THE EFFECTIVENESS OF DEMONSTRATIVE COMPUTER ANIMATION IN DEVELOPING INTUITION: A CASE FOR GRAVITATIONAL ACCELERATION

by

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To my family,
for their endless support
and love.

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ABSTRACT

THE EFFECTIVENESS OF DEMONSTRATIVE COMPUTER ANIMATION IN DEVELOPING INTUITION: A CASE FOR GRAVITATIONAL ACCELERATION

The purpose of this study is to investigate if the gravitational acceleration concept can be intuitively formed in 5th, 6th, 7th and 8th grade students and to investigate the effectiveness of using computer animation technique in the formation of this concept. The design of this study is pretest-treatment-posttest quasi-experimental design. The study is conducted in the first and second semesters of 2005-2006 educational year with the participation of two state schools. The implementation lasted for one hour. The sample of the study is 283 students aging between 11 and 15 years. The subjects were asked to express their estimations about the motion of a flying bird and a free falling apple by locating the positions of the objects at each unit time. After the pretest, the subjects were presented the computer animation which shows the real-event motion of bird and apple. The subjects observed the accelerated motion of apple and constant velocity motion of bird from the computer animation four times, with slower motion each. After the treatment session, the subjects were again asked to locate the positions of apple and bird and to answer the multiple-choice questions related with the motions observed in the computer animation. According to 'Locate the Position' pretest results, it is observed that there is a genral tendency among subjects to expect that both objects would move with constant or irregularly changing displacements. According to McNemar test results, it is concluded that the general expectation among subjects have significantly changed in the posttest. It is observed that there is a significant differnce between Orbay P.S. 5. ve 6. grade and Kami Saadet P. S. 6., 7. and 8. grade subjects' pre and posttest responses in favor of developing intuitive conceptions about gravitational acceleration concept. There is a significant correlation between subjects' science achievement score and their performance in positioning the apple especially in posttest.

ÖZET

BİLGİSAYARLA CANLANDIRMA GÖSTERİMİNİN SEZGİ GELİŞİMİNE ETKİSİ: YERÇEKİMİ İVMESİ ÖRNEK OLAYI

Bu çalışmanın amacı yerçekimi ivmesi kavramının 5., 6., 7. ve 8. sınıf öğrencilerinde sezgisel yolla oluşup oluşmadığını belirlemek ve bilgisayarla canlandırma yönteminin kavramın gelişmesine etkisini saptamaktır. Bu çalışmada ön test – uygulama – son test yarı deneysel yöntem kullanılmıştır. Araştırma iki devlet okulunda, 2005-2006 öğretim yılının 1. ve 2. dönemlerinde bir ders saati sürecek şekilde uygulanmıştır. Uygulamada, yaşları 11 ile 15 arasında değişen, toplam 283 öğrenci yer almıştır. Deneklerden, uçmakta olan bir kuş ile haraketine yeni başlamış, yere düşmekte olan bir elmanın, birim zamanda ulaşmış olabilecekleri konumları işaretleyerek, cisimlerin hareketleri hakkındaki öngörülerini ifade etmeleri istenmiştir. Daha sonra, kuş ve elmanın gerçek zamanlı hareketi bilgisayar canlandırma gösterimiyle deneklere izletilmiştir. Yerçekimi ivmesiyle hareket eden elma ve sabit hızla hareket eden kuşun hareketi, birincisinde gerçek hızla olmak üzere, her defasında yavaşlatılarak, toplam dört defa deneklere izletilmiştir. Cisimlerin hareketini yavaşlatılmış şekilde gözlemleyen deneklerden, tekrar iki hareketlinin birim zamandaki konumlarını belirtmeleri ve canlandırmada izlemiş oldukları hareketlerle ilgili çoktan seçmeli testi cevaplandırmaları istenmiştir. 'Konumu Belirle' ölçeği öntest sonuçlarına göre, denekler arasında cisimlerin birim zamandaki yerdeğiştirme miktarının aynı kalacağı veya düzensiz değişeceği yönünde genel beklenti olduğu ortaya çıkmıştır. McNemar testi sonuçlarına göre, bu genel beklenti sontestte manidar düzeyde değişmiştir. Orbay İ. O. 5. ve 6. sınıflar ile Kami Saadet İ. O. 6., 7. ve 8. sınıf öğrencilerinin yerçekimi ivmesi hakkında sezgisel kavramlar oluşturmaya yönelik anlamlı değişim gösterdikleri gözlenmiştir. Deneklerin fen dersi başarıları ile elma konumlandırmaları arasında, son testte daha güçlenen manidar bir ilişki bulunurken, kuş konumlandırmaları arasında manidar bir ilişki bulunmamaktadır.

