of three best drivers to improve education quality and student learning in developing countries. The other two relate to supply-side elements of education systems, through the provision of additional material and human resources; and the supply-side and demand-side factors influence behaviors. However, this paper argues that the latter two proposed remedial drivers can be achieved through sturdy synergy among education stakeholders as their collective efforts can affect both supply and demand in education.

In line with its purpose, the remainder of this article focuses on the following. Firstly, it justifies why children's education is a shared responsibility and discusses traditionally ascribed roles of policy-makers, school administrators and parents. In addition, it highlights the need for the alignment of their synergies as well as pinpoints some challenges and benefits of synergic alignment aimed at enhancing student learning outcomes. Finally, suggestions geared towards improving student learning outcomes from Pre-K-12 through synergy among education stakeholders are proffered.

## **CHILDREN'S EDUCATION AS A SHARED RESPONSIBILITY**

There is a popular saying that it takes the whole village to raise a child. Though it may sound fascinating, it is practically true. One family can give birth to a child, but



the holistic growth and development of the child needs everyone in the environment that comes across him or her to influence the prospect of 'whom' the person becomes (Knaus, 2015). This is also reflected when one dissects the saying that no man or country is an island, stressing interdependence among individuals and countries (Gbolliè and Gong, 2013). It is widely recognized that there is strength in unity; hence, combined efforts with one collective purpose most often lead to achievement of a target goal, in this case, better learning outcomes for students.

Though it is highly required for all stakeholders in the education sector to work together to guarantee optimal improvement in students' performance (Hornby and Lafaele, 2011), many policymakers, community leaders, and even parents still consider schools and student learning as the singlehanded obligation of educators (Roekel, 2008). As a result, some shift blame on government for poor quality of education (Mashau et al., 2014), instead of joining hands to assist in promoting children's education.

Considering the fact that whatever happens in the education sector negatively or positively affects every aspect of the society in terms of sustainable growth and development, it is strongly argued that children's education must not be the sole responsibility of school workers (administrators and teachers), but a shared obligation for all education stakeholders to provide quality education (Mashau et al., 2014). The authors believe that collaboration of policy-makers, school administrators, teachers and parents is one of the best and most effective solutions to improving student learning outcomes, especially in developing countries. Roekel (2008) suggests that there is no appropriate partnership to assure all students from Pre-K through high school have support and resources they need to succeed in school and life than those from parents, families, educators and communities.

Collaboration is important because school-community engagements can serve many goals ranging from improving student achievement to community development (González and Jackson, 2013; Casto et al., 2016) and education stakeholders have a collective duty for students' learning and development (Epstein and Sheldon, 2006). Sergiovanni et al. (2011) intimated that local passions, beliefs, participation and support are critical to school effectiveness. Singh et al. (2015) found collaborative engagement as the most important predictor of management competency, whereas both individual and collaborative engagements were found to be significant predictors of indirect learning outcomes. On the other hand, Sam and Dahles (2017) asserted that limited collaboration among stakeholders has the tendency to impede educational advancement. Accordingly, Adams et al. (2009) advise that cooperative relationships between parents and schools are very vital and must not be left to exist by chance.

Parents are widely considered as children's first teachers because children begin learning where they live with their families, neighbours and other community members (Mogollón et al., 2011); therefore, parents need to continue as their involvement has impact on parenting knowledge and efficacy (Fasina, 2011; Popp and You, 2016). Bower and Griffin (2011) found parent involvement to be a successful strategy that assisted African American families in promoting their children's achievement. However, this critical role of parents is habitually forgotten, sometimes as a result of misconception that the school is responsible for what a child becomes educationally, which is somehow far from reality. It is maintained that policy-makers, school administrators, teachers, and parents are the nucleus of children's education and their combined efforts are imperative to bring about positive change in the lives of children educationally, in spite of perceived and anticipated roles.

### **SOME ASCRIBED ROLES OF POLICY-MAKERS, SCHOOL ADMINISTRATORS AND PARENTS**

Our increasingly globalized world has shown how much interconnected and interdependent we are. But at the same time, it has stratified and ascribed roles and responsibilities in various forms. The education sector is no exception. Even when one speaks of a school principal, teacher or student it is a portrayal of these roles. Notwithstanding with all of the diverse roles that exist in the education sector, there is one main goal, which entails assisting learners to acquire knowledge, skills, values and attitudes that empower them to contribute to sustainable development (UNESCO, 2017). Against this background, it is important to briefly highlight some prescribed roles before emphasizing their interplay to promote synergy and improved student learning outcomes.

#### **Policy-makers**

In the education sector, who makes policies and how they are made seem to be very critical. No doubt, it is crucial because it sets the tone and leads the way educational programs and services would be rendered. In many countries, when one speaks of policy formulation for the education sector, the Ministry of Education is brought in the limelight as this role is often enshrined in the Constitution or Education Law (New Education Reform Act, 2011). The MoE is to improve or cause improvement of the management and delivery of education efficiently with respect to process, policy and procedure (New Education Reform Act, 2011). Though, this mandate of policy-making is squarely laid in the hands of the MoE, there is always a need for other

stakeholders' participation to accomplish this role.

### **School administrators**

After policies are made at central level (MoE) and triggered down to county and district levels, the next layer is the school. According to Sergiovanni et al. (2011), school administrators' good deal of work entails the implementation of policies that have been developed and adopted. On the other hand, it is expected that the school administrator plays role as the main instructional leader working collaboratively with teachers and community to develop the culture and climate of the school in order to improve students' learning (Sergiovanni et al., 2011; Andrews and Abawi, 2016) as well as forging educational partnerships, which require assertive and effective leadership (Schroeder, 1999). At the same time, the school administrator is to provide mentorship, coaching and assistance to teachers to become highly skilled and effective in the performance of their duties.

### **Parents**

The root of students originates from the family (parents) who begin to teach children mostly in an informal way when they are born, assuming the role of children's first teachers (Mogollón et al., 2011). They normally decide, particularly for children set to enrol in pre-primary to lower basic school and underwrite the costs of school fees, uniforms, books and other necessities to enable them to go to school. This responsibility extends to ensuring that children's enrolment, retention and completion are not hindered. Additionally, parents ought to be involved fully in their children's learning, which relates to parenting and learning at home, and volunteering and parent-teacher communication, and supporting children's progress (Nokali et al., 2010; González and Jackson, 2013; Strier and Katz, 2016; Cetin and Taskin, 2016). Epstein's Framework on Involvement underscores that parenting, communicating, volunteering, learning at home, decision-making, and collaborating with the community are important roles of parents (Roekel, 2008; Cetin and Taskin, 2016), and visitations by members of the parent association made to classrooms (Jimenez and Sawada, 1999). Besides, Millennium Cohort Study's indicators related to parenting have shown a strong impact on factors such as children's development in the family environment, children's health, resilience and readiness for school (Owen and Anderson, 2017).

The involvement of parents is very essential for efficiency and quality of education and achievement (Nokali et al., 2010; Fasina, 2011; Center on Education Policy, 2012; Cassen et al., 2015; Cetin and Taskin, 2016), because it gives a clear picture of the school atmosphere and their involvement in school activities

helps to build strong bonds. In a meta-analysis of 52 studies, Jeynes (2007) found that parental involvement in school increases grades overall and in particular standardized test results. Nokali et al. (2010) concurred and stressed that accumulating evidence suggests that parenting practices are associated with higher academic success in the early grades.

### **WHY SYNERGIC ALIGNMENT MATTERS**

As highlighted, policy-makers, school administrators and parents do have some traditionally assigned roles in the education sector. Considering the fact that they share a common purpose, which incorporates ensuring better learning outcomes for students, the need for synergic alignment of their roles cannot be overstated as it is an appropriate education practice. Hence, consultation with key stakeholders during policy formulation and implementation is vital for the success of interventions in the sector (Nishimura et al., 2009; Casto et al., 2016). Kiddle Quarters argues that even teachers cannot be successful without parental cooperation and participation, noting that parents are an integral part of the classroom community (Santrock, 2011). Adam et al. (2009) contended that parents are not directly responsible for teaching, but their expectations and obligations cross into the teaching and learning environment. It is contended that when one group of the whole (policy-makers, school administrators, teachers, and parents) is ineffective, it affects the entire whole. For this reason, school administrators need to take part in policy-making because they would eventually lead the implementation, while parents should be concerned about school administrators' actions, which affect their children's learning; and policy-makers ought to be interested in happenings at both ends of the device. In short, they are tied to guarantee better learning outcomes for students.

Furthermore, to facilitate a more secured future for children and the society, it would be more meaningful to have each stakeholder fully participate in whatever is being planned and implemented in the education sector. Administrators, teachers and parents must be a part of policy-making and policy-makers must also be involved or concerned about what happens at school and in homes. This is an appreciation of diversity, an essential element in collaboration (Swartz and Triscari, 2011), which often fosters unity and leads to success in every aspect of human endeavour including children's learning. Synergy among group roles is meant to encourage stakeholders' collaboration to build a much stronger school system as understanding their interconnections is key (Hopkins et al., 2014). According to Lee et al. (2012), development of networks has a positive correlation with instruction and subsequent learning. In other words, the proposed synergic alignment aims to re-echo the glaring inevitability of collaboration and partnership among

education stakeholders because everyone has a stake in what is done at each end. More of how advantageous this concerted effort in group roles can impact children's learning would be discussed under the benefits of synergic alignment after we have highlighted some potential constraints.

### **SYNERGIC ALIGNMENT CHALLENGES**

Arguably, to achieve every worthwhile endeavour, there are always challenges. Hence, development of sustainable collaborative partnerships between different role players is not void of challenges (Schroeder, 1999; Nel et al., 2014; Silva et al., 2017), especially in the world where the pursuit for power and supremacy is obvious. Thus, the following challenges are identified and discussed based on the authors' experience in the sector.

#### **Presumed superiority and inferiority in roles**

Presuming that one group role is more important than the other is harmful for the unity of the whole. It is often a recipe for confusion and ineffectiveness. This can happen through dominant posture (Schroeder, 1999), and by not giving the fullest respect and recognition to a segment of the groups. Oftentimes, it is tempting for those in a certain group role like policy-makers to think of being superior, and considering others as inferior, thinking that other groups are meant to comply or be forced to do so. This is a form of dictatorship in education, which can lead to failure in policies and programs implementation. To avoid this, Schroeder (1999) suggested that forging effective partnerships to promote learning entails overcoming this tyranny of custom. It is, therefore, germane to foster collaboration, coordination and cooperation in every aspect of students' education, void of exercising one's perceived authority at the expense of others.

#### **Arbitrary policy formulation and decision-making**

As a show of exercising power and control, some policies and decisions are made without considering the inputs of other stakeholders in the sector. This is contrary to participatory and community management interventions, which entail bottom-up and top-down policies in policy development (Masino and Niño-Zarazúa, 2016). Rather, Masino and Niño-Zarazúa suggested that policy formulation must be done by diffusing knowledge among local communities, parent-teacher associations, and parent committees, raise awareness, and increase participation and involvement in the management of education systems. In contrast, arbitrary policy

formulation and decision-making in the education has prompted other stakeholders such as school administrators, teachers and parents to sometimes revolt, directly or indirectly against said policies and decisions through a non-compliant attitude. One of the ways this can be portrayed is by those who are perceived to have been neglected refusing to give their best towards achieving these arbitrary policies and decisions, thus undermining their true essence and implementation, leading to failure in the implementation of policies and programs in the education sector.

#### **Inconsistency and political interference in enforcement of policies**

It is often difficult to detach education from politics. Many educators have opined that the implementation of educational interventions should be left solely with educators. Advocates of this proposition believe that the interference of politicians in educational matters tends to dent the healthiness of the school system. Without probing into the pros and cons of the debate, it is argued that constant inference of political leaders in various affairs of the education system often undermines efforts to implement policies (Nishimura et al., 2009), which Hornby and Lafaele (2011) claim can limit parent involvement as well. This can lead to lack of credibility, mostly in MoE heads to execute their mandate as required. For instance, if school X in violation of a policy is sealed as a result of interference by a politician, it makes the work of the ministry more difficult as it would lack the moral rectitude to prosecute another school that violates such policy.

#### **Limited capacity of stakeholders**

In order to ensure effectiveness of schools, it is important for each group to be capacitated because limited resources and lack of administrative capacity can hamper policy implementation and school maintenance and performance (Nishimura et al., 2009). Further, Epstein and Sheldon (2006) observed that parents care about their children; nonetheless they need good and clear information from educators in order to remain involved in their children's education from preschool through high school. It is also critical for policy-makers and school administrators to have the much needed capacity including knowledge, skills, passion and resources required to bring about positive change in the school system.

#### **High illiteracy rate**

No doubt the high illiteracy rate among parents has

negative implication in students' learning outcomes. Roedel (2008) noticed that some parents feel uncomfortable to communicate with school officials due to language or their own past experiences with the school; while some uneducated ones may feel inferior (Hornby and Lafaele, 2011), which could be averted and confidence rekindled through collaborative partnership. Because one of the ascribed roles of parents entails guiding and assisting with their children's homework and other materials that may seem challenging to their children, if a parent is not literate it is more challenging for him/her to fully execute this role. Besides, some parents lack the necessary awareness that even though they are not educated, it is possible to provide some motivation to their children to learn more.

### **Disconnect between school teaching and home-based practices**

Reinforcement is an important construct in understanding and promoting learning whether it is positive or negative. It enables an increase or decrease in the probability that a behavior will occur (Santrock, 2011). Whether illiterate or not, parents can still execute this task by helping to stimulate learning environment at home (Center on Education Policy, 2012); and they possess skills and knowledge to transmit information to their children consciously or unconsciously (Mogollón et al., 2011). In fact, Feiler (2005) established the possibility of home-based practice influence on the school literacy curriculum. Especially, pre-schoolers and basic education students, a disconnect between what is taught at school and home-based practices must be consistent to avoid conflict in young learners' minds as to whom they should believe, teachers or parents? On the contrary, students may face the recurrent daily problems of adjusting between the worlds of home and school (Wrigley, 2014). Undoubtedly, learning sometimes becomes much more confusing if such divide exists, thus making it more abstract and futile as children do more of what they see others do in comparison with what they hear others say. It is argued that one of the contributing factors for young learners underperform is because of this harmful divide, which could be lessened through collaboration.

### **Low engagements**

Synergic alignment of group roles requires collaboration. Parent-teacher associations (PTAs) are often established, some by default and everyone who has a child in a given school is an automatic member, in supportive of partnership. However, most PTAs are dormant and ineffective. This is not, however, to insinuate that there are no effective PTAs, but it is a wakeup call due to strong need for increased collaboration among

education stakeholders because low participation of parents seems to create mistrust and poor relationships in schools, especially between teachers and the community (Nishimura et al., 2009). Cetin and Taskin (2016) suggest that in order to intensify the involvement of parents in education, there is a need for functional guidance services at schools, and these coordinated services can be beneficial to schools and communities (Casto et al., 2016). This helps to strengthen parents' confidence and participation in school activities as it is essential to build relationship with parents in a purposeful and planned manner (Adams et al., 2009).

### **High poverty rate**

McKinney (2014) pointed out that child poverty is a global issue that negatively impacts around half of the world's children and it is tied to poverty their parents and families experience. According to Wrigley (2014), it has adverse impacts not only on health and nutrition, but also on social development and self-esteem. Many countries, specifically sub-Sahara Africa including Liberia, are among the poorest countries in the world, defined as less than \$USD1.25 per day (BTI, 2016), making poverty to remain a considerable socioeconomic issue for Liberia (Liberia Ministry of Education, 2016). As a consequence, it seems challenging for many parents to fulfil their various duties of educating children properly as they have to struggle to make ends meet. Unfortunately, some school going children are constrained to join parents to fend for daily bread (Gbolle and Keamu, 2017), contrary to the advice to keep children free from economic activity (Wrigley, 2016), because it is gradually becoming an obstacle to children accessing education (McKinney, 2014). On the other hand, evidence has revealed that socio-economic status of parents and other characteristics plays an important role in promoting quality education and better learning outcomes for students (Fasina, 2011; Center on Education Policy, 2012; Cetin and Taskin, 2016; Pholphirul, 2017).

### **Low budgetary support for education**

One of the biggest challenges confronting the education sector is inadequate financial support. Compared with other sub-Saharan African countries, Liberia remains on the lower end relative to the allocation of government resources to the education sector (Liberia Ministry of Education, 2016). According to the MoE, it is operating on a fragile budget with 94% of funding allocated to the ministry used for compensating employees in 2014/2015 budget. Practically, this means funding for operations and programs is very little and it is plausibly impossible to undertake tangible interventions to revamp schools. As a result, many schools operate under difficult circumstances ranging from poor learning facilities to unqualified teachers. To change the trend requires more practical and

action-oriented financial and moral support from government to resuscitate the sector (Gbollie and Keamu, 2017; Pholphirul, 2017).

## **BENEFITS OF SYNERGIC ALIGNMENT**

The synergic collaboration of policy-makers, school administrators and parents has numerous benefits for the education of Pre-K-12 students including the following.

### **Strong bonds and unity**

As it is often said 'in union strong, success is sure', diverse roles of policy-makers, school administrators, teachers and parents must be viewed as a great necessity and an urge for building strong bonds for better collaboration and partnership. In a research-based framework for organizational alignment, Andrews and Abawi (2017) reported the LRI team suggested cohesive communities as part of alignment process. It is the various contributions and expertise that are brought on board that help to create better schools and in return result to better learning outcomes for students. This can only be done through the effective and functional execution of roles from each group void of strife for supremacy and control.

### **Success in policy and program implementation**

When policy-makers, school administrators, teachers and parents hold together or work collaboratively, much can be achieved by learners. In view of this, Iddings (2009) warned educators to no longer neglect to attend to the wealth of resources that families bring to schools, but rather utilize them to the fullest. This needs to start from the inception of every major activity or decision that has the tendency to positively or negatively affect the school system through group role representation. It is highly vital to ensure each stakeholder group is in the know or indirectly participates before policies are formulated and disseminated for implementation. This would prevent any form of non-compliance posture from a particular group. One obvious evidence is the apparent non-compliance posture by some schools to the Liberian government's policy on WAEC results before 12<sup>th</sup> graders' graduation. In a united front, this could have been avoided even with a simple resistance from parents not to comply with school authorities' request to pay graduation fees in contravention with government/MoE's regulation.

### **School/children education ownership**

Unarguably, the school is the light of the community,

country and the world in general and one of the most important needs of the community as it educates its citizens (Carpenter, 2006), serving as a significant contributor to how well children develop (Feiler, 2005; Hopkins et al., 2014). Accordingly, education is widely considered a pathway out of poverty (Sarvi et al., 2015), because it equips individuals to act in complex circumstances in a sustainable manner, which may need them to strike out in new directions; and to partake in socio-political processes, moving their societies towards sustainable development (UNESCO (2017)). Thus, every individual has a stake and is affected by what happens to children at school and outside the school environment (home). Therefore, stakeholders, especially policy-makers, school administrators, teachers and parents need to take full ownership of children's education. In other words, no group of individuals must think that the other is more responsible and should be held solely accountable for better student learning outcomes. Rather, each must see it befitting to take total ownership of every child's learning as their own to edification.

### **Education becomes enjoyable and fun for children**

Teaching and learning to read and write can be fun, natural and meaningful through collaboration of stakeholders (Mogollón et al., 2011). The synergic alignment of policy-makers, school administrators, teachers and parents can help to make education more enjoyable, impacting and fun for children because they would be able to experience goodness at every point of the educational ladder (at school and home). This can be achieved by education stakeholders rallying efforts to address various challenges of students, especially at school. Mogollón et al. (2011) remind school authorities to respond to the interests and expectations of children's families, who the authors think are often forgotten as it has proven to be a successful strategy (Bower and Griffin, 2011)

### **Improved student learning outcomes**

Literature on this subject has revealed that collaborative involvement of stakeholders leads to better academic performance of students (Epstein and Sheldon, 2006; Nokali et al., 2010; Bower and Griffin, 2011; Sergiovanni et al., 2011; Andrews and Abawi, 2017). When schools, parents, families, and communities work collaboratively to support learning, students tend to earn higher grades, attend school more regularly, stay in school longer, and enrol in higher level program (Roekel, 2008) as well as receive better results in other areas including language literacy (Iddings, 2009). This is because children need complementary support from policy-makers, school administrators, teachers and parents to thrive in their

academics.

### **Win-win benefits**

As mentioned earlier, it takes the whole village to raise a child; hence this applies to educating children to become productive future leaders they ought to be. In view of this, when a child succeeds educationally, gets out of poverty and contributes to a better world, everybody (policy-makers, school administrators, teachers and parents) benefits. This is because the good of each child is not only the good of the family, but the entire society evident by a onetime child, but now grown up adult's impact on the international stage; a discovery from such person could even change the face of the world. This signifies how beneficial collaborative partnership is and the returns thereof. Therefore, kudos must be given to all for students' success as a result of concerted efforts.

### **SUGGESTIONS FOR STRENGTHENING EDUCATION STAKEHOLDERS' SYNERGIES**

It has been clearly articulated from the literature why synergic efforts of education stakeholders matter in spite of some challenges. Moving forward, it is essential to proffer some suggestions geared towards enhancing this all-important inevitability.

#### **Recognizing urgent need for collective efforts to educate children**

The changing world calls for increased collaboration and partnership among policy-makers, school administrators, teachers and parents because they are crucial for the school, students and teachers (Silva et al., 2017). Thus, the importance of recognizing that it is only through concerted efforts that the goal of educating children holistically for future tasks can be fully met cannot be overstressed; it is a sine qua non. This means working together supportively during the planning, implementation, monitoring, evaluation and feedback stages for each intervention must incorporate every group's inputs. In a nutshell, there must be total involvement of all at every step of the way. No group should sit back and watch or be denied the opportunity to get involved. It is therefore advised that MoE takes the lead in ensuring this 'everyone has a stake' phenomenon in the Liberian education system is guaranteed and nurtured.

#### **Strengthening parent-teacher-associations**

Parents' organizations can make crucial decisions for the school (Mogollón et al., 2011). The idea of having PTA in

each school is highly welcoming, but many PTAs ineffectiveness has weakened its real intent. PTAs must be a strong vehicle to support synergic alignment of stakeholders as it comprises of school administrators, teachers, and parents. According to Barton (2003), Child Trends Data Bank reports that students whose parents are involved in their school tend to have fewer behavioral problems and better academic performance, whether their parents are living with them or not. MoE must be actively involved through education officers for the smooth operation of PTAs. Additionally, the division at the Ministry that has oversight on PTAs must be capacitated and empowered to be more robust in working with PTAs to make them more effective and efficient.

#### **Joint monitoring and evaluation (M&E) exercises**

In a study in the Philippines, Tan et al. (1999) demonstrated the feasibility of monitoring and evaluating interventions in the education sector. Additionally, Nishimura et al. (2009) proposed the need for an effective system of monitoring and tightening accountability to ensure the success of universal education policy. As part of building bonds and confidence, it is necessary for stakeholders' assessments of schools in order derive, plan and implement programs (Kuru and Taskin, 2016). Additionally, Popp and You (2016) found that family involvement in service planning was significantly and positively correlated with their satisfaction. Collaborative initiatives are crucial to creating an enabling learning environment of trust and supportive relationships as families feel valued and respected in the process (Adams et al., 2009; Popp and You, 2016), which can help move individuals from being independent agents to dependent partners. According to Jimenez and Sawada (1999), similarly-strategy was crucial for improving students' achievement in El Salvador's EDUCO Program. In the study, the authors found that enhanced community and parental involvement in EDUCO schools improved students' language skills and diminished student absences, which may have long-term effects on achievement.

#### **Using research evidence to enhance synergic collaboration**

Roekel (2008) stresses that research helps to determine educators and families' needs, interests, and ideas about partnering. Evidence from systematic research can go a long way in improving collaboration and student learning outcomes when pieces of evidence thereof are applied in practical situations. Similar suggestion was offered by Gbolliie and Keamu (2017), noting that interventions in the education sector must be backed by empirical evidence to enhance possibilities of programs success.

Gbollie and Keamu believe evidence-based interventions are more effective and efficient as they are backed by facts, rather than mere intuitions. Moving forward, enhancing collaboration among policy-makers, school administrators and parents need more research to deal with challenges. This would help to curtail the countless number of pilot projects, many of which failed because they are not evidence driven, and are, therefore not sustainable.

### **Vigorous national awareness and sensitization campaigns**

To promote intense collaboration, particularly with parents, there is a need for vigorous nation-wide campaigns focusing on the importance and benefits of education, parenting styles, helping children to learn, individual and collective roles and actions, school programs, policies, and loyalty and commitment to quality education by all. The message of educating a child as 'everyone's business' must be preached and practiced at all layers of the country, using different means including jingles, flyers, bill-boards, town hall and religious meetings, dramas, music, radio/TV programs, among others. This would help to curb the considerably low attention being given to children's learning and strengthen parent involvement, thus limiting the disconnect between happenings at school and home. Roekel (2008) suggests the development of outreach strategy as one of the ways to boost parent involvement. Cassen et al. (2015) agree that parents only need to know what they need to do to assist in their children's learning. Even if they do not have requisite formal education, Center on Education Policy (2012) asserts that they can still play pivotal role in their children's learning through positive reinforcements.

### **Aligning education funding with priorities and cost effective programs**

It is prudent to certify that the already scarce resources are aligned with priorities and programs that have proven to be reliable, cost effective and sustainable to tackle the challenge of maintaining both access to and quality of education (Nishimura et al., 2009). Tan et al. (1999) found partnerships with parents to be a contributing factor to cost effectiveness. With innumerable needs in the sector, ensuring the value for money and parents' physical, moral and material contributions could ease burden on projects implementation as parents bring a wealth of resources to the school (Iddings, 2009). Further, producing furniture at a close proximity of the school rather than at the capital city to avoid huge transportation costs and other issues should be carried out as well as ensuring decentralized, equipped and accountable leaderships, some which can be used to

empower parents.

### **Motivation mechanism for high performing stakeholders**

Motivation plays a key role in stimulating and consolidating performance. Thus, it is suggested that there should be annual public recognition of high performing stakeholders (policy makers, school administrators, teachers and parents) to strengthen commitment and foster competition in getting the best in the school system. For example, identifying and awesomely rewarding best (highly performing) school administrators, teachers and parents (like best PTA or parent) would stimulate others to work harder and remain committed to building and maintenance of quality learning institutions.

### **Enabling political will**

To ensure tangible gains in the education sector, national government has a pivotal role to play. For instance, Colombia's national voucher program is a clear demonstration that a central government can effectively mobilize local government resources and private providers to alleviate constraints to public provision of education (King et al., 1999). Further, government interventions in socially disadvantaged schools in the UK have offered good examples for success (McKinney, 2014). Governments must, therefore, demonstrate fervent political will through budgetary allocation as well as instituting radical and practical steps to promote quality education. This must be void of mere pronouncements, but rather taking action oriented dispositions, such as ensuring that the Ministry of Education's budget graduates from salary-based to program-based, non-interference, and upholding other signed international protocols.

## **CONCLUSION**

For any country to move forward, it requires a solid educational foundation for children from Pre-K-12. As countries, especially those in the development process, strive to reform their education systems, building strong synergy among policy-makers, school administrators, teachers and parents in the execution of their roles is very important to improve student learning outcomes. As Coleman (2011) rightly puts it, collaborative working is an unavoidable feature of the 21st-century school. In this article, the vital nature of education stakeholders' collaboration is demonstrated in order to improve student learning outcomes, by providing an enabling and friendly learning environment at home and school, which can lead

to academic and personal success (Epstein and Sheldon, 2006). Based on available literature, we have emphasized why synergic alignment matters and argued that robust synergy among education stakeholders is one of the best and most effective solutions to cultivating student learning outcomes, particularly in developing nations, and Liberia in particular. The paper objected the consideration of children's education as the sole responsibility of school workers (administrators and teachers), while affirming that deeper co-operation and open sharing of ideas at all levels in education helps to strengthen economic competitiveness (Sahberg, 2006). It is suggested that stakeholders will appreciate the diversity of the partners as critical, valuing the relationship as subject and emergent object, requiring physical presence, and bringing confidence and curiosity in a spirit of openness (Swartz and Triscari, 2011) in collaborative partnerships in education.

Further, some conventionally ascribed roles of policy-makers, school administrators and parents were reviewed and highlighted, and the interplay among them and why building synergy matters was underscored. Besides, it identified challenges and benefits of synergic alignment as well as advanced series of suggestions to foster synergic collaboration among education stakeholders. Future efforts at strengthening synergy among education stakeholders should focus on constructing model to harness potential areas of collaboration. Besides, a study that empirically investigates challenges, benefits and feasibility of suggestions offered to improve student learning outcomes is recommended. In a nutshell, Pre-K-12 education of children is unequivocally beneficial both to learners and nations in order to promote sustainable growth and development and poverty alleviation (Gbolle and David, 2014; Sarvi et al., 2015; UNESCO, 2017); hence it must be collaboratively supported by all education stakeholders as the survivability of social institutions and continuity of human existence hinged it.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Full Length Research Paper*

# Anthropological analysis of content knowledge of pre-service elementary mathematics teachers' on graphs

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The purpose of this study is to analyse the content knowledge on graphs of pre-service elementary mathematics teachers from an anthropological perspective. 112 pre-service elementary mathematics teachers participated in the study. Concentric mixed pattern research method has been used in the study. The data was collected through Graphic Content Knowledge Scale and interview method in order to examine the content knowledge of primary school math teacher candidates related to graphics anthropologically. This scale which was developed within the frame of determined institutional recognitions includes graphic concept and its usage conditions, graphic types and different display forms, making proper transformations between graphics related to a given context, graphic reading, graphic interpreting and graphic drawing skills. In addition, for the purpose of having a more detailed review of the individual recognitions of the 10 participants, a semi-structured interview scale has been developed and used during the interviews. Data acquired have been analysed by using ecologic and praxiologic approach suggested within the framework of Anthropological Theory of the Didactic. The knowledge scale and interview data have been subjected to content analysis and descriptive analysis to interpret the individual recognitions of the pre-service teachers within the scope of institutional recognitions. As a result, it has been observed that the individual recognitions of pre-service teachers related to column, circle and line graphs conform to the institutional recognitions, however in institutional recognitions the techniques specified for column graphs are being used for histogram, hence they have difficulties in comprehending the differences between histogram and column graph. It has also been concluded that they were not aware of a theory based on graph knowledge.

**Key words:** Anthropological theory of the didactic, ecological approach, graphic knowledge, mathematical content knowledge, praxiologic approach, preservice teachers.

## INTRODUCTION

Doing mathematics is not only restricted to knowing mathematical concepts, but also the skills of using

concepts and the relations between these concepts in daily life and other disciplines (MoNE, 2013). In this

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direction, when individuals doing mathematics encounter a problem, they reach to a conclusion by using cognitive skills such as classification, reasoning, argument in order to solve the problem and they express these conclusions with various representation forms in mathematics. Representation forms ensure significant mathematical concepts to be comprehended and abstracted (McArthur et al., 1988; National Council of Teachers of Mathematics (NCTM), 2000). Graphics which is a part of the mathematical language is one of this representation forms.

Graphics which has various applications in discipline of mathematics and various discipline fields play a significant role in conceptual understanding by developing problem solving, relating between variables, comparing variables and predicting according to data (Cai and Lester, 2005; Duval, 1999; Friel et al., 2001; Schultz and Waters, 2000; Winn, 1991) while transferring the information to the reader by visualising it simply and essentially (Hiebert and Carpenter, 1992; Roth and Bowen, 2003). Graphics which interpret the information by concreting the abstract thoughts with visual elements (Altun, 2006), is among the essential concepts which is commonly used in reading, science and mathematics literacy (Long, 2000). The usage of graphics in various fields of daily life such as health and economy which concerns society requires the raising of conscious individuals who can comprehend graphics at a basic level.

Even though the graphics have an important role in mathematical thinking; in the conducted studies, it was determined that important problems are experienced in the understanding and usage of graphics in teaching process and students in different levels have various mistakes and concept errors in reading, interpreting and forming graphics (Bayazit, 2011; Bruno and Espinel, 2009; Capraro et al., 2005; Cavanagh and Mitchelmore, 2000; Clement, 1985; Çelik and Sağlam Arslan, 2012; Egin, 2010; Hotmanoğlu, 2014; Kramarski, 2004; Leinhart et al., 1990; Özçelik and Tekman, 2012; Roth and Bowen, 2001; Tortop, 2011; Turhan, 2015). This situation reveals the truth of there being differences between the knowledge which will be taught about graphic knowledge and the knowledge which student learned. It is stated that prior knowledge of students, their experiences (Dunham and Osborne, 1991), their knowledge about the content of the data in the graphic (Roth and Bowen, 2001), teaching activities performed within the class and basic characteristics of graphic knowledge are effective in the occurring of these problems experienced about the learning of graphic concept (Curcio, 1987; Leinhart et al., 1990; Shah and Hoeffner, 2002). These factors which Brousseau (2002) explained with the concept of obstacle are defined as ontogenetic (progress level of the learner not being sufficient), didactic (teacher originated) and epistemological (originated from knowledge learned) obstacles.

One of the important factors in eliminating the problems encountered in the learning of graphic which is a basic subject and representation form in so many fields, mathematics discipline being in the first place, from statistics to social sciences is the knowledge of the teacher who organises the didactic environments and conducts the teaching. The knowledge required by the teacher in the teaching process has been the subject of teacher education studies and it was emphasized that teacher must have pedagogical content knowledge in order to carry out an effective teaching process. (An et al., 2004; Ball et al., 2008; Fennema and Frankel, 1992; Park and Oliver, 2008; Shulman, 1986). Pedagogical content knowledge which is identified as “content knowledge necessary for teaching” requires a deep content knowledge along with the pedagogy knowledge (Shulman, 1986). A teacher whose subject content knowledge is at an adequate level, due to having a holistic view related to the subject, enhances the learning-teaching activities (Cohen et al., 1993) and accordingly increases the student achievement (Ball et al., 2008; Hill et al., 2005). But if the teacher has an incorrect or erroneous knowledge about the content of the knowledge to be taught; then the knowledge which s/he transfers to the student may become an incorrect knowledge which is not valid scientifically (Käpylä et al., 2009).

In this direction, the knowledge of the teacher related to the subject which s/he will transfer to students being compatible with the related discipline has a great importance. The content knowledge is required to be evaluated with a model which analyses in terms of both scientific theories and implementation within the frame of the institution it is included. In this context, this study examines the content knowledge which the pre-service teachers must have within the frame of Anthropological Theory of the Didactic (ATD) which studies on knowledge structure, function and its various usages.

### **The Anthropological Theory of the Didactics**

The body of knowledge has been analyzed in detail in the framework Theory of Didactic Transposition from the French perspective. According to Chevallard (1991), who introduced the theory of transposition, the knowledge transformed from scholarly knowledge via knowledge to be taught and the actual knowledge taught to learnt knowledge. The first step of transformation, the external didactic transposition, takes place in the noosphere (Bergsten et al., 2010) and the scholarly knowledge becomes information to be taught in which curriculum, textbook, etc. play a role in teaching the information to be taught. The second step of transposition, the internal didactic transformation, the transition between the knowledge taught and the knowledge learned. Chevallard (1991) distinguishes the types of teachable information

that live in an institution as knowledge in use and practical knowledge. The Anthropological Theory of the Didactics, which gives an opportunity to make an observable analysis of the transformed body of knowledge in the direction of this division, has emerged as a result of Theory of Didactic Transposition.

In anthropological theory which the knowledge can be evaluated based on actions (Chevallard, 1991), the knowledge structure which individuals have is approached within the frame of institutional recognitions determined by ecological and praxeological approaches based on the conditions of the institution it is in. The institutional recognition of the graphic knowledge within the scope of the study was determined through the examination of the documents used as source in the institution establishment of Elementary School Mathematics Special Teaching Methods by Akar and Dikkartin Övez (2018). Within the frame of determined institutional recognitions, the places (habitat) and functions (niche) of graphics were found out with ecological approach, task types with praxeological approach (T) and also technique which is the actualisation form of task types ( $\tau$ ), technology which explains why the technic is valid ( $\theta$ ) and theories which explain and assert technology scientifically are found out (Chevallard et al., 2015). Within the direction of ecological approach, it was determined in the related institution that graphics are used in the position of tool, goal and both tool and goal in the learning and teaching of the subjects of ratio and proportion, percentage, slope, equations and inequations, equation systems, function, statistics and probability which take place in the learning fields of numbers and operations, algebra and data processing; in mathematical literacy, problem-solving, communication association and development of psychomotor skills.

Within the frame of praxeological approach, it was concluded that there were three mathematical organisations as graphic reading and interpreting (MO1), graphic creation (MO2) and making appropriate conversions between graphics (MO3); including 11 task types related to bar graph, pie chart, line graph and histogram. In the mathematical organization of graphic reading and interpreting; the technique of calculating the height of bars ( $\tau_2$ ) for the task of obtaining information from bar graph (T1); making proportional calculations using the central angle or percentage for the surface area of the pie slice ( $\tau_2$ ) for the task of obtaining information from pie chart (T2); determining the value of the relevant point on the line regarding the vertical or horizontal axis ( $\tau_3$ ) for the task of obtaining information from line graph (T3) and calculating the height and width of bars ( $\tau_4$ ) for the task of obtaining information from histogram (T4). It was ascertained that the technology which explains these techniques ( $\theta_1$ ) is the comprehension of graphic displays including cognitive skills of external recognition, internal recognition and perception of correspondence (Bertin, 1967) and Pinker (1990) explains and asserts the

determined technology with Theory of Graphs Comprehension ( $\theta_1$ ).

In the organization of graphic creating, it is concluded that there are tasks of creating bar graph, pie chart, line graph and histogram, in order to fulfill these task types; it is used as the techniques of drawing rectangles at the heights equal to the frequency of the data groups ( $\tau_5$ ), using technology ( $\tau_6$ ), slicing the pie graph using central angles or percentages in proportion to the frequency of the data groups ( $\tau_7$ ), connecting the consecutive points that represent the data ( $\tau_8$ ) and showing the data groups at certain intervals and with adjacent rectangles ( $\tau_9$ ) to fulfill these tasks; descriptions and appropriate uses of graphics ( $\theta_2$ ) constitute the technology by explaining these techniques; and Basic Perceptual Tasks Theory ( $\theta_2$ ), constructional components of graphics ( $\theta_3$ ), common standards ( $\theta_4$ ) and NCTM standards ( $\theta_5$ ) explain and ascertain this technology. As for making appropriate conversions between graphics; it was seen that the technique of creating a pie chart upon the required angle, area percentage and proportion calculations ( $\tau_{10}$ ) or the technique of create a line graph by determining the points that represent the data on the axes and consecutively connecting these points to each other ( $\tau_{11}$ ) is used for the task of conversion of bar graphs into other graphs appropriate for the data (T9); the technique of drawing bars at the height equal to the frequency of these data groups ( $\tau_{12}$ ) or ( $\tau_{11}$ ) technique is used for the task of conversion line graphs into other graphs appropriate for the data (T10) and ( $\tau_{10}$ ) or ( $\tau_{12}$ ) technique is used for the task of conversion line graphs into other graphs appropriate for the data (T11). The organizations of graphic creating and making appropriate conversions between graphics are local organizations which have the same technology and theory.

Universities which carries out the pre-service education activities doubtlessly perform the biggest duty in the gaining of professional competence of teachers who affect the raising of forthcoming generations directly. Within the teacher education programme, a pre-service mathematics teacher must have deep, correct and important mathematical knowledge with regard to content knowledge from the institution s/he is educated and s/he must apply this knowledge in teaching environments (NCTM, 2007; Niess et al., 2009; Otero et al., 2018). In this respect, it is required to examine the content knowledge of pre-service teachers before going into profession and the deficiencies and mistakes emerging as a result of these examinations should be eliminated. This study aimed to examine the graphic content knowledge of pre-service elementary mathematics teachers anthropologically. In the direction of the objective of the study, the answers to the below questions were searched;

1) How is the content knowledge of pre-service elementary mathematics teachers related to graphics?

2) What extent does the content knowledge of pre-service elementary mathematics teachers related to graphics coincides with the institutional recognitions?

## METHODS

### Research model

The model of this study which is aimed to examine the content knowledge of pre-service elementary mathematics teachers related to graphics anthropologically was determined as exploratory consecutive design which is among mixed research designs. In exploratory design, qualitative research follows quantitative research and explains the relations and tendencies inside quantitative data (Clark and Creswell, 2014). Survey model was used in the quantitative aspect of the study. Survey model is a research approach which aims to put forth a situation in the form it exists (Karasar, 2011). And interview was made in the qualitative aspect of the research.

### Study group

112 (91 female, 21 male) pre-service teachers who study at the Elementary Mathematics Teaching Programme of a midsize public university in Marmara region in 2016-2017 academic year constitute the study group of the research. These pre-service teachers are assigned through proper sampling method which ensures the process to be faster and more practical by minimising the time, labor and cost loss. Objective sampling is defined as a probabilistic and non-random method. Also, it is seen as an ideal method in-depth research (Creswell and Clark, 2011). Besides, due to aiming the examination of content knowledge of the pre-service teachers participating in the research related to graphics in detail, interview was made with 10 volunteer pre-service teacher (7 female, 3 male) in the study group which quantitative data was collected from.

### Data collection tools and the collection of data

The data was collected through Graphic Content Knowledge Scale (GCKS) and interview method in order to examine the content knowledge of pre-service elementary mathematics teachers on graph anthropologically. This scale which was developed within the frame of determined institutional recognitions by Akar and Dikkartın Övez (2018) includes graphic concept and its usage conditions, graphic types and different display forms, making appropriate conversions between graphics related to a given context, graphic reading, graphic interpreting and graphic creating skills. For the content validity of scale, the opinions of an expert group consisting of three academic members who are experts in the field of mathematics teaching and 4 elementary mathematics teachers were received. In the direction of expert opinions, Content Validity Proportion (CVP) was found for each item and Content Validity Indexes (CVI) was calculated by averaging these CVP values (Lawshe, 1975). In the result of the calculations, the CVI value of the scale was found as 0.87. The 9-item scale was applied to 30 different pre-service teachers from the study group. According to the pilot study, required arrangements were made in scale items with regards to incoherency and grammar mistakes. As a result, GCKS which includes 1 question aiming to measure the knowledge of pre-service teachers with respect to habitat and ecological niche of graphic concept, 6 questions aiming to measure the skills of graphic reading, interpreting, creating and conversion and 2

questions aiming to measure the theoretical knowledge in the graphic subject. Developed GCKS (Appendix) was implemented to 112 pre-service elementary mathematics teachers by considering the answer period in the pilot study. Finally, semi-constructed interview technique was used in order to examine content knowledge of the pre-service teachers related to graphics in detail. Within the content of interview form which was developed to be used in interviews, it was given place to graphic concept, graphic types, the relation between features of data and graphic, basic graphical skills and principles and theories used about graphics. The CVI value of the form consisting of 12 questions was calculated as 0.97. Developed interview form was used in semi-structured interviews lasting approximately 30 min with 10 pre-service teachers. The researcher had a long-lasting interactivity with the participating individuals and interviews were made in an environment which participants can express their opinions and thoughts comfortably. Interviews were recorded during this period in order to prevent time, data loss and the effect of the subjective judgement of the researcher.

### Data analysis

In this study which was conducted in order to examine the content knowledge of pre-service elementary mathematics teachers related to graphics anthropologically, obtained data was analysed within the frame of institutional recognitions which were determined through ecological and praxeological approach. In the direction of ecological approach, content analysis was used in the analysing of the answers given to the first question related to the habitat and ecological niche of graphics which was directed to pre-service teachers in GCKS. In the analysis process, the answers given by pre-service teachers to the related question were codified by two field experts and the relation between different coding results were examined. The encoder reliability which was calculated with the formula of  $\text{Reliability} = \frac{\text{Consensus}}{\text{Consensus} + \text{Dissensus}} \times 100$  (Miles and Huberman, 1994) was found as 92.75%. The data which was separated to codes and themes was presented as tables showing frequencies and percentages. In these tables, sample expressions of pre-service teachers were given place under codes and themes.

In the direction of praxeological approach, the other data which were obtained from GCKS was presented as frequency-percentage tables within the frame of praxeological components of mathematical organizations whose institutional recognitions were determined. In these tables task types which were required to be carried out by pre-service teachers in the scales, usage situation of the techniques which were preferred in these task types and the expressions of the pre-service teachers which reflect theoretical knowledge were quantified. The methods used except the components of mathematical organisations related to determined institutional recognitions ( $T_i$ ,  $\tau_i$ ,  $\theta_i$ ,  $\Theta_i$ ) were classified as another category. In addition, the determined categories were supported with the explanations which pre-service teachers made in interview and knowledge scale and with graphics they drew.

## FINDINGS

### Individual recognitions of pre-service elementary mathematics teachers related to ecology of graphics and their relation with institutional recognitions

Within the frame of ecological approach, GCKS related to where (habitat) and why (niche) the graphics were used in the institution was used and various questions were

asked to pre-service teachers in the interviews. The distribution of the answers given by pre-service teachers with regards to the question directed to pre-service teachers in GCKS related to what graphic is and for what purposes it is used in mathematics was presented in Table 1.

When Table 1 was examined, it was seen that pre-service teachers answered by considering the definition of graphic and its niche together. In this direction, answers given by pre-service teachers take place under the themes of presenting knowledge, developing skill, providing learning-teaching and developing concept.

It was seen that according to codes determined under the theme of presenting information, pre-service teachers made definitions by considering graphics under the categories of data display, showing the change of data, showing the relation of data between each other, concreting knowledge, showing numerical characteristics of data and explain their function. The answer given by PMT2 who takes place in the category of data display is expressed below:

“Graphic is the display of relation of two dependent, independent variable with each other on (x,y) coordinate. It is used to display the relation of variables with each other, to display to what extent and in which direction is the change.”