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LIST OF SYMBOLS / ABBREVIATIONS

N	Number
f	Frequency
p	Percentage
V	Velocity
t	Time
g	Gravity
P.S.	Primary School
Std. Dev.	Standard Deviation
LTPS	Locate the Position Test
AT	Animation Test

1. INTRODUCTION

A quick review of literature reveals that intuitive conceptions held by teachers as well as those held by students influence educational practices.

Studies on intuitive physics show that people hold a set of naive beliefs (Chi and Slotta, 1993; diSessa, 1982, 1993; McCloskey, Camarazza and Green, 1980). These studies also reveal that students' learning in the classroom is heavily influenced, and can be impeded, by intuitive conceptions (diSessa, 1983; Larkin, 1983; McCloskey, Camarazza and Green, 1980). Torff and Sternberg (2001) states that people hold powerful intuitive conceptions about teaching and learning, and these intuitive conceptions exert a great deal of influence on the way they think and act in classroom settings. Intuitive conceptions held by teachers and students influence educational outcomes and not always for the better.

The role of intuition in educational settings have been investigated by Sternberg and colleagues (1997). According to these studies, Sternberg and colleagues have concluded that tacit knowledge, which is the product of implicit learning, is a significant predictor of success (Sternberg, 1997; Sternberg *et al.* 1995; Sternberg and Horvath, 1999). These studies also have shown that successful individuals not only have a great deal of explicit knowledge about important tasks in a discipline, they also have extended tacit knowledge about the discipline. Sternberg indicates in his Triarchic Theory of Intelligence that tacit knowledge is a key component of practical intelligence (Sternberg, 1988; Sternberg, Torff and Grigorenko, 1998a, 1998b). Sternberg (2001) and his colleagues also have shown that tacit knowledge is a positive force that supports learning in and out of school. According to these studies, Sternberg's group mentiones that students should not only taught the explicit knowledge required in a discipline, they should also be able to get tacit knowledge that is important in that discipline. Some other theorists have noted an inverse correlation between loss of intuitive capability and scholastic achievement (Weintraub, 1998).

According to a classification method referring to the origins of intuitions, intuitive conceptions can be seperated into two categories, primary and secondary intuitive conceptions. Primary intuitive conceptions are defined as innately specified knowledge structures that are universal to the human species (Torff, 2001; Fischbein, 1987). In contrast, secondary intuitive conceptions comprise knowledge or knowledge structures that result from learner-environment circumstances that produced them (Torff, 2001). According to Resnick (1986), although children have strong and reliable intuitions in their young ages, they fail to reliably sustain school learning with their intuitions. He offers that the reason of this dilemma may be because of overemphasizing rote manipulation of symbols and formulas in school mathematics and science lessons. He also adds that this procedural focus may have been discouraging students from using their intuitions on school-learning tasks (Hiebert and Lefevre, 1986; Resnick, 1986,1989).

Ben-Zen and Star (2001) defense that if one accepts the idea that secondary intuitions exist, than it is possible to learn or develop intuitions. Accordingly, the mathematical or scientific concepts that are initially counterintuitive (or concepts for which we have no intuitions), may eventually become intuitive via correct reasoning. Ben-Zeen and Star (2001) suggests that rather than focusing on how the primary intuitions of students can be applied to school-taught procedures, one can instead seek to establish how new intuitions can be developed.

The significant role of intuition in creativity is mentioned by Weintraub and Heinemann (1998) with these words: “Innovation begins within the embryo of intuition, is nourished by imagination and breathed into life with ingenuity and hard work.”

Many scientists like Newton, Archimedes, Mendeleev, Einstein benefitted from their intuitions to be able to make universally known discoveries.