As seen, PMT2 defined the graphic as displaying of relation between two variables which have a relation with each other on coordinate system. He stated about the function of graphic in institution (niche) that graphic is used to display the relation of two dependent, independent variables with each other on the coordinate system, to show the change of variables which have a relation with each other and to what extent is this change and to show in which direction is this change. When this statement is related to the functions of graphics determined in the institutional recognition, it was seen that it is compatible with functions of A3. Association line graphs with slope, A4. Determining any proportions between to quantities with given graphics, A5. Calculation of the proportionality constant, in the usage of graphics as tool, B1. Interpreting data on bar graph, B2. Interpreting data on pie chart, B3. Interpreting data on line graph, B4. Interpreting data on histogram, B5. Presenting data on bar graph, B6. Presenting data on pie chart, B7. Presenting data on line graph and B8. Presenting data on histogram which take place in usage of graphics as goal, C1. Problem-solving, association, communication and psychomotor skills development, C2. Interpretation of the data that include linear relations and associating them with algebraic representation and C3. Presentation on graphic of the data that include linear relations which takes place in the usage of graphics as tool-goal.

It was seen that according to codes determined under the theme of skill developing, pre-service teachers made

definitions by considering graphics under the categories of comparison, interpretation, relating, problem-solving, prediction, reasoning and mathematical literacy and explain their function. The answer given by PMT105 who takes place in the category of comparison is expressed below:

“Graphic is the display of certain data with figures like line, form, bar etc. It ensures plenty of data to be comprehended easily by displaying them with figures. It also enables the difference between data to be seen easily and facilitates comparison.”

PMT105 defined the graphic as display of data with forms like line, figure, bar etc. Pre-service teacher stated about the niche of the graphic that graphics are used to display the data with with forms like line, figure, bar etc., visualising data with figures, enable the data to be comprehended easily, displaying the difference between data and to compare data. When the answer given is compared with the functions determined in the institutional recognitions; it was seen that the answer is compatible with functions of A2. Calculation openness/average/mode/median, A3. Association line graphs with slope, A4. Determining any proportions between to quantities with given graphics, A5. Calculation of the proportionality constant, in the usage of graphics as tool; B1. Interpreting data on bar graph, B2. Interpreting data on pie chart, B3. Interpreting data on line graph, B4. Interpreting data on histogram, B5. Presenting data on bar graph, B6. Presenting data on pie chart, B7. Presenting data on line graph and B8. Presenting data on histogram which take place in usage of graphics as goal.

It was determined that according to codes determined under the theme of learning-teaching, pre-service teachers made definitions by considering graphics under the themes of facilitating learning teaching, ensuring permanent learning, drawing attention, inter-discipline transition, eliminating misconception and explain their function. The statement of PMT40 who takes place in the category of comparing learning-teaching is expressed below:

“Graphics develop skills of noticing, understanding and interpreting the relation between data. Because of being a visual display graphics enable students to learn easier and funnier and they appeal to the visual intelligence of students.”

When the expression of PMT40 is examined it was seen that s/he defined the graphic as a visual display; s/he stated the niche of the graphic as correlating between data and providing the interpretation of data, displaying the data by using visuals, ensuring students to understand funnier and easier and evoking their visual intelligence. It was determined that the answer given by the pre-service teacher is compatible with functions of A3. Association line graphs with slope, A4. Determining

**Table 1.** The distribution of answers related to graphic and its usage purpose in mathematics.

Usage purpose		f	%	Sample expression
Presenting Knowledge	Displaying data	45	12.61	PMT1- Graphic is formed for the representing of existing data or knowledge with figures and lines. It is used in the display of data.
	Displaying the change of data	36	10.08	PMT2- Graphic is the display of the relation of two dependent independent variables with each other on (x,y) coordinate. It is used to display the relation of variables with each other, to display to what extent and in which direction is the change.
	Displaying the relations of data with each other	15	4.20	PMT41- It is a structure which displays various data concretely by drawing them by figure or line. It adds concreteness to the subject to show the relation between data to students.
	Concreting knowledge	20	5.60	PMT27- Classifying a set of data numerically according to data is called graphic. It can be used in grouping of data, displaying whether there are some characteristics or displaying their degree of presence. For example, bar graph can be used for instructing categorical data.
	Displaying numerical features of data	2	0.56	
Developing Skill	Comparison	40	1.20	PMT105- Graphic is the display of certain data with figures like line, form, bar etc. It ensures plenty of data to be comprehended easily by displaying them with figures. It also enables the difference between data to be seen easily and facilitates comparison.
	Relating	33	9.24	PMT111- It is used to express representations which are long and hard to read easily and to classify them according to certain standards. It strengthens relational consideration and it is the step point of function subject.
	Interpretation	21	5.81	PMT58- Graphic is open and short visual display of data which is long and hard to express verbally. It can express complicated data easier because of enabling various data to be seen well-coordinated and we can interpret it.
	Problem-solving	8	2.24	PMT101- Data collected together by means of axes and by naming axes creates graphic. Graphics may be used in problem-solving. It enables student to see the problem more concrete. Besides, it prepares students for the forthcoming subjects psychologically.
	Prediction	4	1.12	PMT73- Graphics are used for making comparison, predicting about future by seeing data, having an opinion by seeing the rates of data, for seeing the difference between two data set and seeing data as a whole in mathematics.
	Reasoning	2	0.56	
	Mathematical literacy	2	0.56	PMT106- Graphic is required in order to develop literacy, to provide a basis for the subjects of ratio-proportion, function and statistics.
Learning Teaching	Ensuring permanent Learning	23	6.44	PMT17- Definitely it makes people having different intelligence comprehend. In addition, it supports prior knowledge and it provides understanding because it is more permanent for people to remember what they see.
	Facilitating learning teaching	20	5.60	PMT40- Graphics develop skills of noticing, understanding and interpreting the relation between data. Because of being a visual display, graphics enable students to learn easier and funnier and they appeal to the visual intelligence of students.
	Drawing attention	10	2.80	PMT100- They are used for making a subject more comprehensible and interesting.
	Inter-discipline transition	4	1.12	PMT95- Graphic is one of the subjects which provides the basis of more important subjects such as function which student will face at more advanced levels. He will be unsuccessful in lessons such as science and social studies because graphics are also used in that lessons.
	Eliminating misconception	3	0.84	PMT94- It can be used to notice and eliminate student mistakes and concept errors.
Developing Concept	Rate-proportion	19	5.32	PMT43- In mathematics, graphics are used to teach some subjects. SC21- It is used in subjects such as function, proportion, slope, in production, distribution, trade and management.
	Slope	12	3.36	PMT60- It is used in the teaching of subjects of slope, rate-proportion. SC96- Graphics are benefited in order to pass to advanced subjects such as slope, function.
	Function	10	2.80	
	Equation, inequation	9	2.52	PMT86- It is used to instruct equations to student concretely, to show equation, slope and Cartesian coordinate system, to solve inequation systems.

Table 1. Cont'd

Statistical information	8	2.24	PMT24- It is used in interpreting knowledge, sorting, interpreting between statistical information such as mod, median, arithmetic average, standard deviation.
Coordinate system	6	1.68	PMT77- The coordinate system is used for interpreting slope, line equations, providing transition between each other.
Pattern and generalisation	2	0.56	PMT109- Graphics are necessary for the subject of pattern. It is possible to pass to a pattern from a graphic, the general rule can be found. Slope calculation maybe seen easily in graphics. Drawing the graphic of an equation enables us to find its slope easier. Otherwise, we have to deal with formulas. We use it widely in analytical geometry. There are certain operations for rate-proportion. But we can see them directly and comfortably by drawing graphic.
Analytical geometry	2	0.56	
Field	1	0.28	PMT4- It is a form of sorting and evaluating data according to a certain order. We can use data in ascending sorting, area calculation and distance-time formulas.
Total	357	100	

N=112, (PMT:Preservice Mathematics Teachers).

any proportions between to quantities with given graphics, A5. Calculation of the proportionality constant, A6. Determination of the solution for linear equation systems which take place in usage of graphics as tool; B1, B2, B3, B4, B5, B6, B7 and B8 functions which take place in usage of graphics as goal; C1, C2 and C3 functions which take place in usage of graphics as tool-goal of graphics determined by ecological approach.

It was determined that according to codes determined under the theme of concept development, pre-service teachers explained the functions of graphics under the categories of rate-proportion, slope, function, equations and inequations, statistical information, coordinate system, pattern and generalisation, analytical geometry and field. In this direction, the expression of PMT109 is expressed below:

“Graphics are necessary for the subject of pattern. It is possible to pass to a pattern from a graphic, the general rule can be found. Slope calculation may be seen easily in graphics. Drawing the graphic of an equation enables us to find its slope easier. Otherwise, we have to deal with formulas. We use it widely in analytical geometry. There are certain operations for rate-proportion. But we can

see them directly and comfortably by drawing graphic.”

As seen from the expression, s/he thinks that graphic is used as means to develop concept. PMT109 stated that graphics are used in the subject of pattern in order to determine pattern rule and to determine the slope of a line in the graphic belonging to its equation and to show rate-proportion in the relations given in graphic. In this direction, it was seen that the answer is compatible with functions of A3. Association line graphs with slope, A4. Determining any proportions between two quantities with given graphics, A5. Calculation of the proportionality constant, in the usage of graphics as tool, B3. Interpreting data on line graph and B7. Presenting data on line graph functions which take place in the usage of graphics as goal, C2. Interpretation of the data that include linear relations and associating them with algebraic representation and C3. Presentation on graphic of the data that include linear relations which take place in usage of graphics as tool-goal of graphics determined by ecological approach.

It was seen that, similar to the answers given by pre-service teachers with regards to function of

graphic in the institution (niche), in the research conducted by Şahinkaya and Aladağ (2013); the pre-service class teachers also expressed that graphics provide easier comprehension of data, permanency, visuality and concreteness and facilitate learning. But, it was determined that the answers of usage of drawings for tabulation to display data (0.56%), drawing attention in learning-teaching (2.80%), facilitating making numerical operation in rate-proportion (1.12%) and teaching parabola-hyperbola in analytical geometry (0.28%) which pre-service teachers stated as its function (niche) was not given place in institutional recognitions.

Within the frame of ecological approach, the question of “Where graphics take place in mathematics?” was directed to pre-service teachers in order to examine their knowledge related to where the knowledge is in the institution; in other words, the habitat of graphics. The findings obtained from the answers which pre-service teachers gave to this question is presented in Table 2.

When Table 2 is examined, it was determined that pre-service teachers correlates the place of graphics (habitat) in mathematics with learning field, subject, chapter, its usage in different



**Table 2.** The distribution of answers related to usage fields of graphics.

Usage field	f	%	Sample expression	
Learning Field	Data processing	54	25.96	PMT16- Graphics take place in data processing learning field in mathematics teaching programmes. Graphics are used in this learning field in student's transforming data to table incertain research questions, in student's being able to draw various graphic types on the basis of table, in the facilitation of making comparison between research groups.
	Probability	16	7.69	PMT78- Probability and statistic learning field. It is used in relating probable situations, information in the table according to requested information and transforming them into a graph, in central tendency and dispersion measures.
	Geometry and measurement	15	7.21	PMT80- It is included in the geometry learning field. Drawing figure, usage of coordinate axes, collecting data and displaying them on graphic. It also takes place in data processing learning field.
	Algebra	14	6.73	PMT46- Data processing: It is forming, interpreting, reading of graphic and relating them to other display forms by processing data. It exists in every grade level. Algebra: There are especially linear equations in 7. grade algebra field, equations of line whose slope is known in 8. grade algebra field.
	Number and operations	10	4.81	PMT65-It takes palce in learning fields such as data processing, geometry and measurement, algebra, number and operations.
	Logic	1	0.48	PMT87- Graphics are included in the logic learning field. A student understanding graphics correlates better.
Chapter	Data analysis	7	3.37	
	Data collection, organisation, evaluation and interpretation	6	2.88	PMT94- It takes place in the part of data processing, analysis and interpretation.
Subject	Equations and inequations	15	7.21	
	Problems	11	5.29	
	Slope	10	4.81	
	Function	10	4.81	
	Coordinate system	8	3.85	
	Rate-proportion	5	2.40	
	Area-volume	5	2.40	PMT22- Graphics of slope of lines, coordinate system area volume relations, distance and speed problems connected to time, function, inequations are related to many other subjects. It is not possible to consider them apart. Meanwhile, benefiting from graphics while instructing the subjects eases our work with regards to mathematical teaching. Teaching by correlating as a whole will also help the development of relational consideration skills of students in front of us.
	Central tendency and dispersion measures	5	2.40	PMT4- It exists in data collecting, organising and graphic forming, in the field of statistics. It is used in area calculation, in speed-time-distance relations, in trigonometry, derivative, integral.
	Pattern	4	1.92	
	Derivative-integral	4	1.92	
	Fraction and perceptions	3	1.44	
Trigonometry	1	0.48		
Chapter	Data analysis	7	3.37	
	Data collection, organisation, evaluation and interpretation	6	2.88	PMT94- It takes place in the part of data processing, analysis and interpretation.
Other	4	1.92	PMT17- Algebra learning is used in the subject of data processing. It develops the skill of graphic reading in questions of interpreting from the graphic in social studies lesson.	
Total	208	100		

disciplines and daily life problems and stated in different categories under its other themes. According to institutional recognitions obtained with ecological approach; in addition to geometry and measuring, probability learning fields along with number and operations, algebra and data processing learning fields in which graphics take place, one pre-service teacher showed logic learning field which takes place in high school curriculum as the address of graphics. The 70.9% of 110 answers given as learning field constitutes the learning fields determined in institutional recognition. In this direction, it was stated that graphics take place in data processing learning field at the most (25.96%).

When the subjects in which graphics take place stated by pre-service teachers in Table 2 is examined, it was seen that the subjects of derivative-integral and trigonometry (6.17%) stated by pre-service teachers are different from the determined institutional recognitions. It was concluded that the subject having the higher percentage (7.21%) in the answers given under the subject theme is equations and inequations. In this direction, even though the pre-service teachers show data processing learning field mostly in learning fields as the habitat of graphics, it is seen that they are directed to subjects which take place in number and operations learning field with regards to subjects. While pre-service teachers specify only central tendency and dispersion measures in data processing field; they mentioned the subjects in number and operations learning field by 45.68%, the subjects in algebra learning field by 30.86%, the subjects in geometry and measuring learning field by 17.28 %.

It was determined that 3.37% of the answers of the pre-service teachers under chapter theme is data analysis and 2.88% of them is data collection, organisation, evaluation and interpretation. Besides, different fields except the mathematics discipline were specified as the fields which graphics were used. Within this scope, while 0.96% of pre-service teachers specify that graphics are used in daily life, 0.96% of them stated that they are used in social sciences field aside from determined institutional recognitions.

When the total of 208 answers given by pre-service teachers was examined in general, it was concluded that logic learning field, derivative, integral and trigonometry subjects along with social sciences field (3.84%) are aside from determined institutional recognitions.

### **Individual recognitions of pre-service elementary mathematics teachers related to the praxeology of graphics and their relation with institutional recognitions**

In the direction of institutional recognitions determined with praxeological analysis, questions related to bar graph, pie chart, line graph and histogram aimed at

graphic reading and interpreting, graphic creating and making appropriate conversions between graphics were directed to pre-service teachers. In the (a) ve (b) items of the second question of GCKS, the pre-service teachers were asked to fulfill the obtaining information from bar graph (T1) task type. According to determined institutional recognitions, the technique which must be used for T1 task type is  $\tau_1$  technique which is calculating the height of bars given in the graphic. The classification of techniques which pre-service teachers used in obtaining information from the given bar graph is presented in Table 3.

According to Table 3, in the task of obtaining information from the bar garph (T1) for the item (a) 96.43% of the pre-service teachers reached correct result by using  $\tau_1$  technique (calculating the height of bars) and 2.68% of them left the question unanswered. As for the item (b) 87.5% of the c pre-service teachers reached correct result by using  $\tau_1$  technique, 8.04% of them reached incorrect result by using the same technique and 4.46% of them left the question unanswered. Pre-service teachers did not use a technique which is different from  $\tau_1$  technique determined in institutional recognitions for both of the items. The answers of PMT47 and PMT49 who used  $\tau_1$  technique in the related question, but gave different answer are presented in Figure 1.

According to Figure 1, PMT47 and PMT49 used  $\tau_1$  technique by calculating the height of the bars while determining the frequency of categorical data. This situation is seen obviously in the frequency tables formed by PMT47. These pre-service teachers answered “rose” like the other answering pre-service teachers for the item (a); and as for item (b) they reached to different numerical results. It was determined that PMT49 made proportion mistake for the item (b) which was directed about how many times the number of students which like rose is of the total number of students in the classroom.

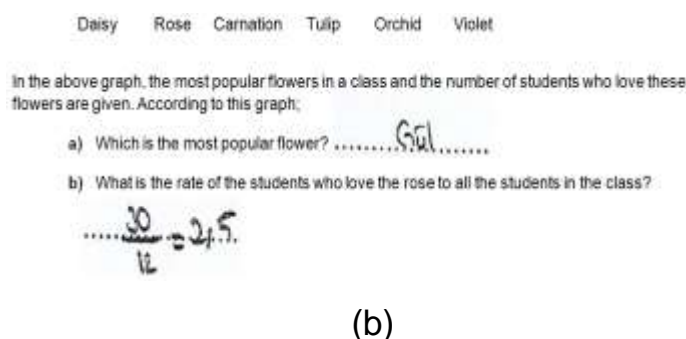
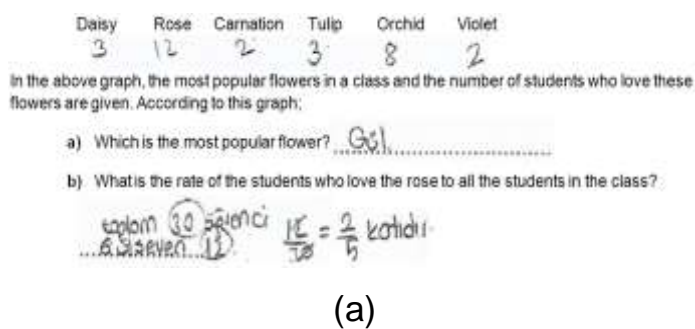
Consequently, it was seen that pre-service teachers used  $\tau_1$  technique (calculating the height of the bars) for the duty of T1 (obtaining information from the bar graph). PMT15 who answered the question compatible with institutional recognitions by using  $\tau_1$  technique specified that he considered the height of the bars while acquiring information from bar graph by his explanation of “Bar Graph which is easier due to being interesting and comprehensive. Besides, it has a simple structure. The number is at the value of the height of the bar.” In the interview made, although the pre-service teachers correctly answered frequency determining question (a), they made mistake in the question with regards to rate calculation. This situation resembles the research findings about having difficulty in determining the relation between data while interpreting single variable bar graph (Hotmanoğlu, 2014).

In the item (c) of the same question, pre-service teachers were asked to form a pie chart by using  $\tau_{10}$  (creating a pie chart upon the required angle, area

**Table 3.** The classification of the answers belonging to (a) ve (b) items of the second question including obtaining information from bar graph.

Answer		Question items			
		(a) Which is the most liked flower?		(b) How many times is the number of students which like rose of the total number of students in the classroom?	
		f	%	f	%
Calculating the height of bars (τ1)	Correct result	108	96.43	98	87.5
	Incorrect result	-	-	9	8.04
Unanswered		3	2.68	5	4.46

N=112.



**Figure 1.** Answer examples of pre-service teachers (a) PMT47 and (b) PMT49 who use τ1 technique.

**Table 4.** The classification of the answers belonging to item (c) of the second question including the task of conversion bar graph into pie chart.

Answer		Question item	
		(c) Draw pie chart showing pie slices with central angle measures.	
		f	%
Slicing the pie graph using central angles or percentages in proportion to the frequency of the data groups (τ7)	Correct drawing	69	61.61
	Incorrect drawing	22	19.64
Other		4	3.57
Unanswered		17	15.18

N=112.

percentage and proportion calculations) technique within the frame of conversion bar graph into other graphs proper to data (T9) task type. According to institutional recognitions, pre-service teachers are expected to use τ7 technique (slicing the pie graph using central angles or percentages in proportion to the frequency of the data groups) in order to form pie chart. In Table 4, the classification of the techniques which pre-service teachers used for conversing bar graph into pie chart is given.

According to Table 4, 61.61% of the pre-service

teachers made correct drawing by using τ7 technique, 19.64% of the pre-service teachers made incorrect drawing by using the same technique with 3.5% of them forming pie chart by using the other technique, whereas 15.18% of them did not draw any graphs. 17.86% of the pre-service teachers making incorrect drawing did not consider the area represented by the angle while slicing the pie chart with central angle in proportion to the frequency of data groups, whereas 2.56% of them miscalculated the rates. Also, the pre-service teachers using other techniques were not included in institutional

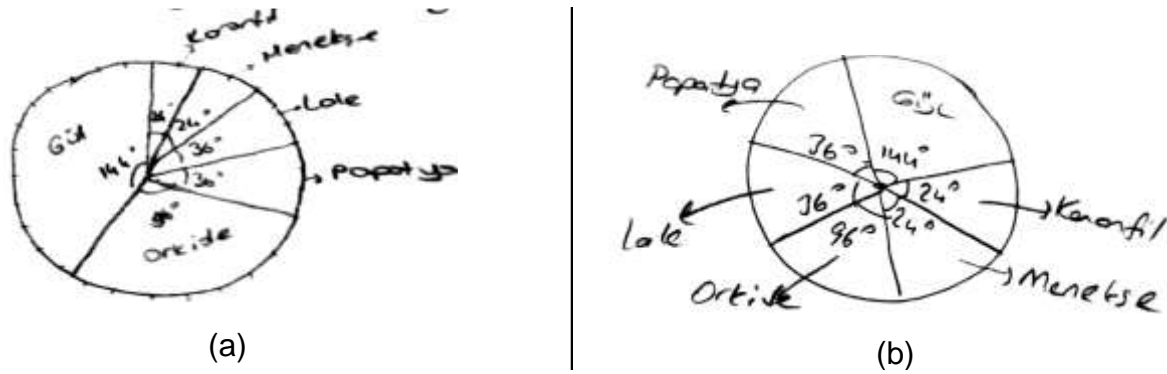


Figure 2. Pie charts drawn by (a) PMT39 and (b) PMT95.

recognitions, they did not specify the rates of variables numerically with percentage or central angle, but just wrote the variable names. The graphics which was drawn for second problem by PMT39 and PMT95 who used  $\tau 7$  technique but made different creating are given in Figure 2.

When the pie chart drawn by PMT39 in Figure 2 was examined, it was seen that the pre-service teacher cut the pie to 30 equal units and specified every number of students liking the related flower kind in a way corresponding to  $12^\circ$ . For example, 2 students liking violet was displayed with an angle of  $24^\circ$  by slicing violet slice into two pieces. PMT95 who calculated central angle measures correctly and used the same technique could not display the area tracked by the angles in his/her drawing correctly. In the pie chart drawn according to institutional recognitions, the total of the number of students which like rose and which like tulip or daisy should correspond to  $180^\circ$  which is half of the pie in such a way showing 15. But PMT95, in the graphic he drew displayed the angle measure corresponding to half of the pie bigger than  $180^\circ$ . The pre-service teacher determined the central angles representing the number of daisies, roses and tulips as  $36^\circ$ ,  $144^\circ$  and  $24^\circ$  consecutively, but he failed to draw the pie slice which is  $180^\circ$  corresponding to the total of daisy, rose and tulip flowers in such a way representing the half of the pie. Instead, s/he drew the pie slice having a central angle of  $204^\circ$  which s/he determined as the total of daisy, rose and tulip in such a way corresponding to  $180^\circ$  by cutting in half of the pie.

The graphic drawn for second problem by PMT73 who used another technique aside from technique of slicing the pie graph using central angles or percentages in proportion to the frequency of the data groups ( $\tau 7$ ) for the creating pie chart (T6) duty is given in Figure 3.

In the pie chart given in Figure 3, it was seen that PMT73 cut the pie into random slices equal to the number of variables and he did not use an identifier specifying the size of slices with regards to area. According to the theory of structural elements of graphics

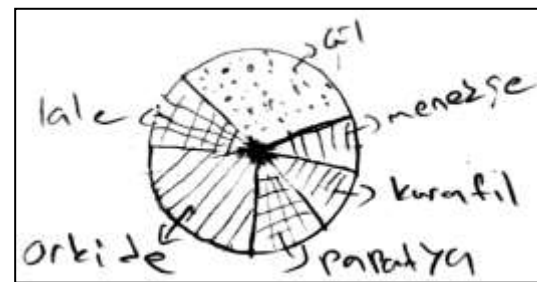


Figure 3. Pie chart drawn by PMT73.

determined in institutional recognitions ( $\Theta 3$ ), there should be elements of frame, identifier, label and background in a graphic drawn completely. But the pre-service teacher did not specify central angle or percentage rate representing the size of slices. In this context, the pre-service teacher did not use identifier element of the graphic.

In the interview made with PMT41 who used the technique of slicing the pie graph using central angles or percentages in proportion to the frequency of the data groups ( $\tau 7$ ) while forming the pie chart and made the correct drawing, the statement of the pre-service teacher related to the technique used is as below:

*"According to me, it is hard to form pie chart. Because we know the data. But it is required to be displayed by proportioning in such a way that the whole of the pie slices should be 360. And also there is the issue of calculating what percentage each slice will be. This requires a long period of time. In my opinion pie chart is inclined to error. Percentage and angle may be mixed. For example, in the past I thought that  $25^\circ$  and 25% were the same. Moreover, since I did not know what 25% is, I was drawing 25% bigger than 30%. Or I was slicing it by giving random values to slices. In bar graph, we can directly transfer data, but in pie chart operations are required."*

**Table 5.** The classification of answers belonging to third question

Answer	Question item		
	Ali and Veli who have 7 TL and 10 TL successively in their money box, save from their pocket money 4 TL and 3 TL successively after the shopping for their money box every week. According to this, draw a line graph showing the amount of money saved in their money box for 6 weeks.		
		f	%
Connecting the consecutive points that represent the data (τ8)	Correct drawing	66	58.93
	Incorrect drawing	27	24.11
Unanswered		19	16.96

N=112.

When the opinions of the pre-service teachers are examined, it is emphasized that knowing angle and percentage concepts is a must as prior knowledge to form pie chart. In this context, PMT41 stated that problem may be experienced in geometric correlation with angle and percentage features of pie chart. In a similar way to the situation stated in the explanation, 17.86% of pre-service teachers participated in the research drew pie charts incompatible with institutional recognitions by failing in correlating between angle and area while forming the graphics (Turhan, 2015). It is considered that these drawings which are erroneous in terms of institutional recognitions originated from lack of knowledge related calculations of area of circle.

Within the frame of graphic creating organization, connecting the consecutive points that represent the data (τ8) techniques was used while fulfilling the creating line graph (T7) task. In the third question of the scale, after giving two data groups pre-service teachers were asked to draw their graphic. In the graphic created according to institutional recognition, they are supposed to draw two lines which do not intersect x-axis and whose starting points are (0,7) and (0,11), which increase and intersects at a point. The classification of techniques which pre-service

teachers used for T7 duty is given in Table 5.

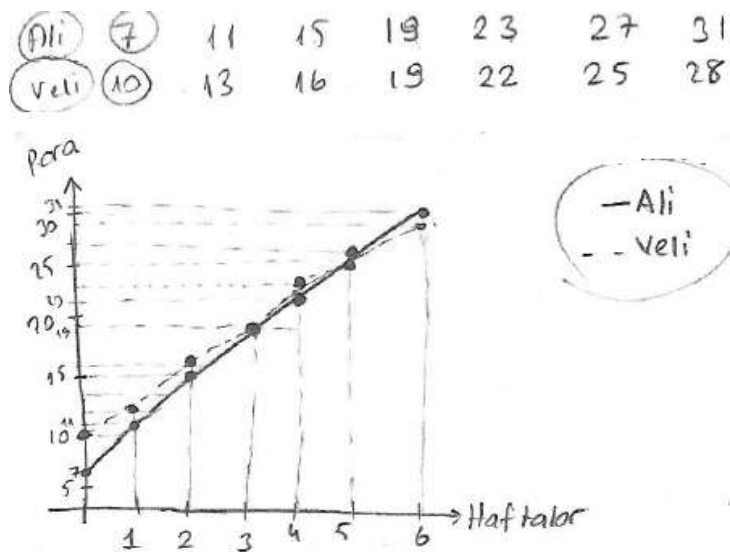
When Table 5 was examined, it was seen that 58.93% of the pre-service teachers made correct drawing by connecting the consecutive points representing the data with a line (τ8) technique, 24.11% of them made incorrect drawing by using the same technique and 16.96% of them did not draw any graphs. In Figure 4, the graphics which was drawn for third problem by PMT55 and PMT62 who used line graph by using τ8 technique but made different drawings are given.

When Figure 4 was examined, it was seen that PMT55 formed a frequency table for the amount of money corresponding to every week, marked the points s/he determined in the graphic and connected these points consecutively with a line. It was seen from the figure that the pre-service teacher drew axes as the frame which is among the structural elements of graphics, placed the labels of the graphics by naming the axes and lines, used two different designs for lines as dotted line and continuous line, displayed the identifier of the graphic by using leader line and used the grid which shows matching of points for the background of the graphic. Also, PMT62 used the same technique (τ8) but determined data values incorrectly and started the lines from the origin. Similarly, it was determined that pre-

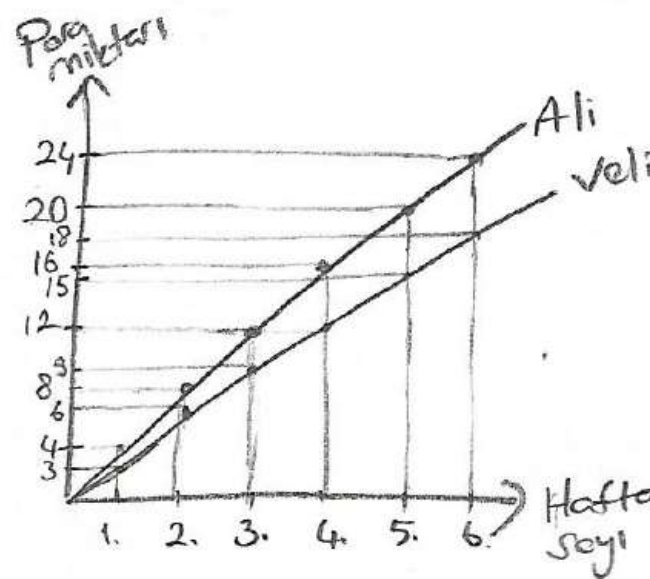
service teachers who drew incorrectly by using the same technique formed line graph by ignoring initial value or drawing the lines which have to intersect in a parallel way. But all pre-service teachers who drew graphic used structural elements of frame, identifier, label and background in the drawn graphic completely.

In the sixth question of the scale, it is expected to fulfill the (T7) task type which is regenerating a line graph by changing the axes of a line graph. In this task, since the data whose graphic is asked to be drawn takes place on line graph, firstly the task of obtaining information on line graph which ensures the data set to be formed (T3) by interpreting the graphic should be fulfilled. The classification of techniques which pre-service teachers used for changing the axes of the graphic is given in Table 6.

When Table 6 was examined, it was seen that 97.32% of the pre-service teachers determined the values of related points on horizontal and vertical axis by using (τ3) (determining the value of the relevant point on the line regarding the vertical or horizontal axis) technique, 2.68% of them left the question unanswered because of not drawing the graphic. For the duty of creating line graph (T7), it was seen that 92.86% of pre-service teachers created line graph correctly by using τ8



(a)



(b)

Figure 4. Line graphs created by (a) PMT55 and (b) PMT62.

Table 6. The classification of answers belonging to the sixth question including the task of changing the axes of the line graph.

Answer		Question Item			
		In the adjacent graphic, the temperature measurement of A city is given. Redraw the graphic by changing its axes.			
		Obtaining information from line graph (T3)		Creating line graph (T7)	
		f	%	f	%
Determining the value of the relevant point on the line regarding the vertical or horizontal axis (r3)	Correct result	109	97.32	-	-
	Incorrect result	-	-	-	-
Connecting the consecutive points that represent the data (r8)	Correct drawing	-	-	104	92.86
	Incorrect drawing	-	-	2	1.79
Drawing rectangles at the heights equal to the frequency of the data groups (r5)		-	-	2	1.79
Other		-	-	1	0.89
Unanswered		3	2.68	3	2.68

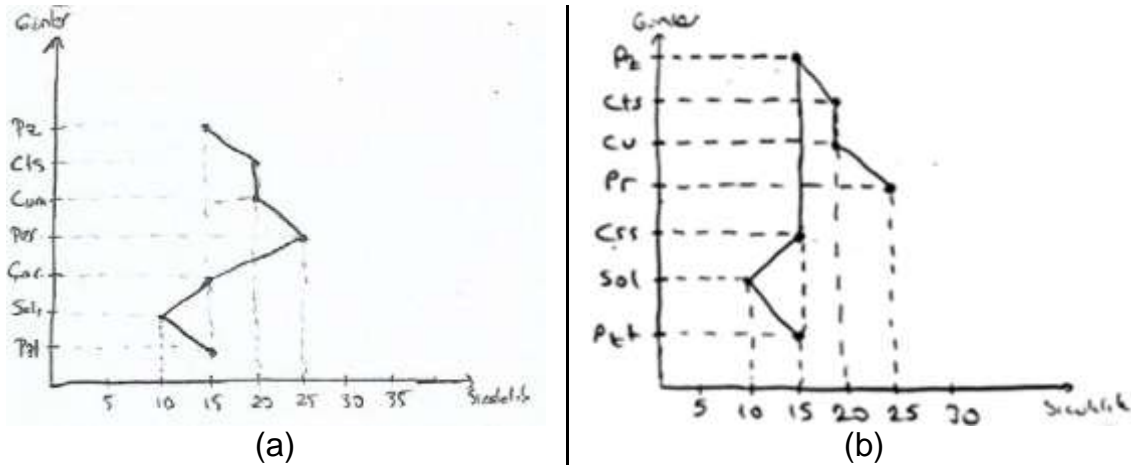


Figure 5. Line graphs drawn by (a) PMT37 and (b) PMT34.

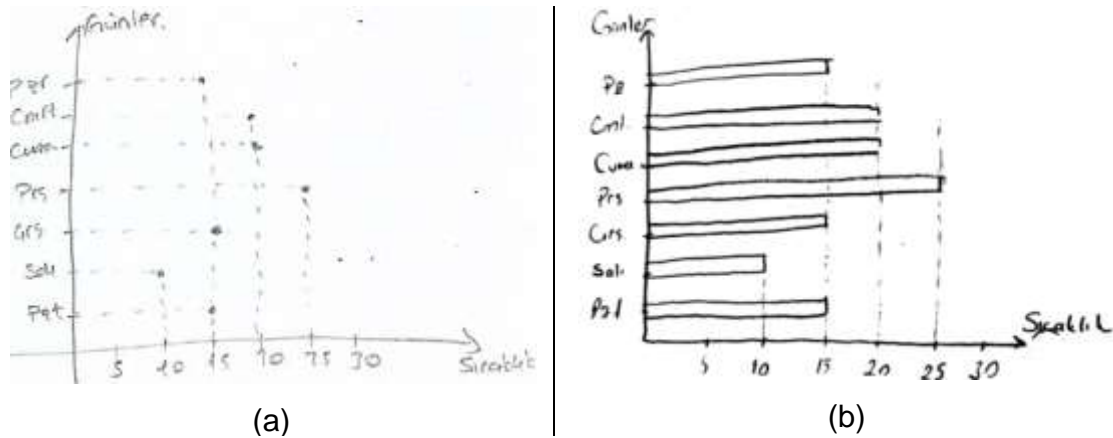


Figure 6. Graphics drawn by (a) PMT3 and (b) PMT63.

(connecting the consecutive points that represent the data) technique, 1.79% of them made incorrect drawing by failing in connecting the consecutive points, 1.79% of them drew horizontal bar graph by using  $\tau_5$  (drawing rectangles at the heights equal to the frequency of the data groups) technique and 0.89% of them form dot graph by using other techniques aside from the ones determined in institutional recognitions. The graphics which was drawn for sixth problem by PMT37 who used  $\tau_8$  technique compatible with institutional recognitions and the graphic drawn by PMT34 who used this technique incorrectly are given in Figure 5.

When Figure 5 is examined, both pre-service teachers draw line graph by using  $\tau_8$  technique. But, PMT34 neglected that consecutive points should be connected in this technique. In his/her drawing s/he directed from Wednesday to Sunday in day variable whose line proceeds consecutively. The pre-service teacher paid attention to temperature instead of day variable

consecutively. The graphics which was drawn for sixth problem by PMT3 and PMT63 who drew dot graph by specifying just the dots representing data or who drew bar graph by using  $\tau_5$  technique for this question are given in Figure 6.

In the interview made with PMT37 who made drawing by using technique of connecting the consecutive points that represent the data ( $\tau_8$ ), the answer of the pre-service teacher about which way s/he had followed while changing the axes and to what s/he paid attention is as below:

*“Graphics with axis are generally functional graphics. Parabola graphics etc. Pie chart, graphic without axis, figure, object graphics at lower grades are graphics without axis in a tabulated form. It is required to be careful in changing the axes. Most people make mistake. They change the axes directly and the form of the graphic remains the same. Or even the numbers remain the*

**Table 7.** The classification of answers belonging to the fifth question including the task of obtaining information on line graph.

Answer		Which of the following graphics display the way (distance)which someone going first to the east, then to the north and then again to the east with a constant speed against time covered?	
		f	%
Determining the value of the relevant point on the line regarding the vertical or horizontal axis (τ3)	Correct selection	101	90.18
	Incorrect selection	-	-
Other		10	8.93
Unanswered		1	0.89

same, as there are people who just change only the names of the axes. In conclusion, the data in the graphic should change. In fact graphic changes entirely, it does not remain the same.”

PMT37 who talked about graphic with and without axis tried to explain what should be done while changing axes with the mistakes made. According to her/him, it is not enough to change only axes and values, also the form of the graphic changes. PMT23 who made the correct drawing by using the same technique explained the method s/he used while changing the axes as below:

“For example, there is data in the graphic in a way that the number of students is on the horizontal and the point is on vertical. First, I transform them into normal data to prevent confusion. If there are 5 of 10 points, first I write these points side by side. In other words; I tabulate the points first. Then I turn that table into a graphic again. Maybe I lost some time by doing this but I minimize the risk of making mistake.”

When the explanation was made for change of axis; PMT23 stated that the graphic which came out as a result of the change does not remain the same, the values on the axes should be changed, it may be useful to benefit from frequency table for not confusing data.

In the fifth question of GCKS, pre-service teachers are asked to select the graphic representing real life context including direct relation for the task of obtaining information on line graph (T3). Within the frame of institutional recognitions, the usage of the determining the value of the relevant point on the line regarding the vertical or horizontal axis (τ3) technique is expected in order to acquire information from line graph. Pre-service teachers are expected to notice that data constitutes a linear increasing graphic within the frame of the given context.

When Table 7 was examined, it was seen that 90.18% of the pre-service teachers considered the values of the points on the line graph on horizontal and vertical axis by using τ3 technique, 8.93% of them made selections which is not compatible with institutional recognitions by focusing the form of the way within the frame of other

techniques and 0.89% of them did not answer the question. Pre-service teachers using other technique selected the graphic which is the same with the form of the way. These pre-service teachers may have picture-like graphic misconception because of preferring the same graphic with the way. In the picture-like graphic concept error, the graphic displaying the same of the way is perceived as the correct one by ignoring the relation between variables (Clement, 1985; Leinhardt et al., 1990; Roth and Bowen, 2001). In the interviews, pre-service teachers are asked with regards to line graphs about how it is drawn and how they interpreted the line graph. In this direction, the opinions of PMT15 about line graph is as follows:

“Line graph, from my point of view, is the hardest graph to be comprehended. Because the visuality of the line graph is at a lower level. We determine the points. We form the graphic by connecting these points. When we take a look to a drawn line graph it is required to see what the points represent and to which values they correspond in both axes. The line being increasing or continuous changes the meaning, meaning of the graphic. Moreover, as far as I know, there are misconceptions about this graphic. The mistakes such as drawing continuously increasing in any condition, displaying the data with line graph even though it is discontinuous, starting always with 0 or perceiving the graph as picture may be made.”

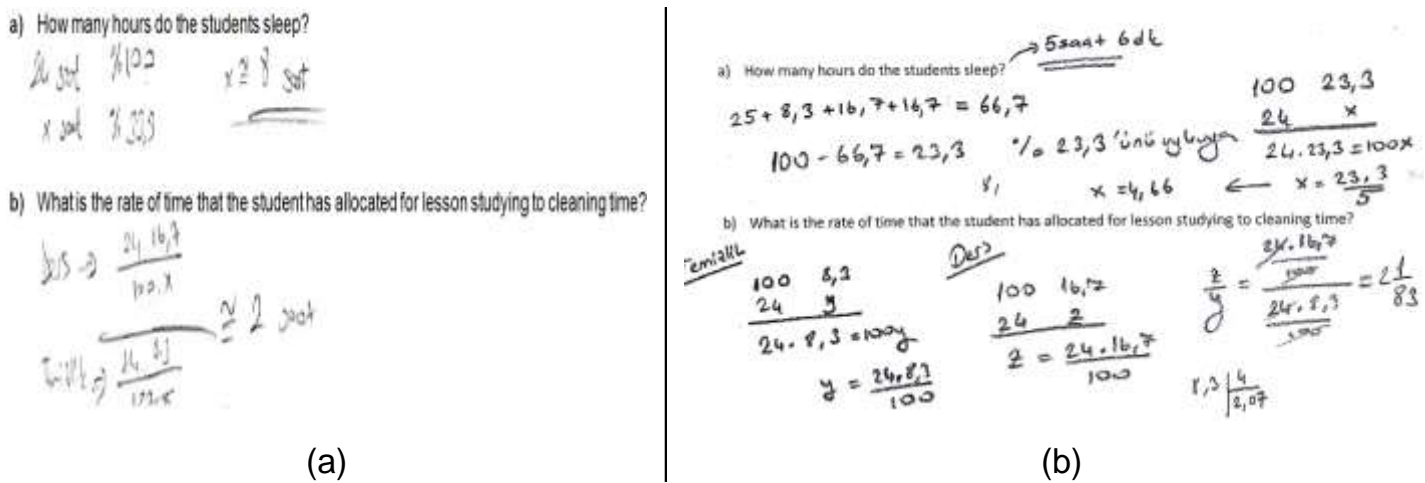
In the explanation, it is stated that line graph was drawn by connecting the consecutive points that represent the data namely, τ8 technique is used in drawing. And in the interpretation of the graphic, it is stated that the values of the points in the graphic on both axes are taken into consideration. 60% of the pre-service teachers who were interviewed showed line graph as the graph type which people have the most difficulty due to having less visuality. In addition, they stated that there are misconceptions originating from not comprehending the meaning of the line in the graphic. In the (a) and (b) items of the fourth question of GCKS; pre-service teachers are asked to fulfill the task type of obtaining information from the given pie chart (T2). According to institutional



**Table 8.** The classification of answers belonging to (a) and (b) items of the fourth question including the task of obtaining information from the given pie chart.

Answer		Question item			
		(a) How many hours does the student reserve for sleeping?		(b) What is the rate of the time s/he reserved for studying to the time s/he reserved for cleaning?	
		f	%	f	%
Making proportional calculations using the central angle or percentage for the surface area of the pie slice (τ2)	Correct result	83	74.11	100	89.29
	Incorrect result	9	8.04	2	1.79
Unanswered		20	17.86	10	8.93

N=112.



**Figure 7.** Example answers of (a) PMT66 and (B) PMT81 which used τ2 technique.

recognitions, the technique which should be used for T2 task type is the technique of making proportional calculations using the central angle or percentage for the surface area of the pie slice (τ2). The classification of techniques which pre-service teachers used in obtaining information from the given pie chart is given in Table 8.

According to Table 8, in the task of obtaining information from the given pie chart, it is seen that for the item (a) 74.11% of the pre-service teachers which used τ2 (making proportional calculations using the central angle or percentage for the surface area of the pie slice) technique answered correctly, 8.04% of them gave unexpected answers and 17.86% of them left the question unanswered; for the item (b) 89.29% of the pre-service teachers which used τ2 technique gave the correct answer, 1.79% of them gave incorrect answer and 8.93% of them left the question unanswered. The rate of the answering of item (a) which requires knowing that the whole of the pie (circle) is 100% and operations should be done on this basis is lower than item (b) which can be concluded by proportioning the slices only. The answers of PMT66 and PMT81 who answered correctly

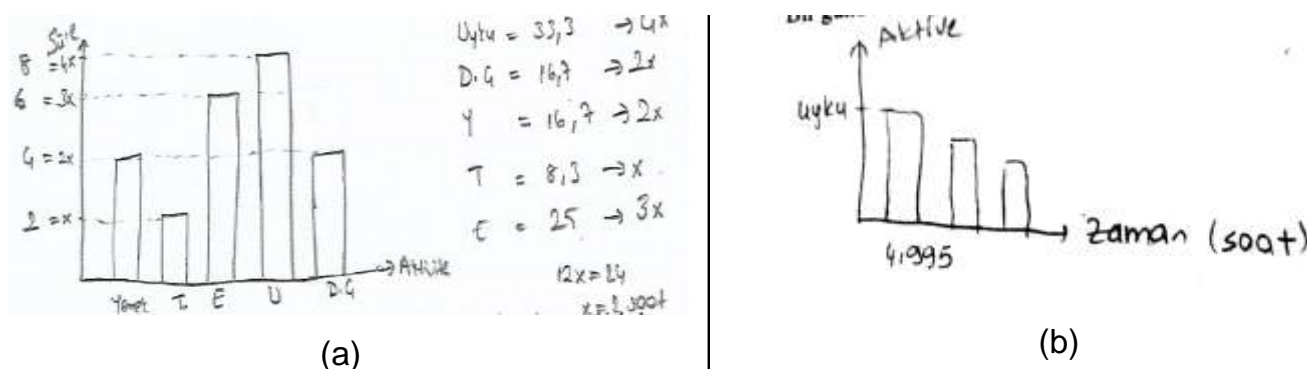
and incorrectly by using τ2 technique is given in Figure 7.

When the answers given by the pre-service teachers on Figure 7 are examined, it is seen that in item (a) all pre-service teachers tried to determine the percentage rate corresponding to area of pie slice in order to find the time reserved for sleeping, even though they used the same technique, due to the mistakes made in arithmetic operations they reached to different conclusions. While PMT66 calculated the time roughly, PMT81 made calculation error. And pre-service teachers who reached correct conclusion generally proportioned the percentages of related pie slices like PMT62 instead of calculating the frequency of two data group like PMT81. The rate of answers given compatible with institutional recognitions being correct is above 70%. In this direction, it may be said that in general the knowledge of pre-service teachers obtaining information from pie chart is compatible with institutional recognitions.