According to the study results mentioned so far, it is shown that the intuitive conceptions have significant role on people’s teaching and learning aspects. Because misconceived intuitive notions may negatively affect students’ learning, it is important to help children develop correct intuitive conceptions. Starting from the point of how Newton developed his “the law of gravitation” theory, in this research it will be investigated if 5., 6., 7. and 8. grade students will be able to develop intuitive conceptions about accelerated and constant velocity motion by watching a computer animation.

2. REVIEW OF LITERATURE

2.1. Intuitive Conceptions Among Learners

Anonymous anecdote taken from the book "Understanding and Teaching the Intuitive Mind: Student and Teacher Learning" (Torff and Sternberg, 2001):

"In a high school physics class, Julie and her teacher, Mr. Ewing, are talking about the forces involved as he tosses a coin in the air. Julie suggests that Mr. Ewing's arm imparts a certain amount of force to the coin, and when this force dissipates, the coin starts to fall. Julie's classmates indicate agreement with this commonsense analysis of the physics of a coin toss. Mr. Ewing is in his first year in the classroom and wants this matter cleared up, so he decides to inform the class about Newton's laws. Objects, he explains, do not collect and expand "force". Once the coin is set in motion, its path is influenced only by gravity and air resistance. During the lecture the students nod their heads, but a few days later they perform rather poorly on a physics test. The test results show that students can define and describe Newton's laws, but they continue to use naive notions to make sense of real-world problems. Later Mr. Ewing whispers to colleagues that this group of students is not especially strong in physics."

This anecdote reveals the influence in classrooms of intuitive conceptions, which can be defined as preexisting knowledge or knowledge structures that predispose individuals to think and act in particular ways without much conscious reflection.

The process of activating these conceptions might be called intuition. The studies carried out by diSessa (1983), Larkin (1983), McCloskey, Camarazza and Green (1980) show that students' learning in the classroom is heavily influenced, and can be impeded, by intuitive conceptions. Like in this example, students may hold to misconceived intuitive notions about force even after participating in a lesson featuring the prevailing scientific view of the physical world (Newtonian dynamics; diSessa 1983; Larkin 1988; Mc Claskey, Camarazza and Green 1980).

Torff and Sternberg (2001) states that even people who are trained in education hold powerful intuitive conceptions about teaching and learning, and these intuitive conceptions exert a great deal of influence on the way they think and act in classroom settings. Intuitive conceptions held by teachers, as well as those held by students, influence educational outcomes and not always for the better.

The philosophical, psychological and educational researchs look for the answers of four sets of questions about the workings of the intuitive mind. These questions are:

i. Defining intuition and intuitive conceptions:
- What are intuitive conceptions?
- How are they structured?
- How do they work?
- Where do they come from?
- What factors facilitate and constrain their functioning?

ii. Development of the intuitive mind:
- How do intuitive conceptions change of over time?
- What factors facilitate and constrain this development?

iii. Consequences of intuitive conceptions for learning in valued contexts:
- What results do intuitive conceptions produce in classrooms and other learning environments?
- What factors facilitate and constrain the use of intuitive conceptions in classroom learning?

iv. Implications for education:
- What sorts of pedagogical recommendations have been made?
- What kinds of interventions are required to develop (or counter) intuitive conceptions in valued contexts of learning, especially in schools?

2.2. Conceptualizing the Intuitive Mind

2.2.1. Classicism and Interactionism

The notion of intuition has a long history that begins in the discipline of philosophy. The classic view, identified with Spinoza and Bergson, holds that intuition is a form of intellectual process that is separate from conscious thought and that yields qualitatively different knowledge than the explicit reasoning of the conscious mind.

Opposing the classicists are the interactionists such as Dilthey and Wittgentein, who agree that intuition is conceptually distinct from reason but locate intuition in the person's interaction with the social world (Torff and Sternberg, 2001).

2.2.2. Definition of Intuition and Intuitive Conceptions

The root of the word intuition comes from the Latin verb tuere, meaning "to guard, to protect". Torff (2001) defines intuition as a handy notion for describing a way to make sense of the world – a form of perceiving and thinking that comes to people spontaneously and naturally without much deliberate conscious reflection. Although definitions of intuition and intuitive conceptions vary according to different theorists and researchers, one of the accepted approaches suggest that the human mind benefits from multiple ways to represent knowledge. Some of them operate outside of conscious reasoning and can therefore be considered intuitive. Intuitive conceptions are defined as knowledge or knowledge structures that need not be available to conscious reflection but that act to facilitate or constrain task performance. Intuitive conceptions are a subset of cognitive representations. Accordingly, intuition can be defined as the process through which intuitive conceptions are acquired and used (Torff and Sternberg; 2001).