In the interviews, pre-service teachers put emphasis on the concepts of circle, angle, rate and percentage while stating their opinions about pre-knowledge required for pie chart. In this context, PMT47 talked about his/her

**Table 9.** The classification of the answers belonging to item (c) of the fourth question including the task of conversion pie chart into graphs proper to data.

Answer		(c) Draw a graph in another type displaying the time spent for each activity in a day	
		f	%
Drawing rectangles at the heights equal to the frequency of the data groups (τ5)	Correct drawing	78	69.64
	Incorrect drawing	1	0.89
Showing the data groups at certain intervals and with adjacent rectangles (τ9)		14	12.5
Connecting the consecutive points that represent the data (τ8)		2	1.79
Unanswered		19	16.19



**Figure 8.** Bar graphs drawn by (a) PMT32 and (b) PMT56.

experiences in his/her educational life related to pie chart.

*“While pie chart was taught me, teacher draw pie chart after instructing angle, rate and circle first. While using the information given in the graphic, for example while looking for the biggest amount, we were getting results by proportioning the area with the number in the big pie slice. We were correlating the angles in the sliced pie with 360° and judging about data. The operations we do are the same. We are reaching a conclusion while interpreting pie chart by proportioning angles with 360°.”*

In the (c) item of the fourth question, the pre-service teachers are asked to fulfill conversion of pie graphs into other graphs appropriate for the data (T10) task type. Within the frame of determined institutional recognitions, τ12 (creating a bar graph by placing the variable values of the relevant data groups on the axes and drawing bars at the height equal to the frequency of these data groups) or τ11 (creating a line graph by determining the points that represent the data on the axes and consecutively connecting these points to each other) techniques in order to convert pie chart into other proper graphs. In the context of the question, activity data given in pie chart, because of being categorical and discrete, is more convenient to be converted into bar graph. The classification of the techniques which pre-service teachers

used for converting pie chart into other graphs proper to data is given in Table 9.

When Table 9 was examined, it was seen that 69.64% of the pre-service teachers who drew bar graph by using τ5 technique draw the graphic correctly, 0.89% of them made incorrect drawing, 12.5% of them drew histogram by using τ9 (showing the data groups at certain intervals and with adjacent rectangles) technique; 1.79% of them formed line graph by using τ8 (connecting the consecutive points that represent the data) technique and 16.19% of them did not answer this question. In Figure 8, the graphics which was drawn by PMT32 and PMT56 who drew bar graph by using τ5 technique are given.

When Figure 8 was examined, it was seen that PMT32 proportioned the quantiles and benefited from algebraic statements in order to draw the graphic and find the time reserved for each activity. According to this, s/he solved the equation which s/he set up by equating 24 h to the total time s/he found out, he calculated the time reserved for each activity by finding the rate and drew equidistant bars at the same height with this time periods. As for PMT56, s/he drew the graphic by using the same technique (τ5), but while s/he was drawing bars at the same height with the frequency of data, s/he placed the bars to incorrect axes and did not complete the graphic. Even though the graph drawn is a bar graph the drawing of the pre-service teacher did not coincide with the

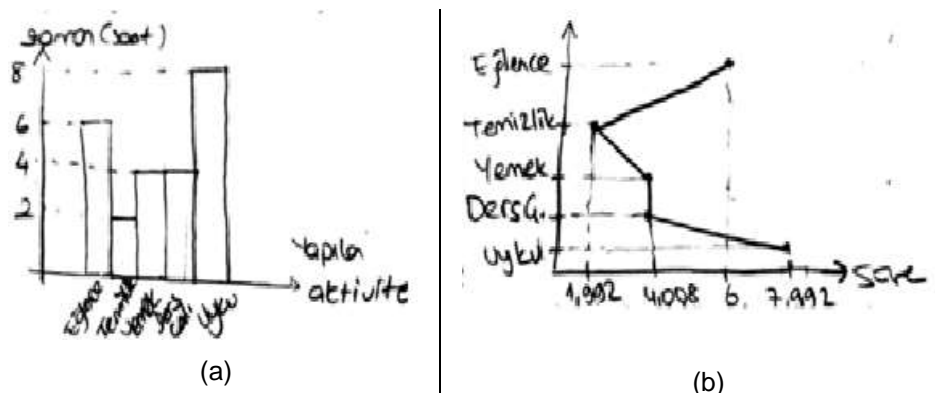


Figure 9. The histogram and line graph drawn by (a) PMT74 and (b) PMT100.

Table 10. The classification of the answers belonging to (a) and (b) items of the seventh question including the task of obtaining information from histogram.

Answer	Question items				
	(a) Which class interval has the highest frequency?		(b) Is there any class interval having the same frequency? If there is, how did you determine these intervals?		
	f	%	f	%	
Calculating the height and width of bars ( $\tau_4$ )	Correct result	18	16.07	18	16.07
	Incorrect result	-	-	-	-
Calculating the height of bars ( $\tau_1$ )	Correct result	-	-	63	56.25
	Incorrect result	63	56.25	-	-
Other		16	14.29	14	12.5
Unanswered		15	13.39	17	15.18

N=112.

determined institutional recognitions. Because while the height of the bars should represent the scalar quantity, in this graph the heights of the bars were matched with activity variables. In addition, the scaling made on horizontal axis being erroneous attracted attention. The height of the bars started to decrease through right. Yet, in institutional recognitions, it was specified that the graphic proceeded in a way increasing to the right (American Statistical Association, 1915).

Histogram and line graph is more convenient for discrete, continuous data. But, according to context given in pie chart, activity variable is a categorical variable. In this direction, the graphics of PMT74 for fourth problem who used  $\tau_9$  technique and PMT100 who used  $\tau_8$  technique are given in Figure 9.

PMT74 who drew histogram wrote the time reserved for each activity by calculating the percentages given in pie chart approximately and drew the graphic by connecting the bars. Also, PMT100 calculated the activity times in the form of decimal numbers; he drew the graphic on a form that activities are on vertical axis and time is on horizontal axis considering data as continuous. In these drawings which are not compatible with institutional

recognitions, the rate of pre-service teachers drawing histogram are quite higher than the ones drawing line graph. In this direction, it is thought that pre-service teachers confuse bar and line graph. In the conducted studies, it was stated that the confusing of bar and line graph originates from not paying attention to the differences between these two graphs (Capraro et al., 2005; Tairab and A-Naqbi, 2004). As seen from the histogram drawn, histogram resembles bar graph structurally. But, two graphs have different characteristics with regards to displaying of numerical and discrete data, stating frequency as area and drawing of bars adjacently (Friel et al., 2001; Lee and Meletiou, 2003).

In the seventh question of the scale, pre-service teachers are asked to fulfill the task of obtaining information from inequally spaced histogram ( $\tau_4$ ). According to institutional recognition, the technique of calculating the height and width of bars ( $\tau_4$ ) is used while obtaining information from histogram. In Table 10, the classification of the techniques used in this task is presented.

When Table 10 was examined, for the item (a) which the class interval having the highest frequency is asked, it

was seen that 16.07% of them used calculating the height and width of bars ( $\tau_4$ ) technique, 56.25% of them used calculating the height of bars ( $\tau_1$ ) technique, 14.29% of them used other technique by calculating the width of bars and 13.39% of them did not answer this question. And for the item (b) it was seen that 16.07% of them answered correctly by using  $\tau_4$  technique, 56.25% of them answered correctly by using  $\tau_1$  technique, 12.5% of them used other technique by calculating the width of bars and 15.18% of them did not answer the question. For the item (b), it was determined that since the calculation of the areas of the bars or the heights of the bars did not change the result, the answer of the pre-service teachers which used either  $\tau_4$  or  $\tau_1$  technique is correct. The answers given by PMT110 used  $\tau_4$  technique, PMT100 used  $\tau_1$  technique and PMT62 used other technique for the task of obtaining information from histogram. When the answers given by pre-service teachers are examined, it was seen that PMT100 used  $\tau_4$  technique by calculating the areas of bars and answered both items correctly according to institutional recognitions. PMT100 used  $\tau_1$  technique by calculating the heights of bars and specified that the frequency is 12 for item (a). These pre-service teachers who used two different techniques ( $\tau_1$  ve  $\tau_4$ ) stated that there is no equal-frequency class interval which is the correct answer for item (b). PMT62 who used the other technique by calculating the widths of bars which was not determined in institutional recognitions interpreted the histogram according to the width of bars in both items. When the answers of the pre-service teachers for the task of obtaining information from histogram (T4) were examined; it was concluded that the individual recognitions of most of the pre-service teachers (70.54%) are not compatible with institutional recognitions. While pre-service teachers read histogram, they mix histogram with bar graph by calculating the height of bars instead of their areas ( $\tau_1$ ). Also in the task of creating bar graph (T5), it was seen that the drawings which are not compatible with institutional recognitions are histograms. In this context, it is considered that pre-service teachers participating in the research experienced serious problems about distinguishing bar graph and histogram. This situation shows that pre-service teachers could not interpret the concepts of group width and group number in histogram (Ulusoy and Çakıroğlu, 2013).

30% of the interviewed pre-service teachers specified that histogram is the most troubling graph type. In this direction, the opinion of PMT17 about histogram is as below:

*“Histogram may be the most troubling graph type. Because histogram can be confused with bar graph. Histogram may be perceived as bar graph and the area may be neglected. Namely, we can read histogram like bar graph. After all, they are quite alike, the only difference between them is with regards to gaps between*

*bars.”*

As can be understood from the expression of PMT17, it was seen that the answers of teacher pre-service teachers about histogram coincide with the institutional recognitions of bar graph. Within this scope, it is considered that there are deficiencies in theoretical knowledge of pre-service teachers related to differences between two graphics and the usage of these graphics for which data is more suitable. In the eight question of GCKS, there are seven items measuring the theoretical knowledge related to basic features of bar graph, pie chart, line graph and histogram within the scope of the research, in which cases it is proper to use them and how they are drawn. The classification of the answers given by pre-service teachers about these items is given in Table 11.

According to Table 11, for the item (a) related to graph type displaying the rates of variables in a whole with percentage or central angle measurements, 96.43% of the pre-service teachers answered as pie chart and 3.57% of them did not answer.  $\theta_2$  which is the common technology of mathematical organisations of creating graphics according to institutional recognitions and making proper conversions between graphics explains graphic definitions and proper usage conditions. In this direction, the graph type which is suitable for displaying the rates of variables in a whole is pie chart. In addition, in the item,  $\tau_7$  technique which is used in the drawing of pie chart is stated with regards to creating of graphic. Pre-service teachers, while drawing pie chart, made drawings which are incompatible with institutional recognitions at the rate of 23.21%. In this context, it was seen that pre-service teachers are more successful in cases requiring theoretical knowledge than requiring practice.

It was seen that for the item (b) asking the proper graph to display the change of data by time 75.89% of the pre-service teachers answered as line graph, 8.93% of them bar graph, 3.57% of them histogram, 0.89% of them frequency table and 10.71% of them did not answer. Within the frame of related technology ( $\theta_2$ ) in institutional recognitions, it was specified that the suitable graph type for displaying the change of data by time is line graph. Even though, it was answered as different graph types (bar graph, histogram) apart from line graph, the rate of these is quite low (12.5%). In this direction, it can be said that pre-service teachers are aware of theoretical knowledge related to intended use of line graph in general.

According to Table 11, it was seen that for the item (e) which straight line graph is correlated with graph types, 59.82% of pre-service teachers preferred line graph, 0.89% of them preferred frequency polygon and 6.25% of them mentioned different concepts such as coordinate system, axis, slope, equation. While line graph is formed within the frame of mathematical organisation of

**Table 11.** The classification of answers related to graph types.

Answer	Figure graph		Bar graph		Line graph		Pie chart		Histogram		Frequency Polygon		Frequency/ scoretable		Other (equation, slope, etc.		Unanswered	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
a) The graphic displaying the rates of variables in a whole with percentage or central angle measurements .....							108	96.43									4	3.57
b) ...is proper to display the change of data by time.			10	8.93	85	75.89			4	3.57			1	0.89			12	10.71
c) Bar graph and .....are different from each other in terms of gaps and area.					15	13.39	7	6.25	68	60.71	5	4.46					17	15.18
d) .... The frequency of each class is represented by the areas of adjacent bars whose vertical axis is parallel.			17	15.18	1	0.89			64	57.14	11	9.82	1	0.89			19	16.96
e) ..... is also the line graph.					67	59.82					1	0.89			7	6.25	37	33.04
f) .....is formed by the marking of the values of data on horizontal and vertical axis and connecting the determined points.			1	0.89	92	82.14			2	1.79	2	1.79			1	0.89	14	10.71
g) ..... is more suitable for the comparison of different classified data sets.	1	0.89	43	38.39	6	5.36	6	5.36	11	9.82	5	4.46	5	4.46			35	31.25

creating graphic (MO2), it was specified that line graph which was created in case of data being continuously increasing, decreasing or fixed is the straight line graph. In this context, all of the answering pre-service teachers except 7.14% of them answered as line graph. But, since the question requires reasoning, its rate of being answered is lower than other line graph questions. According to Table 11, it was seen that for the item (f) which stands for line graph creating technique, 82.14% of pre-service teachers preferred line graph, 0.89% of them bar graph, 1.79% of them histogram and frequency polygon, 10.71% of them did not answer the question, whereas 1 pre-service teacher answered polygonic graphic in the category of "other". In institutional recognitions, line graph is formed with connecting the consecutive points that represent the data (τ8). Pre-service teachers could implement this item representing theoretical data related to

creating line graph in the third and the sixth questions. In this direction, it can be said that the individual recognitions of most of the pre-service teachers are compatible with institutional recognitions.

When Table 11 was examined, it was seen that for the item (g) which the more suitable graph type for the comparison of different classified data sets is asked, 38.39% of pre-service teachers answered as bar graph, 9.82% of them histogram, 5.36% of them pie chart and line graph, 4.46% of them frequency polygon and frequency table, 0.89 of them figure graph and 31.25% of them did not answer the question. In determined institutional recognitions, the comparison purpose of the graphics is emphasized in technology element of the organisations in which the definitions and usage situations of graphics are stated. In this context, the rates of answering as each category being close to each other except bar graph show

that the opinions of the pre-service teachers are compatible with usage of graphics generally for comparison purposes in institutional recognitions. In this context, pre-service teachers expressed that figure graph, frequency polygon and frequency tables are also used for data comparison along with all graph types within the scope of the research.

For the item (c) about graph types specifying that bar graph and histogram are different from one another with regards to gap and area, 60.71% of pre-service teachers preferred histogram, 13.39% of them line graph, 6.25% of them pie chart and 4.46% of them frequency polygon and 15.18% of them did not answer the question. The graph types differ from each other in terms of area and gap within the frame of theoretical block of organizations of graphic creating and making appropriate conversions between graphics. In this direction, it was seen that more than half of the

pre-service teachers distinguish histogram and bar graph in terms of theoretical knowledge. But, in the seventh question of the scale directed for obtaining information from histogram, 56.25% of the pre-service teachers confused bar graph with histogram; they used for histogram the valid technique for bar graph according to institutional recognitions. Within this scope, the rate of correct answering for theoretical knowledge and the usage of techniques which are incompatible with institutional recognitions in implementation, in using knowledge are nearly the same.

According to Table 11, for the item (d) in which the technique used related to creating of histogram which class frequency is represented by the areas of adjacent bars parallel to vertical axis is specified, 57.14% of pre-service teachers answered as histogram, 15.18% of them bar graph, 9.82% of them frequency polygon, 0.89% of them line graph and 16.96% of them did not answer the question. Within the organization of graphic creation, it is known that in order to create histogram, adjacent rectangles at regular intervals are drawn ( $\tau_9$ ). In this context, half of the pre-service teachers know how histogram is drawn according to institutional recognitions. In the formed mathematical organisations, the explanation of how the graphics are drawn constitutes the technology element of graphic reading and interpreting organisation. In this context, it is considered that pre-service teachers not knowing the histogram forming technique compatible with institutional recognitions affects their graphic interpretations in a negative way. In addition, giving answers which are not compatible with institutional recognitions to other questions of GCKS related to histogram supports this situation.

In the scale, branched tree including theoretical knowledge about the graph types within the scope of the research is given in order to describe their general judgement about the characteristics of graph types. In this context, pre-service teachers are asked to reach a point of exit by deciding whether the sentences are true or false. According to this, the classification of the answers of the pre-service teachers are presented in Table 12.

When Table 12 is examined, it was seen that 80.36% of the pre-service teachers reached to correct exit door by evaluating the general statements given in the question correctly. It was seen that 7.14% of the pre-service teachers reaching the incorrect exit have the opinion of "The biggest number marked on the axes represents the maximum value reached.", 5.36% of them have the opinion of "Graphics must always intersect two axes", 3.57% of them have the opinion of "In pie chart, the variables are only represented with percentage" and 0.89% of them have the opinion of "In bar graph, there is the condition of sorting name data."

In the interviews, pre-service teachers are asked whether there is a theory about graphics or not. Within this scope, 20% of the pre-service teachers answered "I

have never heard a theory about graphics", 30% of them "I think there is no theory. And if there is, I do not know about it." and 40% of them "I do not know." In the interview made with PMT17, the pre-service teachers expressed his/her opinion about the theory as below:

*"Probably there is theory. But we don't know that. In fact, before coming to the university, we did not even know what was theorem, what was proof. But during our educational life, graphics are always instructed based on examples. Generally, we were reading the graphic drawn on the board or we were rarely drawing graphics. Because drawing graphics were taking time. Moreover, I think we started learning graphic drawing in the analysis lessons."*

In his explanation, PMT17 stated that they have never been confronted with knowledge structures which take place in theoretical block about graphics in their educational life and they reached to bachelor's level despite their insufficiency of knowledge. In this context, it is thought that pre-service teachers embrace knowledge without interrogating its reasons.

## DISCUSSION

In the research conducted for examining the content knowledge of pre-service teachers participating in the research related to graphics anthropologically, content knowledge of pre-service teachers was examined based upon institutional recognitions related to graphics determined by Akar and Dikkartın Övez (2018). The answers of the pre-service teachers given in GCKS and interviews were analysed within the frame of praxeologic elements of mathematical organisations of habitat and niche of graphics, graphic reading and interpreting, creating graphic and making appropriate conversions between graphics which were determined in institutional recognitions.

In the direction of ecological approach, it was seen that in general, pre-service teachers who participated in the research stated the habitat of graphics as data processing, learning field, equations and inequations, problems, slope and functions subjects and data analysis, data collection and organisation, and its function (niche) as comparison and correlation, facilitating learning-teaching and the teaching of the subjects of ratio-proportion, slope, function, equations etc. It was determined that along with these answers compatible with institutional recognitions, in the habitat of graphics, they also answered logic learning field and subjects of derivative, integral and trigonometry; and in its niche they answered tabulating for displaying data, drawing attention in learning-teaching, facilitating making numerical operation and teaching parabole and hyperbole curves. It was determined that the rate of these answers which

**Table 12.** The classification of the answers belonging to the ninth question.

Answer	f	%
Correct	90	80.36
The biggest number marked on the axes represents the maximum value reached.	8	7.14
Graphics must always intersect two axes.	6	5.36
In pie chart, the variables are only represented with percentage.	4	3.57
In bar graph, there is the condition of sorting name data.	1	0.89
Unanswered	3	2.68

were incompatible with institutional recognitions is 3.84% for habitat and 4.76% for niche. In this direction, it was concluded that generally the individual recognitions of pre-service teachers related to habitat and niche of graphics in the institution is compatible with institutional recognitions.

When the answers given by pre-service teachers in order to fulfill the task types determined within the frame of praxeological approach were examined, it was considered that in the task of obtaining information from graphics, graphic creation and conversion between graphics which requires the usage of techniques related to practical block of mathematical organisations, in general, the individual recognitions of pre-service teachers are compatible with institutional recognitions except for histogram. It was seen that in mathematical organisations of graphic reading and interpretation related to histogram within the frame of institutional recognitions and graphic creation, more than half of the pre-service teachers experienced difficulty in distinguishing task types related to bar graph and histogram. Within this scope, it was determined that in the task of obtaining information from histogram (T4), they used calculating the heights of bars ( $\tau_1$ ) technique which is valid for bar graph in institutional recognitions instead of using calculating the height and width of bars ( $\tau_4$ ) technique. A similar case was seen in mathematical organisations of making appropriate conversions between graphics and graphic creation. In this direction, for the task of creating bar graph (T5), instead of using drawing rectangles at the heights equal to the frequency of the data groups ( $\tau_5$ ) technique, pre-service teachers used showing the data groups at certain intervals and with adjacent rectangles ( $\tau_9$ ) technique which was determined for histogram creation (T8) task. It was determined that, in the answers given to the questions directed in the scale and interviews related to theoretical blocks of mathematical organisations, the correct answering rate of items related to histogram is low and the pre-service teachers are directed to bar graph in their answers. In this direction, it was concluded that pre-service teachers have deficient and incorrect knowledge which are not compatible with institutional recognitions in their individual recognitions related to histogram and bar graph.

In the other studies conducted about graphics (Bruno and Espinel, 2009; Capraro et al., 2005; Lee and Meletiou, 2003; Tairab and Al-Naqbi, 2004), it was seen that bar graph and histogram were used instead of each other without considering the differences between them, similar to the results obtained from the research. It was concluded that institutional infrastructure of education situations given to individuals about histogram is an important factor in the learning of the individuals. It must be taken into consideration that the teacher understandings (Ulusoy and Çakıroğlu, 2013) which regards histogram unnecessary by not interpreting the histogram knowledge during their education and by thinking that it has no difference from bar graph dominated the teaching processes (McLeod, 1992; Thompson, 1984). In this context, it can be said that the curriculums including graphic knowledge which changes according to social and cultural needs (Chevallard, 1991) led to conceptual knowledge insufficiency (Baki and Kartal, 2004) of pre-service teachers who are in the position of student in didactic system about histogram. This graphical type, which has recently entered the curriculum in the elementary years of teacher candidates has been exited from the curriculum again in which the candidates have not yet completed their education life (MoNe, 2013, 2017). In this direction, it is suggested that knowledge of the teacher be examined by taking institutional recognitions determined by ecological and praxeological analysis of the documents such as textbook, curriculum which are used in teaching as a reference and curriculums modified due to educational policies should include the concepts required for mathematical literacy. Anymore, studies in recent years have focused on how to teach better than what to teach.

In cases where individual and institutional recognitions are not consistent, related individual is not regarded as a good subject of the institution. In this direction, it is considered that the individuals which will undertake the task of instructor cannot conduct qualified teaching related to the institution. It is predicted that the differences between the knowledge in the institution and the knowledge which the individuals who will transform this knowledge to the students have will cause the students to diverge from the institution in learning knowledge. From

this point of view, the differences between the knowledge of the individuals in the role of instructor and the knowledge in the related institution should be determined and eliminated. So minimization of failure situations which students will experience in the future and their developing mathematical concept compatible with institutional values can be provided.