According to Westcott, and experimental psychologists, intuition is the phenomenon which occurs "when an individual reaches a conclusion on the basis of less explicit information than is ordinarily required to reach that conclusion" (Westcott, 1961). According to Bastick's (1982) view, the properties that have been ascribed to intuition include sudden appearance, emotional involvement, pre-conscious process, contrast with logical thought, understanding by feeling, associations with creativity, instinctive knowledge and a subjective certainty of correctness (Woolhouse and Bayne, 1999).

Bowers' and Reber's definition of intuition are as follows. Bowers *et al.* (1990) defines intuition as "a preliminary perception of coherence (pattern, meaning, structure) that is at first not consciously represented, but which nevertheless guides thought and inquiry toward a hunch or hypothesis about the nature of the coherence in question." Similarly, Reber (1989) defines intuition as the end product of an implicit learning experience in which subjects unconsciously learn the associations that exist in the complex patterned information presented.

2.2.3. The Classification of Intuitions

Intuition has been classified differently by different theorists.

2.2.3.1. Poincore's Classification. Henri Poincare (1920) classified intuition in three categories. These are:

- Intuitions related to the senses and imagination.
- Intuitions expressed in empirical induction.
- The intuition of the pure number, which represents the source of mathematical induction (mathematical reasoning) (Fischbein, 1987; Poincore, 1920 p.20).

2.2.3.2. Bahm's Classification. Bahm (1960) has mentioned three types of intuition:

- Objective intuition: immediate apprehension of the external world.
- Subjective intuition: immediate apprehension of the self.
- Organic intuition: immediate apprehension of the objects and subject together (Fischbein, 1987; Westcott, 1968 p.19).

2.2.3.3. Piaget's Classification. A much more complex classification is made by Piaget in 1966. Firstly, he divided intuitions into two categories; empirical and operational (Beth and Piaget, 1966, p. 223-225; Fischbein, 1987).

- Empirical intuitions refer to the evaluation of physical properties of objects (for instance, the weight of an object), or to real psychological experiences known by introspection (for instance, the intuition of duration).
- Operational intuitions refer to actions related to objects and pschological phenomena.

Piaget made another classification referring to operational intuitions and mentioned the general distinction between pictorial intuitions, intuitions expressed by images and logico-mathematical intuitions (Beth and Piaget, 1966, p. 223-225; Fischbein, 1987).

2.3. Primary and Secondary Intuitive Conceptions

According to another classification method referring to the origins of intuitions, one may distinguish primary and secondary intuitive conceptions.

Primary intuitive conceptions are defined as innately specified knowledge structures that are universal to the human species. They develop in individuals independently of any systematic instruction as an effect to their personal experience (Torff, 2001; Fischbein, 1987).

In contrast, secondary intuitive conceptions comprise knowledge or knowledge structures that result from learner- environment circumstances that produced them (Torff, 2001).

2.3.1. Implicit Learning

In the last three decades, some studies have been carried out in cognitive psychology aiming to investigate the processes of how people acquire knowledge outside of their conscious awareness. Most of these researches have been focusing on implicit learning. Reber (1993, p.5) defines implicit learning as “acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge of what was acquired” (Torff and Sternberg, 2001). This theory defends the idea that people benefit from a knowledge acquisition mechanism that operates without the conscious awareness of the learner. Implicit learning is thought to “give rise to the phenomenal sense of intuition. That is, people do not feel that they actively work out the answer but they learn it implicitly (Berry and Dienes, 1993, p. 14). Although the educational implications of implicit learning have not been discussed extensively, in general it is seen as a fundamentally positive process that supports learning in the classroom, and everyday situations (Berry and Dienes, 1993, p. 14).

2.3.2. Tacit Knowledge

The product of implicit learning is often called tacit knowledge (Sternberg and Horvath, 1999; Sternberg, Wagner, Williams and Horvath, 1995; Torff, 1997, 1999). Sternberg and colleagues define tacit knowledge as “procedural knowledge that guides behavior but is not readily available for introspection” (Sternberg, 1999, p.231).