Another important finding related to content knowledge of pre-service teachers about graphics is that the theoretical knowledge of the pre-service teachers related to graphic reading, interpreting, creating and transforming is not at an adequate level. While pre-service teachers use the techniques in mathematical organisations they are not aware that these techniques are valid or not. In the interviews, it was seen that pre-service teachers explain the method (technique) of fulfilling task types related to graph types, but they could not explain why they use that technique. Within the frame of determined organisations, the pre-service teachers using mathematical knowledge only in practical sense prevents the development of level of mathematical thinking (Po-Hung, 2003) which exists with skills such as guess, reasoning, proving etc. in the field of mathematics which has a unique structure (Alkan and Bukova Güzel, 2005). In this direction, it is thought that teaching which is conducted by individuals which have low mathematical thinking capacity transferring to others the information he/she got by memorising without a reason will not be in the requested level. Since taught knowledge is not the simplified version of academical knowledge (Artigue and Winslow, 2010), it is emphasized that knowledge to be learned is to be learned by experience and forming new knowledge from the prior one in an active way like a mathematician (Altun, 2006; NCTM, 2000). In this context, in the teaching of graphic subject practical knowledge and theoretical knowledge should be given in a balance. The validity of the methods used in the implementation and applicability of different methods should be interrogated by benefiting from the historical development of graphics along with graphic reading, interpreting and drawing activities in the teaching process. In the teacher education, how to teach the knowledge structure of the target group of the teacher is discussed within the framework of special teaching methods lessons, it is applied in schools within the framework of the lessons such as school experience and teaching practice. Even though pre-service teachers take the theoretical part of the information required in the content knowledge courses, they do the theorems and proof studies at a higher level than the theory of the knowledge to be taught. The theoretical knowledge should be consistent with its application. It may be appropriate that how information is to be taught and the history of science including the theory target approach the knowledge to be taught in a common way. The differences can be examined by performing longitudinal investigations covering all of the knowledge that have

been transformed in further studies.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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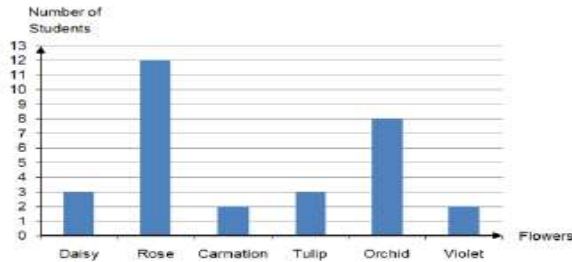
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APPENDIX

GRAPHIC CONTENT KNOWLEDGE SCALE

- Please give information about the concept of graph and its usage in mathematics. Where are the graphics located in mathematics?
- 



In the above graph, the most popular flowers in a class and the number of students who love these flowers are given. According to this graph;  
 a) Which is the most popular flower?  
 b) What is the rate of the students who love the rose to all the students in the class?  
 c) Draw circle chart showing circle slices with center angle measurements.

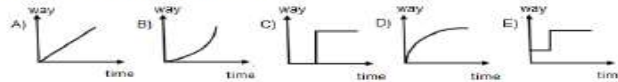
- After shopping, Ali and Veli's coins are 7 TL and 10 TL respectively. Ali and Veli are saving 4 TL and 3 TL each week for their moneybox. Draw a line graph showing the amount of money accumulated by Ali and Veli in their moneybox during 6 weeks.
- 

The length of time a student allocates activities

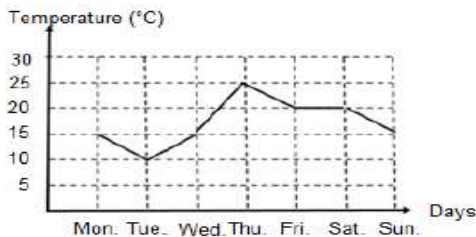


The pie chart shows how a student evaluates a day. According to the chart;  
 a) How many hours do the students sleep?  
 b) What is the rate of time that the student has allocated for lesson studying to cleaning time?  
 c) Draw a different type of graph that shows the time each activity is spent in a day.

- Which one of the following charts shows the way against time that someone who travels first to the east, then to the north, then back to the east at a constant speed?

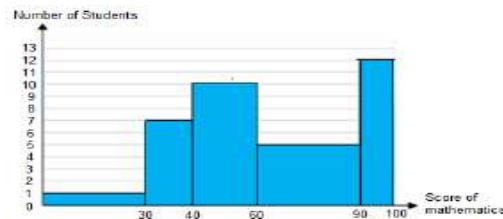


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In the graph on the side, a weekly temperature measurement of city A is given. Redraw the graph by changing its axes.

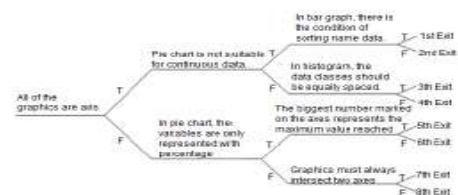
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Look at the graph, the scores of the students in a class are shown in the mathematics exam. According to this graph,  
 a) Which class interval has the highest frequency?  
 b) Are there class intervals with equal frequencies? If so, how do you specify these intervals?

- Fill in the following blanks with the appropriate graph type (s).  
 a) ..... The graphic displaying the rates of variables in a whole with percentage or central angle measurements  
 b) ..... is proper to display the change of data by time.  
 c) Bar graph and ..... are different from each other in terms of gaps and area.  
 d) ..... The frequency of each class is represented by the areas of adjacent bars whose vertical axis is parallel.  
 e) ..... is also the line graph.  
 f) ..... is formed by the marking of the values of data on horizontal and vertical axis and connecting the determined points.  
 g) ..... is more suitable for the comparison of different classified data sets.

- The following are true / false statements about the bar graph, pie chart, line graph and histogram. Specify the exit number that you reached by deciding whether the judgments in these statements are true or false



*Full Length Research Paper*

# Articulation of ethnomathematical knowledge in the intercultural bilingual education of the Guna people

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The aim of this research is to study the fundamental elements used to broaden mathematical knowledge and to establish guidelines for its development using Intercultural Bilingual Education (IBE) framework. This study is an experimental quantitative research. Problem solving pretest and posttest were given to the students of Carti Tupile School (control group) in Spanish and students of Sayla Olonibiginya School (experimental group) in their mother tongue. A didactic guide was used as the learning method in IBE for the fourth grade students of Sayla Olonibiginya School. It was used to motivate them to discover the principles and concepts of mathematics in arithmetic and geometry. The results showed that traditional methodologies are not better than the didactic guide used for contextualized development under the IBE.

**Key words:** Intercultural Bilingual Education, mother tongue, ethno-mathematics, problem-solving, didactic guide.

## INTRODUCTION

This research was conducted at Sayla Olonibiginya School and Carti Tupile School. The participants were primary students (4th grade) from Guna-Yala Region. Pre-test and posttest were applied in Spanish and mother tongue of the participants. Basic mathematical education

is required for developing their mathematical reasoning. It is an unlimited mathematical education for obtaining terminology knowledge and performing mathematical operations. Basic mathematical education also helps one to identify and understand the role that mathematics

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plays; it enables one to make sound judgments. The objective of this work is to use a didactic guide (problem solving strategy) for arithmetic and geometry problems under Intercultural Bilingual Education (IBE) for the fourth-grade students at Sayla Olonibiginya School.

It is required that the students based on the Intercultural Bilingual Education have at least two cultures and two languages. Using Spanish to teach students who do not understand the language mathematics is ineffective. This is evident in the Ministry of Education of Panama, in particular, the census evaluations done with grades III and VI of Basic Education. The children who use more than two languages and those who belong to indigenous communities had the lowest achievement.

There is, therefore, a need to clarify and expand mathematical knowledge based on the IBE framework. The implementation and development of these guidelines will help the learning needs of Panamanian students efficiently and effectively. This will enable them to improve learning conditions, since mathematics and communication makes one to be competent in other curricular areas. Therefore, the didactic guides that are presented in the proposal consist of:

1. Entering sums and identifying the place value of the digits of a natural number: Students write their answers in the guide, then discuss, and check answers and use arithmetic writing as a conclusion.
2. Adding decimal numbers: There are three different techniques used to find the sum of decimal numbers. Students in Activity No. 1 can present the techniques of addition in column. In Activity No. 3, students can build their hypotheses on the calculation, compare them with reality, reject errors and look for a mathematical explanation.
3. Using different materials to represent  $\frac{1}{2}$ : The students are to use the representation of flat figures, while in reality, there exists many forms that represent  $\frac{1}{2}$ .
4. Recognizing the concept of perimeter (activity 4): It is necessary that the learning of this concept is done using real-world models and objects and in a way that allows the students to acquire perimeter concepts that are generally very abstract.

All the activities of the didactic guide involve Gunas' practices. In Activity 4, the students are asked to make a mola (textile sewn with complex designs by the Gunas with realistic and abstract representations of flowers, animals and sea); the students are asked to recognize the perimeters of the said representations involved as other geometric elements. The notion of geometric figures developed by Guna women in the making of molas, connecting ethno-mathematics with school

mathematics was contextualized.

Through the didactic guides, this proposal motivates students to discover the principles and concepts of mathematics in arithmetic and geometry. It gives one the ability to wonder, to understand how and why things happen, and be involved in the systematic search for answers. It is expected that the application of the didactic guides proposed in this work, under the problem-solving approach, will significantly affect students' learning.

### Theoretical framework

Panama, rich in diversity and with an intercultural education, recognizes ethno-mathematics as part of their math education; it makes mathematical knowledge valid in its cultural context. In IBE, mathematics syllabi include ethno-mathematics expressed in students' original language and the mathematics of the national curriculum. The goal of IBE is to develop the languages, cultures and knowledge of each indigenous nationality without giving up on understanding Spanish (Fabara, 2017).

From a perspective of facilitating the development of an intercultural mathematical education and considering the contributions of researchers (D'Ambrosio, 1985; Bishop, 1988; Ascher & Ascher, 1981; Urton, 2003), who have studied the relationship between mathematics and culture, and based on the studies that we have been doing since the 80s, this paper aims to show the knowledge of the identified socio-cultural group based on the following activities: counting, measuring, locating, designing, playing and explaining. This implies that both the knowledge of mathematics and the ethno-mathematics of one's own culture constitute curricular content. It is achieved by students together with the development of their skills and attitudes. In this sense, ethno-mathematics is oriented towards helping students to live in harmony with Mother Earth, identify with their culture and solve problems in their own context. Learning mathematics helps them to solve other real problems and facilitates their link with other cultures.

From an intercultural perspective, indigenous mathematics or ethno-mathematics and the national mathematics curriculum have the same values. Teachers take into consideration the linguistic background of the students they teach. During the learning process, they use the language they understand and propose activities that enable the proper articulation of their own ethno-mathematics knowledge using national curriculum mathematics knowledge.

In recent years, many countries have incorporated problem-solving strategy into their curriculum either as a transversal axis or as a content. Some people consider it as applying previously acquired knowledge in new and

unknown situations or to solve practical problems related to everyday's life situations. In other countries, the development of problem-solving strategies is emphasized and it is suggested that they should be used as basic heuristics for problems resolution, according to Pólya (1965). Singapore designed its mathematics curriculum for problem resolution; it established the use of heuristics for it, through the so-called "model". Currently, Costa Rica has adopted the Educational Mathematical Reform Project that began in 2012. Therefore, there are countries that have spoken on this subject for thirty years, but others are quite new. This depends on the context and the country, but the important thing is to know that it is an old issue in the curriculum (Gaulin, 2001).

In addition, different entities such as the Association of Teachers of Mathematics (ATM), the National Council of Teachers of Mathematics (NCTM) and the Organization for Economic Co-operation and Development (OECD) have promoted the inclusion of problem solving strategy in teaching mathematics. These institutions have been able to influence curriculum development in many countries, since they show an effort to identify problem-solving as the main axis of mathematics education (Santos-Trigo, 2008; Schoenfeld, 2007).

Taking this current trend into account, problem-solving strategy can help to implement educational environments in which the students participate with peers in solving mathematical problems. Schoenfeld (1992) proposes that problems be solved in small groups, in order to promote the development of skills related to a subject, so that each one can learn how others control their work.

Besides, NCTM states that when students think, argue and communicate their ideas to others, either in writing or speaking, they are often clear and convincing. Learning to expose and solve problems is adopted as a central strategy to generate those skills. The intellectual challenge is consubstantial for an intelligent and motivating classroom work.

Therefore, the didactic guide has many functions, including suggesting curriculum approaches, promoting self-learning and encouraging students to study by themselves (Aguilar, 2004). The strategic plan of the Ministry of Education (2009-2014) proposed that the increase of didactic materials in 2014 offers a Methodological seminars Guide to all teachers in the country; it proposes learning activities that represent an intellectual challenge for students and generate interest in finding at least one way to solve them.

A problem-solving strategy in learning mathematics allows the use of non-routine mathematical situations and conceptual constructions by students. For that reason, it is necessary to use real situations; it is not just to do a routine algorithmic solution exercises that make students to believe that mathematical problems have a single correct answer; there are few problems or activities that involve several reasoning or multiple solution strategies for mathematical problems. Only then, will it be possible

to engage students in an active way. This leads to the following research questions:

Does didactic guide under the Intercultural Bilingual Education lead to better performance than traditional method?

## METHODOLOGY

Mathematics education concept is broader than "teaching Mathematics". In this sense, mathematics education comprises the formal and non-formal educational processes that lead to cognitive-type learning achievement and values development.

In this context, we agree with Bishop (1988) when he says that educating people mathematically is much more than just teaching them some math. It is much more difficult. The problems and pertinent issues constitute a much broader challenge. Solving them requires a fundamental awareness of the underlying values in mathematics and acknowledging the complexity of teaching these values to children. It is not simply enough to teach them mathematics; we must also educate them on mathematics, through mathematics and with mathematics.

The research seeks to help Grade III students of Sayla Olonibiginya School in building their learning, developing concepts with meaning and not only to memorize rules, definitions and algorithms.

Nowadays, socio-constructivist perspective is being adopted. When learning things, cognitive activity does not only help, but also interaction with other people; it is a support factor and it accelerates knowledge (Gaulin, 2001). Guzmán (1993) points out that in relation to the cognitive aspect and development of capacities, that it is mainly interesting to emphasize the thought processes of mathematics, problem-solving, reasoning and communication more than transferring content. Since mathematics is, above all, practical, it is a science whose method clearly predominates over its content. For this reason, high importance is attached to the study, largely bordering the cognitive psychology, which refers to the mental processes of problem-solving.

In fact, in constant change in which we find ourselves, it is evident that many times you have to prioritize some content and leave others aside. Instead, truly effective thought process does not become obsolete so quickly.

This research aims to use the problem-solving strategy as a didactic guide to teach Grade III mathematics class. In this work, the didactic guide was first proposed to the students and then taught how to use it in such a way that it will help their cognitive skills to address modern societal challenges, where information, knowledge and the demand for a greater mental abilities are needed.

Also, it is necessary to clarify that the Guna Yala region schools are located in difficult access areas and the distance between them forced the authors to work with a reduced sample for the study. This means that from 45 schools, 6514 primary school students participated in the study (Meduca, 2013). Therefore, only two schools are taken as sample in this research. The two samples are homogeneous in comparison with the study population, since all the students belong to the same indigenous region, where the curriculum is the same for all the schools using their native language and Spanish. For this reason, the research results are expected to occur in other schools in the region.

Through this study, it is proposed to implement didactic guides as a methodological resource for the benefit of indigenous students and to have better performance. Also, it is suggested that the Intercultural Bilingual Education should be the main focus of problem-solving curriculum, be useful to other researchers for them

to be able to complete the study in other parts of the region.

In this way, the didactic guide as an active strategy contributes to the achievement of educational purposes and serves as a means to promote students' participation, and to obtain a better learning; it also proposes a favorable classroom climate that generates interest in finding different solutions and suggests alternatives for a good way to study mathematics at the primary level.

### Type of investigations

The research is an explanatory model since it supports the description, analysis and interpretation of the knowledge level of arithmetic and geometry of Grade III students of Sayla Olonibiginya School and Carti Tupile School. It is a basic research, according to the classification made by Del Rincón et al. (1992), oriented towards the search for new knowledge on the phenomenon of study; it uses a path of inductive analysis in field study.

### Research design

Nowadays, studies mark a descriptive character, as they aim to describe the methodological aspects of the field research. This is because they are carried out where the problem is presented, thus establishing an interaction between the studies' objectives and reality. However, it is considered that there are quasi-experimental methodology elements because two groups are used (control and experimental): both groups are subjected to previous tests (Shadish et al., 2001). The tests were done in Spanish and mother tongue of both groups. This allows one to estimate population values from smaller size samples. The teachers are in the same groups, and given equal content during the course development.

### Variables

The dependent variable is "Mathematical Learning" and the independent variable is "Didactic guide for solving problems of arithmetic and geometry using the IBE".

### Conceptual definition

#### Mathematical learning

Mathematical learning: NCTM (2000) stated that it is important for the students to learn beyond the rules and be able to express relationships in mathematical language. Schoenfeld (1985) mentioned that the main goal in learning mathematics is to identify connections and to understand the meaning of mathematical structures. Furthermore, he mentions that finding the solution to a mathematical problem is not the end of the mathematical enterprise, but the starting point for finding other problem solutions and extensions. In order to achieve these goals, students need to discuss their ideas, negotiate their points of view, speculate possible outcomes, and use various examples to help confirm or adjust their ideas.

Didactic guide for solving arithmetic and geometry problems in IBE<sup>2</sup>: It is conceived as a structure that fosters students' creative

capacity; it provides them with skills and strategies development tools that allow them to work, research, discover and build their own knowledge with teachers' guidance.

### Operational definition

#### Mathematical learning

Students share the strategies they use in resolving the pre-test problems. In subsequent sessions, the four steps suggested by Pólya (1965) are used. The general idea is that the students, during the learning period, build a frame of reference that will help to understand and solve mathematical problems. However, the students are not expected to strictly use them. The posttest results provide evidence that students show clear qualitative improvement.

Didactic guide presented in the proposal consists of:

1. Identifying the position of the digits of natural numbers
2. Addition of decimal numbers.
3. Representing 1/2 number.
4. Recognizing the concept of perimeter.

When we work with the experimental group, the didactic guide is used and at the end a posttest is applied to both groups. It uses a weighting qualification of requirement from 810 Decree (October 11, 2010) established in chapter 11-12 in elementary, middle and high school stages. The grading scale is one (1) to five (5). The equation below serves as a basis for its generation and can be used to match the grade with any score:

$$C = 4 \times \frac{\text{Score obtained}}{\text{Total score}} + 1$$

In the control group, the teachers use a methodology where their class presents mathematical problems (in Spanish) that are little contextualized. This methodology is what is usually used throughout the Guna Region, which is always displayed in Spanish language.

### Population and purposive sampling

There are 45 students in grade and multi-grade schools in primary education level at Guna Yala Region; fourth grade students consist of 1123 population (Meduca, 2013). Meanwhile, with the fourth grade students, only 36 students from Sayla Olonibiginya and Carti Tupile Schools were worked with. In 2015, the sample consisted of students of the two schools.

### Data collection techniques and tools

The followings are the instruments used for data collection

#### Mathematical knowledge pretest

This was given to the two groups of students (fourth grade) with objective to measure the mastery of the mathematical concepts; the same was written in Spanish and Gunagaya, which is their mother tongue.

decision-making and problem-solving tool for their daily life (General Gunas Congresses, 2011). IBE Guna Curriculum Proposal, p.130.

<sup>2</sup> The curricular proposal of IBE (IBE Guna, formalized by Executive Decree No. 687 of December 23, 2008), seeks to correct, correct and consolidate the educational reality in Guna Yala, for that it should create concrete spaces and times where students not only Learn, but also train and use their knowledge as

### **Mathematical knowledge posttest**

This was given to the same population of students which allowed the authors to know the results obtained in the investigation.

### **Procedures**

Before applying the pretest to the students, they received an induction process as follows:

1. Familiarizing with the experimental situation.
2. Objectives and structure of the test (indications supplied in the test).
3. Developing the ability to perform logical problem-solving processes, using the logical sequence of steps in the Polya's method.

The pretest and posttest problems with significant questions and a close and comprehensible context for children seek to evaluate mathematical problem-solving skills. There is the elaboration, comparison and exercise of procedures, using the Polya's method. All the questions used in the application are multiple-choice ones with only one answer; they have statement and four response options, called A, B, C, D. Only one of them is correct and valid in relation to the situation.

With the didactic guide activities, it is recommended to solve the same problem in several ways. Addressing a problem in different ways, developing arguments for solutions and analyzing which one is better are necessary for mathematics development. In that way, students expand their steps using the Polya's method and then apply posttest to allow a comparison before and after the implementation of the methodological proposal. The data obtained are presented in graphics with explanation and comments which give us a clear result of the research.

### **Data analysis**

As the study is described, the data instrument responses are presented and analyzed in frequency and proportions terms through statistical charts. The results basis and alternatives proposed the use of arithmetic and geometry problem-solving didactic guide, as a learning method in Intercultural Bilingual Education for third grade students of Sayla Olonibiginya School.

## **RESULTS AND DISCUSSION**

Accordingly, with the current trends in mathematics education, students are expected to be competent. This helps them to, which build knowledge, develop skills and attitudes that allow them to have perform with confidence in themselves in many situations for personal, social and work life.

In the Panamanian curriculum Mathematics, competencies must be achieved through the activities carried out by the own students themselves, specially, problem solving, reasoning and mathematical communication processes. Mathematical knowledge requires a construction process and a determined intention to learn. It is necessary to select and organize sequentially, the activities that will be proposed to the

students. In this sense, the activities to be proposed will be selected and organized in levels; they, so that can start from situations that generate processes at a concrete level, then through representations at the graphic and symbolic level. So, students can be supported in the formation of their abstract thinking. It is important to keep in mind that abstraction occurs when students have the opportunity to have done an adequate job in the previous levels.

In the research development, two groups of fourth-grade students from the carti tupile schools (control group) and Sayla Olonibiginya School (experimental group) participated in the study. The first group has 15 students and the second group has 21 students. This research lasted for one week, from 5th to 9th October and from 26th to 30th October, which corresponds to the second month of the third quarter in 2015.

It was considered that the best way to collect information is through the pretest application. The posttest was applied to both groups on the first day. The difference is that for the experimental group, the tests were written in their mother tongue.

The posttest was applied to the two groups, after solving different problems. The exercises applied in pretest were mentioned, using the problem-solving strategy obtained by observations and measurements that are very important for the study. Next, some figures and tables that are necessary were added in the pretest and posttest.

Figure 1 shows the result obtained by the control group students during the pretest of the Table 1; 4 students could not solve any problems, 4 students solved a problem, 4 students solved two problems and 3 students solved three problems; 1.0 to 5.0 scale was used for qualification, according to 810 Decree from October 11, 2010.

Figure 2 shows the result obtained by the control group in posttest of the Table 2. These results are shown in percentage. One student could not solve any problems, 3 students solved a problem, 10 students solved two problems and 1 student could solve three problems. A study reveals that many of the teachers have problems on the expected learning outcomes in other languages (Canbulat and Dilekci, 2015).

Figure 3 shows the results obtained by the experimental group in the pretest of the Table 3; 2 students could not solve any problems, 2 students solved a problem, 3 students solved two problems, 6 students solved three problems, 7 students solved four problems and 1 student solved all the problems.

Figure 4 shows the results obtained by the experimental group in post-test of the Table 4, where 5 students solved a problem, 6 students solved two problems, 1 student solved 1 problem, 4 students solved 4 problems and 5 students solved all the problems. The use of didactic guides translated into the mother tongue



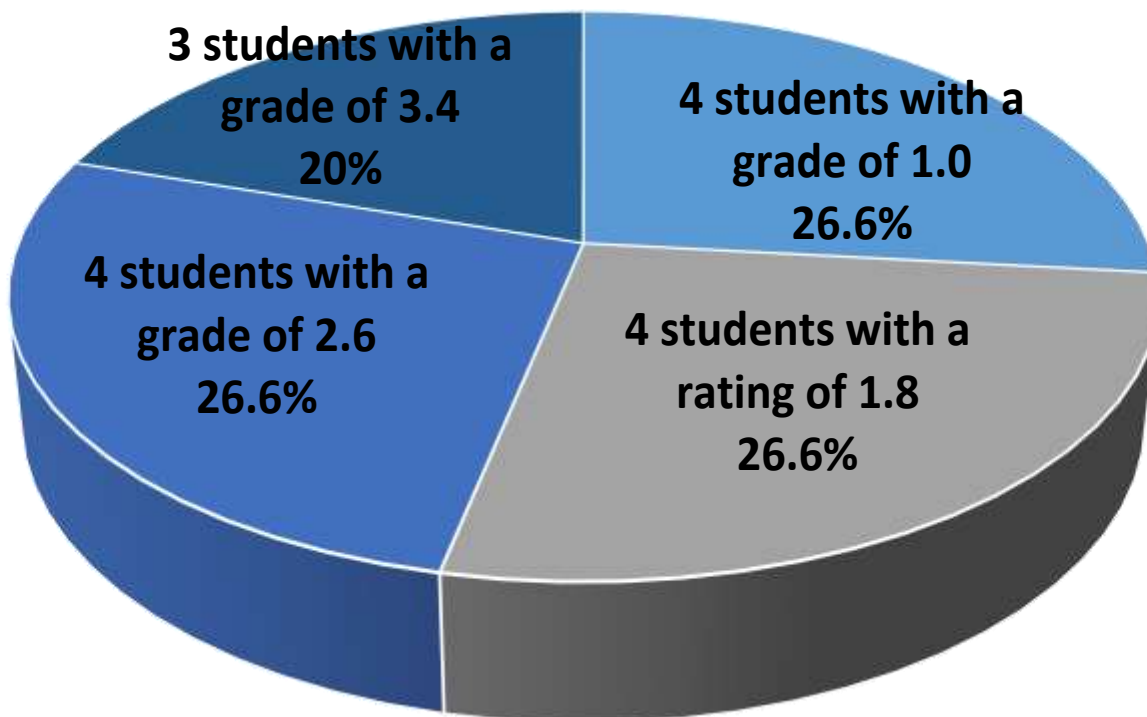


Figure 1. Items solved by students in the pretest test of the control group.

Table 1. Results of the pretest of the control group.

Qualification	Number of students
1.0	4
1.8	4
2.6	4
3.4	3
Total students	15

Source: Pretest applied to the fourth-grade students of the Carti Tupile School.

reflects a substantial improvement in problem solving in the experimental group since it is supported by IBE. In this sense, Naštická (2016) stated that if students are able to understand the problem, then they can solve it.

**Choice of statistical test**

There is a descriptive model with two independent samples, for which the “T” test is used for unrelated data (independent samples).

There is a descriptive model with two independent samples, for which the “t” test is used for unrelated data

(independent samples).

**Approach of the hypothesis**

1. Alternate hypothesis (Ha): There are differences in the mean of the control group and experimental group that properly applied the pretest and posttest using the problem-solving strategy.
2. Null hypothesis (Ho): There is no significant difference in the mean of the control group and experimental group that correctly apply the pretest and posttest using the problem-solving strategy.

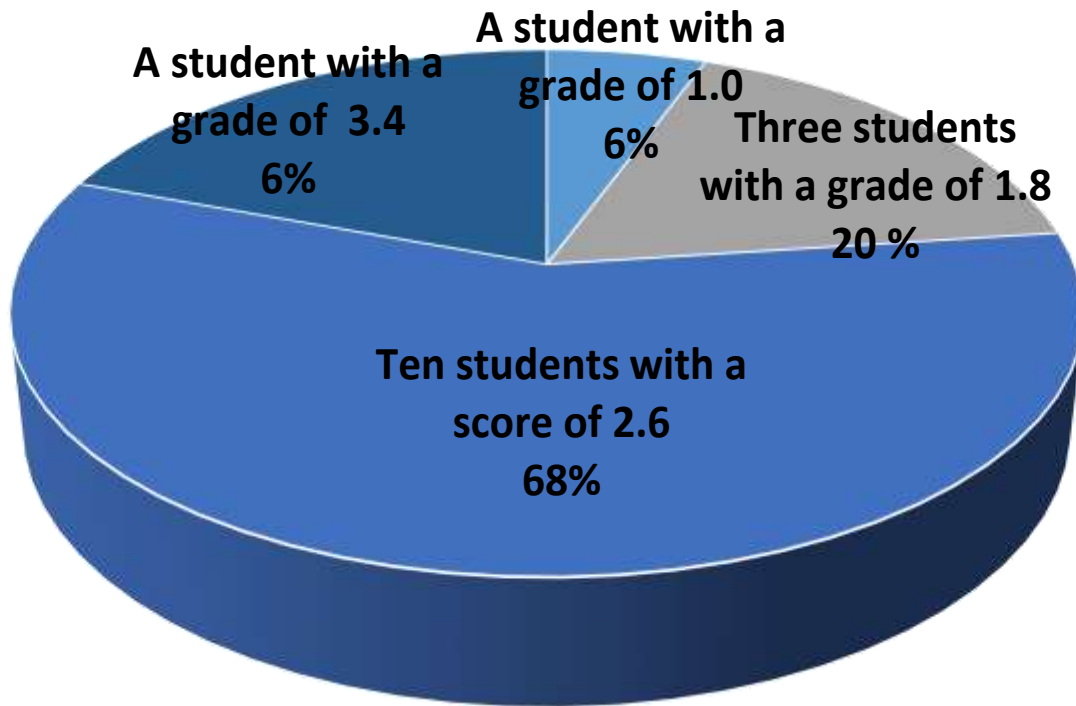


Figure 2. Items solved by students in the control group posttest.

Table 2. Results of the control group posttest.

Qualification	Number of students
1	1
1.8	3
2.6	10
3.4	1
Total students	15

Source: Post-test applied to the fourth-grade students of the Carti Tupile School.

**Level of significance**

For all probability values equal to or less than 0.05, Ha is accepted and Ho is rejected.

**Rejection zone**

For any probability value greater than 0.05, Ho is accepted and Ha is rejected.

$$SC_1 = \sum(x_1 - \bar{x}_1)^2 = 4.4373$$

$$SC_2 = \sum(x_2 - \bar{x}_2)^2 = 31.8781$$

$$\sigma_p = \sqrt{\frac{SC_1 + SC_2}{N_1 + N_2 - 2}} = \sqrt{\frac{4,4373 + 31,8781}{15 + 21 - 2}} = \sqrt{\frac{36,3154}{34}} = 1.0335$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sigma_p \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}} = \frac{2,3867 - 3,3238}{1,0335 \sqrt{\frac{1}{15} + \frac{1}{21}}} = \frac{-0,9371}{0,3494} = -2,6820$$

$$gl = N_1 + N_2 - 2 = 15 + 21 - 2 = 34$$

$$P(t_{34} < 2.7) = 0.994$$

$$P(t_{34} < -2.7) = 1 - 0.994 = 0.006$$

Considering an alpha error of 0.05 (5%), the acceptance

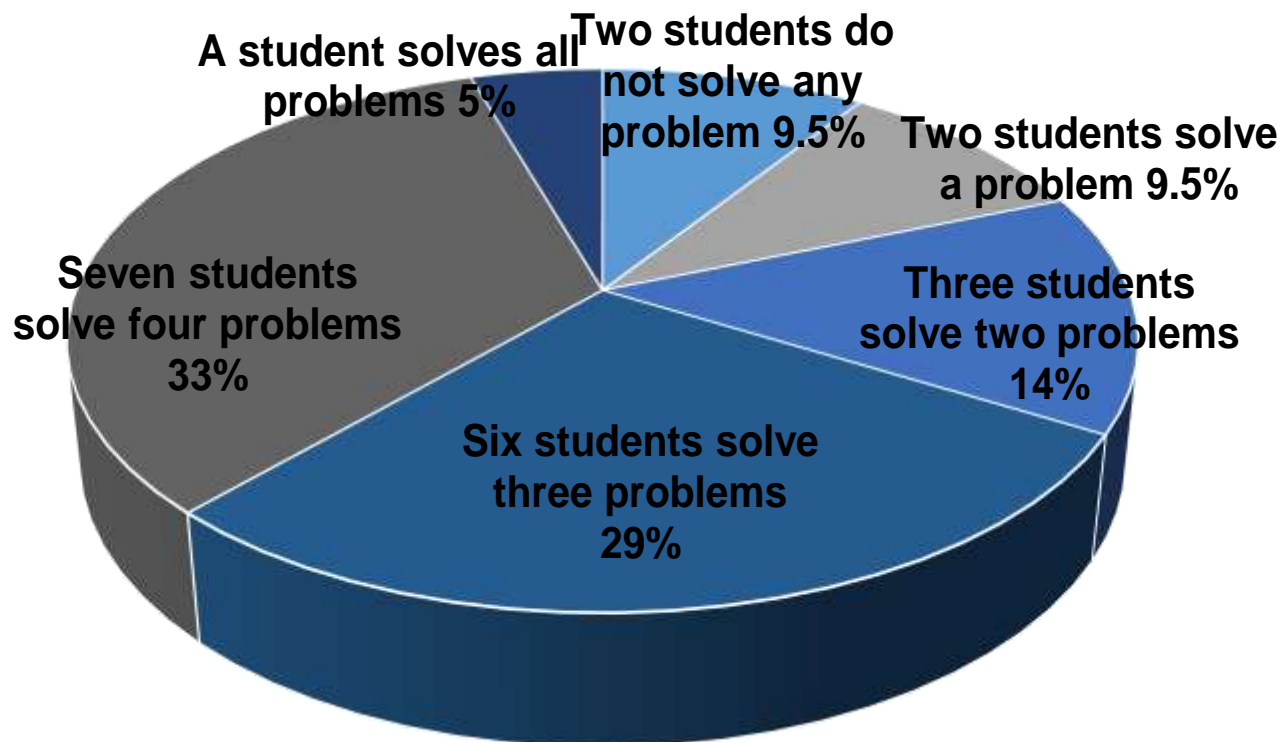


Figure 3. Items solved by students of the experimental group of the pretest test.

Table 3. Results of the pretest test of the experimental group.

Qualification	Number of students
1.0	2
1.8	2
2.6	3
3.4	6
4.2	7
Total	21

Source: Pretest test applied to 4th grade students at Sailsa Olonibiginya School.

region of null hypothesis and the critical region (or rejection of null hypothesis) in a t-distribution of student had an alpha of 0.05 and 34 degrees of freedom in between the critical values of -2.03 and 2.03. These critical values were calculated using the Excel INV function, t (alpha, degrees of freedom), with the probability of 0.975 (1- (0.05 / 2)) and 34 degrees of freedom. Thus, the acceptance region (according to the t-student table) would be between t values greater than –

2.03 and lesser than 2.03 (results obtained using Table 5).

**Decision**

Since the value of t (-2.6820) has a probability of less than 0.006, it is also less than 0.05, where  $H_a$  is accepted and  $H_o$  is rejected. Moreover, since t = -2.6820, which is

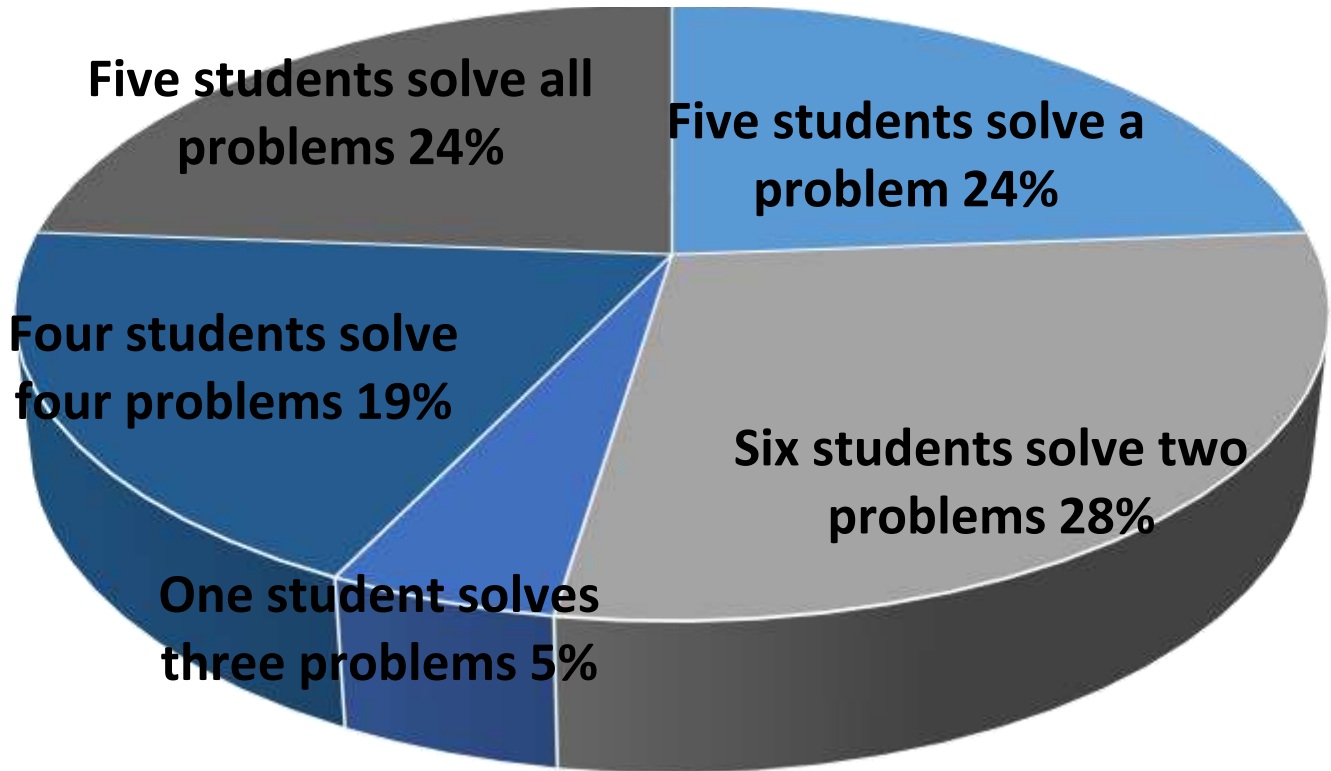


Figure 4. Items solved by students of the experimental group of the posttest.

Table 4. Posttest result of the experimental group.

Qualification	Number of students
1.8	5
2.6	6
3.4	1
4.2	4
5.0	5
Total	21

Source: Posttest test applied to 4th grade students at Saila Olonibiginya School.

less than -2.03 and is outside the acceptance region of the null hypothesis, we accept the alternative hypothesis.

From the research with the two groups (experimental and control groups), there are an initial and a final evaluation; only the experimental group receives the treatment. In order to conclude that the experience is effective, it is shown in Figure 5 that the students of the experimental group (lower box) obtain higher scores than the control group (top box).

The result of the research makes us to change the teaching method and to make appropriate pedagogical use of sequences in which the ethno-mathematics

resources are offered by the culture that stimulates students' mathematical thinking development and contributes to their learning achievement. Several formulas could be used to calculate the effect size. According to Cohen:

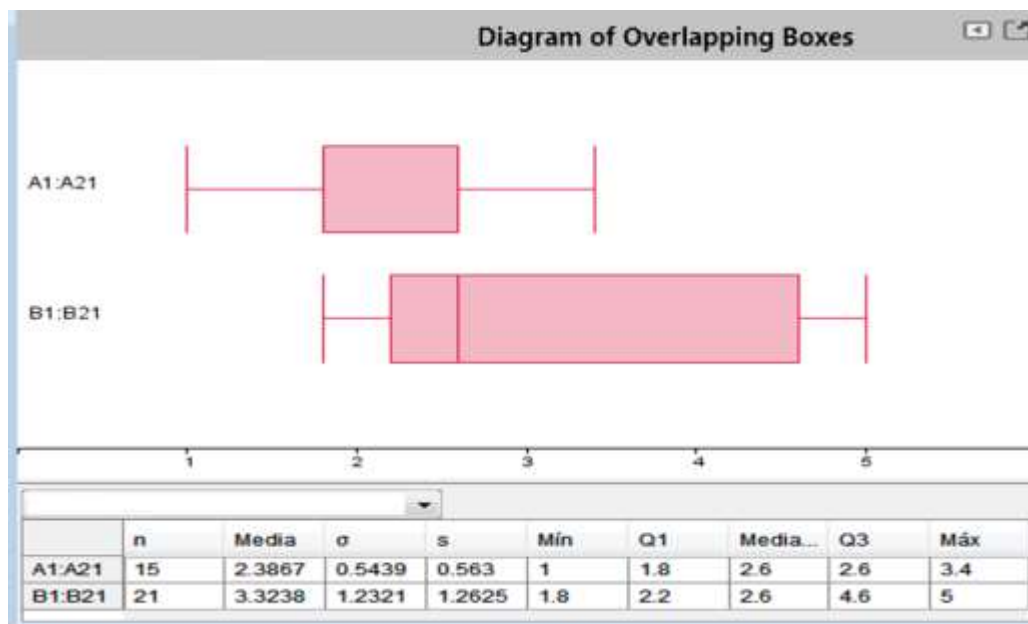
$$d = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{(s_1^2 + s_2^2) / 2}}$$

$$d = \bar{X}_1 - \bar{X}_2 / \sigma \text{ where } \sigma = \sqrt{\sum(X - M) / N}$$

**Table 5.** Qualifications of the control and experimental students in the posttest.

Rating of the control group in the post	Group qualification experimental in the post	$(x_1 - \bar{x}_1)$	$(x_1 - \bar{x}_1)^2$	$(x_2 - \bar{x}_2)$	$(x_1 - \bar{x}_2)^2$
1.0	1.8	-1.3867	1.9228	-1.5238	2.3220
1.8	1.8	-0.5867	0.3442	-1.5238	2.3220
1.8	1.8	-0.5867	0.3442	-1.5238	2.3220
1.8	1.8	-0.5867	0.3442	-1.5238	2.3220
2.6	1.8	0.2133	0.0455	-1.5238	2.3220
2.6	2.6	0.2133	0.0455	-0.7238	0.5239
2.6	2.6	0.2133	0.0455	-0.7238	0.5239
2.6	2.6	0.2133	0.0455	-0.7238	0.5239
2.6	2.6	0.2133	0.0455	-0.7238	0.5239
2.6	2.6	0.2133	0.0455	-0.7238	0.5239
2.6	2.6	0.2133	0.0455	-0.7238	0.5239
2.6	3.4	0.2133	0.0455	0.0762	0.0058
2.6	4.2	0.2133	0.0455	0.8762	0.7677
2.6	4.2	0.2133	0.0455	0.8762	0.7677
3.4	4.2	1.0133	1.0268	0.8762	0.7677
	4.2			0.8762	0.7677
	5.0			1.6762	2.8096
	5.0			1.6762	2.8096
	5.0			1.6762	2.8096
	5.0			1.6762	2.8096
	5.0			1.6762	2.8096
$\bar{x}_1 = 2.3867$	$\bar{x}_2 = 3.3238$		$\sum(x_1 - \bar{x}_1)^2 = 4.4373$		$\sum(x_1 - \bar{x}_2)^2 = 31.878$

Source: Data from field (2016).



**Figure 5.** Final comparison of sample groups.

**Table 6.** Cohen's d

	$\bar{X}$	S	n*
	*Optional – for Hedges g only		
Group 1	3.323	0.543	21
Group 2	2.386	1.232	15

Results: d-based, Cohen's  $d = 0.9839$ , Glass's  $\Delta = 0.7605$ , Hedges'  $g = 1.0249$ .

In this case X is the raw score, M is the mean, and N is the number of cases.

Since the value of Cohen is greater than 0.8 (Table 6), it indicates a high magnitude effect. Therefore, the intervention in the experimental group is viable. The children whose mother tongue is Spanish and understand the original language in the community are taught by the teachers. This would make them not to have difficulties in their Mathematics learning process. In either cases, it is evident that the students will not learn Mathematics if they use a language they do not understand. The only thing that is achieved when the student does not understand a language is that he or she repeats mechanically names of numbers or tables of operations without any meaning to his life; this method of work generates in the students, a negative attitude towards Mathematics (Romero-Bojórquez et al., 2014).

Figure 5 presents the final comparison of the two research groups in which the experimental group scored 0.94 higher than the control group. This shows that problem-solving strategy helps the students to solve problems. In addition, the degree of concentration of 50% of the observations indicates that the students in the experimental group manage and obtain higher grades. Gamboa (2007) argued that a contextualized guide increases the reflection and exploration of the students who use it, which promotes the articulation of their learning processes.

The idea that many of our students have about math is that they are done and the last thing they have to do is to learn the rules, formulas, algorithms and repeat it over and over again because, as we all know, math is an exact science and is already well established. Also, many people think that with mathematics, any problem can be solved. In fact, mathematics is not an exact science and the sense of always giving a perfect result does not exist; on the other hand, good problems must produce new questions. Villalobos (2008) argued that with problem-solving skill, students can develop intellectual skills such as relating, drawing conclusions, organizing and linking mathematical arguments, compare, interrogate, inquire, among others.

Thus, didactic guide under the problem-solving strategy motivates students to discover the principles of mathematics and concepts of some arithmetic and

geometry topics; in this way, the capacity of wondering is fostered and the attitude of asking why things happen is maintained, as well as the systematic research for answers.

The elements that constitute the didactic guide contextualized are the theme, objective, content, didactic resources and development activities. It is considered an activity in such a way that it falls into the students' cognition and identifies information that can be a relationship between data and unknowns patterns.

## Conclusion

It is evident that a lot of the Panamanian heritage can be found in mathematics, and therefore the indigenous people's culture can be found in ethnomathematics. Indeed, architectural monuments, ceramic works, typical textiles of a typical town, among others, are regional resources to be taken into consideration for a design and an activity proposal related to patterns, numeric system, space distribution, geometric shapes, measurement system, plane and space transformation, etc.

The proposal gives special attention to heritage because in many of our towns and cities, there is a great historical and natural wealth that we must know, value and care for. It is important that children investigate their origins, meanings and the archaeological natural monuments that exist in the places where they live. The current work has the following conclusions:

1. Using the IBE learning in grade IV students from Sayla Olonibiginya School from 2015, will improve with the use of arithmetic and geometry didactic guides to solve problems.
2. The posttest proves that students are able to develop different Polya's method stages significantly and improve in their analysis in solving arithmetic and geometric problems.
3. This methodological alternative promotes the interaction between teachers and the students, as well as among the students.
4. The use of traditional methodologies leads to poor algorithmic mathematical knowledge; that is why when students are faced with mathematical challenges, they

tend to have lower academic performance.

## RECOMMENDATIONS

1. Problem-solving strategy should be the main focus of the IBE project.
2. Elementary teachers should propose learning activities that represent an intellectual challenge to the students and generate interest in finding a way to solve them.
3. Students' activities as well as strategies and procedures used to solve problems should be evaluated.
4. The students' previous knowledge should be used as a basis for a new didactic guide development.
5. It is important to present contextualized problems, in which language regularities are visualized in the resolution of arithmetic and geometric problems, supported by specific materials and graphic representation.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Full Length Research Paper*

## Investigation of art literacy levels of fine arts education students

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The purpose of this study is to examine the art literacy levels of fine arts education students. The study group consists of 111 music teacher candidate and 90 art teacher candidate, 201 students in total from Niğde Ömer Halisdemir University, Fine Art Education Branch. The data of the work were collected by "Art Literacy Scale". The study was designed in a causal-comparative research model. In data analysis, "independent groups t-test technique" and "one-way variance analysis technique" were used. As a result of the study, it was determined that art literacy levels are similar in terms of department (music-picture), gender and class level change in education. In terms of the enjoyment of reading art books, it was seen that the level of using art literacy information of the individuals, the level of the need of defining information they have and the level of transferring their knowledge to performance were high, while the level of reaching art literacy information was similar. It was observed that students who liked or disliked to do research in the library had similar levels of using art literacy knowledge, transferring knowledge to performance, and attainment of art literacy information, while the level of the need of defining information they have was higher. In terms of reading frequency, those who read books daily as compared to those who read a book monthly were found to have higher levels of using their knowledge, knowledge transfer to performance and level of accessing their knowledge, while the levels of the need of defining information they have were similar.

**Key words:** Literacy, art literacy, music.

### INTRODUCTION

When the aims and objectives of current education and training curriculum are investigated, the concept of literacy seems to be emphasized directly or indirectly. Reading, writing, speaking and listening skills often come to mind as the most important elements of literacy. The changing conditions of the world we live in and therefore the innovations and changes in the individuals desired

education are inevitable. Literacy is also a concept for an individual that needs to be possessed beyond basic skills, such as communication, reasoning, decision-making, which may also be reflected effectively in life. Literacy can be addressed by the ability of learners to use the knowledge and skills they have gained in their core lessons at the time and place they are needed, to

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analyze and reason about the problems in various situations, and to present the results in an effective way (Organization for Economic Co-operation and Development [OECD], 2003). This change in the concept of literacy is reflected in many areas and various types of literacy have emerged. These include computer literacy, cinema literacy, television literacy, visual literacy, information literacy, science literacy, environmental literacy, media literacy, mathematics literacy, screen literacy, game literacy, technology literacy, internet literacy, library literacy, visual art literacy, art literacy and so on. (Adıgüzel, 2005; Afacan and Şentürk, 2016; Alpan-Bangir, 2008; Andrelchik, 2015; Apaydınlı and Özkeleş, 2013; Aslan and Deniz, 2011; Aşıcı, 2009; Aydın and Alakuş, 2012; Barnett, 2013; Barton, 2013; Csíkos and Dohany, 2016; Göçer and Tabak, 2013; Gündüz-Kalan, 2010; Heinich et al., 1989; Kesik, 2016; Kurbanoglu and Akkoyunlu, 2002; Kurtaslan-Yıldırım, 2017; Kurudayıoğlu and Tüzel, 2010; Lozenski and Smith, 2012; Maniaci and Chandler-Olcott, 2010; Mercin and Alakuş, 2007; National Core Arts Standards, 2018; Nethery, 2013; Okan-Akın, Yüçetoker, 2014; Önal, 2010; Özgen and Bindak, 2011; Roth, 2002; Shenfield, 2010; Tallim, 2010; Timur et al., 2013; Yalçınkaya and Eldemir, 2013; Yıldız et al., 2012; Yılmaz and Timur, 2014; Tüzel, 2010; Ünsal, 2015; Zoet-Moody, 2014). Art literacy is defined as the ability to contribute to and understand artistic issues that include visual arts (painting, drawing, pottery, etc.). Artistic literacy is the knowledge and understanding necessary to truly participate in the arts (National Core Arts Standards, 2018). Art literacy is the development of interest and love for individuals in fine arts and artworks. And it is having the basic knowledge and skills to express personal feelings and thoughts using the universal language of art (<http://sanatseverturkiye.blogspot.com.tr>). Art teachers express art literacy in two interrelated perspectives. The first is literacy in a particular context while the other is used in a deeper disciplinary approach where students learn their skills and lead themselves in becoming artists (Barton, 2013). When each of these stages is examined, the individual must be able to understand how and where to find missing information on art, understand how to find the source of artistic information to be investigated, evaluate the obtained information by putting it in a conceptual framework and understand how and where to use the information work he/she evaluates (Okan-Akın and Yucetoker, 2016). The purpose of this study is to examine the art literacy levels of fine arts education students. For this purpose, the following sub-purposes are needed.

1. Is there any difference in terms of branches of education the students participate?
2. Is there any difference in terms of the sex of students?
3. Is there any difference in terms of readiness to read art books?

4. Is there any difference in terms of enjoying doing research in the library?
5. Is there any difference in terms of the different classes the students attend?
6. Is there any difference in terms of the reading frequency of the students?

## METHODOLOGY

### Research model

This research is designed in a causal-comparative research model. Gay et al. (2011) point out that in the causal-comparative research model, the investigator tries to determine the cause of differences in behaviors or situations of groups or individuals. This study was conducted in a causal-comparative research model to examine whether there is any difference in art literacy in terms of the department of education, gender, grade level, liking of reading art books, liking to use the library and reading book frequency.

Dependent variables of this research are using art literacy information, defining art literacy information needs, transferring art literacy knowledge to performance, and accessing art literacy information. The independent variables of the study are the branch that has been studied, gender, class level, readability of art books, liking to use library and book reading frequency.

### The study group

The study group consists of 201 students studying at the fine arts department in Educational Faculty of Niğde Ömer Halisdemir University, 129 of whom are female and 72 are male. Totally, the art and music departments have 300 students. 201 voluntary students out of 300 took part in data collection tools. Therefore, most students were reached.

### Data collection tools

The "Art Literacy Scale" developed by Yucetoker (2014) was used as data collection tool in the research. The art literacy scale is rated in 5 types of likert as follows: "I am not having any difficulties at all", "I am not having difficulties", "I am undecided", "I am having some difficulties" and "I am having difficulties". The scale consists of 4 sub-factors which are "Using Art Literacy Information", "Defining Art Literacy Information Need", "Transferring Art Literacy Knowledge to Performance" and "Accessing Art Literacy Information". Internal Consistency Coefficients were calculated for reliability calculations of the scale. As a result of these calculations, reliability coefficients for sub-dimension of art literacy knowledge using, the definition of art literacy knowledge need, transferring of art literacy knowledge to performance and accessing art literacy knowledge are found as 0.75, 0.71, 0.78 and 0.74, respectively.

### Data analysis

In this study, it was first checked whether there are missing values in the dataset. As a result of this review, there was no missing data found in the dataset. After that, it is examined whether there are any extreme values in the dataset. Z scores were calculated to examine extreme values, and no Z scores were found with a score greater than 3.29. For normality assumption, skewness and kurtosis values and histogram graph were examined. As a result of these examinations, it was seen that the data set has a normal distribution. In light of these, independent groups t-test and one-

**Table 1a.** Examining the use of art literacy knowledge in terms of branch of education.

Branch	N	$\bar{X}$	sd	t	p
Music	111	34.59	6.28	-0.90	0.37
Picture	90	35.43	6.98		

**Table 1b.** Examination of the need for definition of art literacy in terms of branch of education.

Branch	N	$\bar{X}$	sd	t	p
Music	111	17.94	3.64	-0.71	0.48
Picture	90	18.31	3.81		

**Table 1c.** Examination of transferring art literacy knowledge to performance in terms of branch of education.

Branch	N	$\bar{X}$	sd	t	p
Music	111	22.68	4.64	0.35	0.73
Picture	90	22.44	5.13		

**Table 1d.** Examination of reaching art literacy information in terms of the branch of education.

Branch	N	$\bar{X}$	sd	t	p
Music	111	18.81	4.08	-0.80	0.43
Picture	90	19.27	3.95		

way variance analysis techniques were used for data analysis. Finally, the homogeneity of the variances was tested and it was found that the variances are homogeneous. The level of significance was determined as 0.05.

## RESULTS

Independent groups t-test technique was used to examine whether art literacy levels changed in terms of variables such as the branch of education, gender, the likelihood of reading and liking to use the library, and findings are presented in the tables.

### Findings related to art literacy in terms of the branch of education

There is no significant difference in the level of use of art literacy information in terms of the branch of education. ( $t(199)=-0.90$ ,  $p> 0.05$ ). In other words, the level of use of art and literacy by students of music and painting/art departments are similar (Table 1a). There is no significant difference in the need of definition on art literacy in terms of the branch of education. ( $t(199)=-0.71$ ,  $p> 0.05$ ). In

other words, the need of art and music students for definition on art literacy is similar to each other (Table 1b). There is no significant difference in the level of transferring art literacy knowledge to performance in terms of the branch of education ( $t(199)=0.35$ ,  $p> 0.05$ ). In other words, the level of music and painting students' transferring art literacy knowledge to performance skill is similar (Table 1c). There is no significant difference in the level of access to art literacy information in terms of the branch of education ( $t(199)=-0.80$ ,  $p> 0.05$ ). In other words, music and painting department students have similar levels of access to art literacy information (Table 1d).

### Findings on art literacy in terms of gender

There is no significant difference in the level of using art literacy information in terms of gender ( $t(199)= 1.63$ ,  $p> 0.05$ ). In other words, the levels of use of art literacy by male and female students are similar (Table 2a). There is no significant difference in the level of the need for definition on art literacy in terms of gender ( $t(199)= 0.65$ ,  $p>0.05$ ). In other words, the levels of definition on artistic

**Table 2a.** Examining the use of art literacy knowledge in terms of gender.

Gender	N	$\bar{X}$	sd	<i>t</i>	<i>p</i>
Female	129	35.53	6.32	1.63	0.10
Male	72	33.96	6.99		

**Table 2b.** Examining the definition of art literacy information needs in terms of gender.

Gender	N	$\bar{X}$	sd	<i>t</i>	<i>p</i>
Female	129	18.23	3.63	0.65	0.52
Male	72	17.88	3.94		

**Table 2c.** Examination of transferring art literacy knowledge to performance in terms of gender.

Gender	N	$\bar{X}$	sd	<i>t</i>	<i>p</i>
Female	129	22.95	4.50	1.48	0.14
Male	72	21.90	5.38		

**Table 2d.** Examination of access to art literacy information in terms of gender.

Gender	N	$\bar{X}$	sd	<i>t</i>	<i>p</i>
Female	129	19.30	3.85	1.36	0.18
Male	72	18.50	4.30		

literacy knowledge of male and female students are similar (Table 2b). There is no significant difference in the level of transferring art literacy knowledge to performance in terms of gender ( $t(199)= 1.48, p > 0.05$ ). In other words, the levels of female and male students' transfer of art literacy knowledge to performance are similar (Table 2c). There is no significant difference in the level of access to art literacy information in terms of gender. ( $t(199)= 1.36, p > 0.05$ ). In other words, the levels of access to art literacy by male and female students are similar (Table 2d).

#### Findings related to art literacy in terms of enjoyment from reading

There is a meaningful difference in the level of using art literacy information in terms of enjoyment from reading ( $t(199)= 2.84, p < 0.05$ ). In other words, individuals who enjoy reading art books are more likely to use art literacy knowledge (Table 3a).

There is a meaningful difference in definition for art literacy knowledge in terms of enjoyment from reading ( $t(199)= 2.28, p < 0.05$ ). In other words, individuals who enjoy reading art books are at a higher level of defining

their artistic literacy needs (Table 3b). There is a meaningful difference in the level of transferring art literacy knowledge to performance in terms of enjoyment from reading ( $t(199)= 2.73, p < 0.05$ ). In other words, individuals who enjoy reading art books have a higher level of transfer of art literacy knowledge to performance (Table 3c). There is no significant difference in the level of access to art literacy information in terms of enjoyment from reading ( $t(199)= 1.76, p > 0.05$ ). In other words, the level of access to art literacy information by individuals who get enjoyment from reading is similar (Table 3d).

#### Findings on art literacy in terms of liking to do research in the library

There is no significant difference in the level of using literacy information in terms of library research. ( $t(199)= 1.83, p > 0.05$ ). In other words, the level of use of art literacy information by students who love or dislike research in the library is similar (Table 4a). There is a meaningful difference in the level of the need of definition on art literacy knowledge in terms of liking to do research in the library ( $t(199)= 2.35, p < 0.05$ ). In other words, individuals who love to do research in the library are

**Table 3a.** Examination of using art literacy knowledge in terms of enjoyment from reading.

Enjoyment from reading	N	$\bar{X}$	sd	t	p
Yes	149	35.74	6.62	2.84	0.01*
No	52	32.77	6.06		

\*p&lt;0.05.

**Table 3b.** Examination of the need for definition of art literacy knowledge in terms of enjoyment from reading.

Enjoyment from reading	N	$\bar{X}$	sd	t	p
Yes	149	18.46	3.56	2.28	0.02*
No	52	17.10	4.07		

\*p&lt;0.05.

**Table 3c.** Examination of transferring art literacy knowledge to performance in terms of enjoyment from reading.

Enjoyment from reading	N	$\bar{X}$	sd	t	p
Yes	149	23.12	4.64	2.73	0.01*
No	52	21.01	5.13		

\*p&lt;0.05.

**Table 3d.** Examination of reaching art literacy information in terms of enjoyment from reading.

Enjoyment from reading	N	$\bar{X}$	sd	t	p
Yes	149	19.31	3.91	1.76	0.08
No	52	18.17	4.25		

more likely to define art literacy needs (Table 4b). There is no significant difference in the level of transferring knowledge of art literacy to performance in terms of liking to do research in the library ( $t(199)= 0.87, p> 0.05$ ). In other words, the levels at which students who love or dislike research in the library convey art literacy knowledge to performance are alike (Table 4c).

There is no significant difference in the level of access to art literacy information in terms of liking to do research in the library ( $t(199)= 1.01, p>0.05$ ). In other words, the level of access to art literacy information by students who love or dislike research in the library is the same (Table 4d).

### Findings related to art literacy in terms of class level variables

One way analysis of variance (One Way Anova) technique was used to investigate whether there is a meaningful difference in using art literacy knowledge in terms of class level, defining art literacy information need,

conveying art literacy knowledge to performance, and accessing art literacy information.

There was no significant difference in the level of using art literacy information in terms of class level ( $F(3,197)= 1.65, p> 0.05$ ). It was concluded that the level of use of art literacy information by students in terms of the class levels they are studying is similar (Table 5). In terms of class level, there was no significant difference in the level of need of definition on the art literacy information ( $F(3, 197)= 0.35, p> 0.05$ ). It was concluded that the levels of the need of definition on the art literacy knowledge are similar in terms of the class levels in which students learn. There was no significant difference in the level of transferring art literacy knowledge to performance in terms of class level ( $F(3, 197)= 2.26, p> 0.05$ ). It was concluded that the level of students' transferring literacy to the performance in terms of the class levels they are studying is similar. There was no significant difference in the level of art literacy information in terms of class level ( $F(3, 197)= .52, p> 0.05$ ). It is concluded that the levels of access to art literacy information are similar to each other in terms of class levels in which students learn (Table 6a).

**Table 4a.** Examining the use of art literacy knowledge in terms of liking to do research in the library.

Liking to do research in the library	N	$\bar{X}$	sd	t	p
Yes	119	35.67	6.72	1.83	0.07
No	82	33.95	6.31		

**Table 4b.** Examining the need for definition of art literacy in terms of liking to do research in the library.

Liking to do research in the library	N	$\bar{X}$	sd	t	p
Yes	119	18.61	3.71	2.35	0.02*
No	82	17.37	3.68		

\*p&lt;0.05.

**Table 4c.** Examination of transferring art literacy knowledge to performance in terms of liking to do research in the library.

Liking to do research in the library	N	$\bar{X}$	sd	t	p
Yes	119	22.82	4.98	0.87	0.39
No	82	22.22	4.66		

**Table 4d.** Examining access to art literacy information in terms of liking to do research in the library.

Liking to do research in the library	N	$\bar{X}$	sd	t	p
Yes	119	19.25	3.93	1.01	0.32
No	82	18.67	4.15		

**Table 5.** Examination of art literacy in terms of class level.

Dimension	Class level	N	$\bar{X}$	Source of Variance	Sum Squares	df	Mean Square	F	p
Using art literacy information	1. Class	63	33.49	Between Groups	213.65	3	71.22	1.65	0.18
	2. Class	40	35.73						
	3. Class	60	35.90	Within Groups	8488.17	197	43.09		
	4. Class	38	35.16	Sum	8701.82	200			

There is a significant difference in the level of using art literacy information in terms of reading frequency ( $F(4, 196)= 3.57, p< 0.05$ ). The Tukey test was used to determine the source of the difference and it was found that daily readers of books had higher levels of using art literacy information than those who read one book in a month (Table 6b).

In terms of reading frequency, it was seen that there was no meaningful difference in the level of need of definition on the art literacy information ( $F(4, 196)= 2.07, p> 0.05$ ). In terms of the frequency of reading books, the levels of students' need of definition on art literacy are

similar.

In terms of reading frequency, there was a significant difference in the level of transferring art literacy knowledge to performance. ( $F(4, 196)=2.84, p< 0.05$ ) Tukey test was conducted to determine the source of the difference and it was found that those who read books daily had a higher level of skill of transferring art literacy knowledge to performance than those who read a book once a month (Table 6c).

It was found that there is a meaningful difference in the level of reaching art literacy information in terms of reading frequency ( $F(4, 196)=2.84, p< 0.05$ ). The Tukey

**Table 6a.** Examination of art literacy in terms of reading frequency.

Dimension	Reading Frequency	N	$\bar{X}$	Source of Variance	Sum of Squares	df	Mean Square	F	p	Difference
Using art literacy information	Daily	27	38.48	Between	590.25	4	147.56	3.57	0.01*	1-4
	Once a week	32	35.22	Groups						
	Twice a week	40	35.28	Within Groups	8111.57	196	41.39			
	Once a Month	75	33.19	Sum	8701.82	200				
	I never read	27	35.67							

\*p&lt;0.05.

**Table 6b.** Examination of in the level of need of definition on the art literacy information

Dimension	Reading frequency	N	$\bar{X}$	Source of variance	Sum of squares	df	Mean square	F	p
Defining art literacy information needs	1. Daily	27	19.74	Between	113.07	4	28.27	2.07	0.09
	2. Once a week	32	17.69	Groups					
	3. Twice a week	40	17.95	Within Groups	2681.73	196	13.68		
	4. Once a Month	75	17.55	Sum	2794.81	200			
	5. I never read	27	18.74						

**Table 6c.** Examination of in the level of transferring art literacy knowledge to performance

Dimension	Reading frequency	N	$\bar{X}$	Source of Variance	Sum of squares	df	Mean square	F	p	Difference
Transfer of art literacy knowledge to performance	1. Daily	27	24.74	Between	257.94	4	64.48	2.84	0.03*	1-4
	2. Once a week	32	22.38	Groups						
	3. Twice a week	40	22.35	Within Groups	4447.12	196	22.69			
	4. Once a Month	75	21.53	Sum	4705.06	200				
	5. I never read	27	23.89							

\*p&lt;0.05.

test was conducted to determine the source of the difference and it was found that readers who read books daily had a higher level of access to art literacy information than those who read a book once a month (Table 6d).

## DISCUSSION

According to the findings, there is no meaningful difference for levels of art literacy in terms of the coefficient of the departments of the students. The levels of art literacy are found to be similar in terms of gender. Okan-Akin and Yucetoker (2016) found that the art literacy scale is similar to the gender variable in the application of the scale of art-work education in the field of education. But Ozgen and Bindak (2011) and Unsal

(2015) found no difference in terms of gender in their research regarding high school students' self-efficacy beliefs for mathematics literacy. The results of these studies also coincide with the results of this work. Yildiz et al. (2012) found that there was a significant difference in some literacy subscales in terms of gender and school type variables in their studies called "examining the level of numerical literacy of secondary school students in Siirt according to gender, class and education variable". These outcomes do not coincide with the outcomes of our work. In this study, while the level of using art literacy information, the level of defining information needs, and the level of transferring knowledge to performance were found to be high in terms of enjoyment from reading, the levels of access to art literacy information were similar. Okan-Akin and Yucetoker (2016) found that art literacy levels of students who liked art books were higher than

**Table 6d.** Examination of the level of reaching art literacy information in terms of reading frequency.

Dimension	Reading frequency	N	$\bar{X}$	Source of variance	Sum of squares	df	Mean square	F	p	Difference
Access to art literacy information	1. Daily	27	21.07	Between Groups	240.29	4	60.07	3.93	0.00*	1-4
	2. Once a week	32	19.16							
	3. Twice a week	40	18.90	Within Groups	2992.67	196	15.27			
	4. Once a Month	75	17.89	Sum	3232.96	200				
	5. I never read	27	20.07							

\*p&lt;0.05.

those of art literacy levels of students who did not like art books. The result coincides with the results of the study. These results were expected. Because the students reading art books may enjoy art researches more than the ones who do not. While students who liked or disliked to do research in the library were found to be similar in their level of using art literacy knowledge, level of knowledge transfer to performance, and access of art literacy information, the levels of defining the need for knowledge were higher. Okan-Akin and Yucetoker (2016) found that students who liked to do library research had higher art literacy levels than students who do not like doing library research. The result shows that library research is important for art students. In this study, the levels of art literacy were found similar in terms of grade level coefficient. In a similar study, Ozgen and Bindak (2011) and Unsal (2015) found no difference in terms of grade level in their research regarding high school students' self-efficacy beliefs for mathematics literacy. The results of these studies also coincide with the results of this work. However, Yucetoker (2015) found that literacy levels rose as the class level increased in his research titled as "evaluation of art literacy levels of fine arts education students". These results of these studies do not coincide with the results of this work. According to another result of this study, daily book readers as compared to those who read a book once a month had same levels of using their knowledge, transferring their knowledge to performance and accessing their knowledge which shows how important and useful reading books daily is.

## SUGGESTIONS

Taking the results of the study into consideration, throughout art education, every student should be improved in line with their own unique personality. He or she should be guided in the direction of their own personality and tendencies and should express themselves freely. Also, students should be encouraged to read art books and do research in libraries. Children

and young people need to be directed at artistic activities that will help them improve their personality. Art education is seen as a theory course with emphasis on art history and education in the course curriculum. It is believed that having these lessons allows students to do more library research. However, when it comes to music education curriculum, it is seen that the number of these courses is limited. For this reason, music education students cannot achieve efficiency in this area other than through their own research. According to these results, restructuring of the curriculum of music education is thought to be important in terms of increasing literacy levels of students in the curriculum of courses such as art literacy. It is very important for students to be directed to the libraries as library research for the students of the fine arts department is very important. It is also thought that art teachers' suggestions for scientific articles, texts or art books that can be useful for students to develop themselves will be effective in this field and thus contribute to the field.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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