Many studies that have been carried out by Sternberg and colleagues have shown that tacit knowledge is a significant predictor of success (Sternberg, 1997; Sternberg, 1995; Sternberg and Horvath, 1999). These studies also have shown that successful individuals not only have a great deal of explicit knowledge about important tasks in a discipline, they also have extended tacit knowledge about the discipline. Sternberg indicates in his Triarchic Theory of Intelligence that tacit knowledge is a key component of practical intelligence (Sternberg, 1988; Sternberg, Torff and Grigorenko, 1998a, 1998b).

The studies carried out by Sternberg and his colleagues have shown that tacit knowledge is a positive force that supports learning in valued contexts, in and out of school (Sternberg, 2001). According to these studies, Sternberg also mentiones that failures in acquiring and using tacit knowledge when needed, may underlie many difficulties that people evince in school and in their job. Sternberg’s group states that students should not only taught the explicit knowledge required in a discipline (eg. the formulas of physics), but they should also get tacit knowledge that is important in that discipline (eg., how physicists conceptualize a project or how they make a discovery). According to them, the first step should be to analyze the tacit knowledge that is fundamental to a discipline, and the second step should be to design vehicles for curriculum and assessment that teach both tacit and explicit knowledge required in the discipline.

2.4. Educational Implications of Intuitive Conceptions

The crucial question from the educator's viewpoint is, whether the intuitive conceptions are helpful or harmful in valued contexts of learning (such as schools) and what educators should do in response. In order to answer this question, one should be able to make the distinction between intuitive conceptions that are supportive of learning and intuitive conceptions that are unsupportive (misconceived notions about physics may actively impede learning).

Intuitive conceptions may work both for and against educators and learners. To be able to determine the extent to which a particular one is helpful or harmful, requires a detailed analysis of both the intuitive conception and the context in which it is used.

2.5. Executive Intuition

Some theorists suggest that up to 80 per cent of our actions are based on unconscious motives (Weintraub, Heinemann, 1998). Therefore, we may seldom be aware of the thoughts that precede our behavior. Also, it can be said that our unconscious mind directs our life for more than conscious awareness.

Jagdish Parikh (1994) from Harvard Business School performed a study investigating how often business executives use their intuitive and logical skills. According to his study, business executives attribute their success to acting on intuitive insights, which enable them to perceive whole situations in sudden leaps of logic (Weintraub, 1998; Parikh, 1994). Parikh received over 13 000 responses to his questionaire and found that over 75 per cent of those respondents felt they used intuition and logic about equally. 48 per cent of female respondents said that they use more intuition than logic in their personal lives. Between 52 and 79 per cent of respondents agreed or strongly agreed with the following statements (Weintraub, 1998; Parikh, 1994):

i. Many senior managers use intuition in making decisions, at least to some extent.
ii. Higher intuitive capabilities would contribute to greater success in business.
iii. Intuition has a role to play in almost every facet of life.
iv. Intuition is a characteristic associated more with women than with men.

52 to 79 per cent of people in the sample agreed to all of the above statements but they also mentioned not wishing to admit to the use of intuition. Although it is generally agreed that higher intuitive capabilities may contribute to greater success in business, few managers admit to using it (Weintraub, 1998). The reason of this dilemma may be that intuition remains “secret” in many of the cultures. Because we live in a left brain culture which is dependent on logic and analysis, people may not afford to trust information based on intuition.

Another study has been designed about intuition by Daniel J. Isenberg, a professor at the Harvard Business School. In this study, Dr. Isenberg has spent days observing sixteen senior managers in major corporations. He made interviews with them and he tried to identify five different ways that successful managers use intuition (Weintraub, Heinemann, 1998):

i. Successful managers use intuition to sense when a problem exists.
ii. Intuition assists in rapidly performing well-learned behavior pattern. Once managers are “fluent” at performing specific tasks, they can execute programs without conscious effort. Isenberg defines intuition as the smooth automatic performance of learner behavior.
iii. Intuition is used to synthesize isolated bits of data and experience into an integrated picture, often with an “aha” experience.

iv. Intuition is used to check on the results of rational analysis. Executives work on the issue to find a match between feelings and logic.
v. Intuition is used to bypass in-depth analysis and come up with a quick solution.

Dr. Isenberg concluded: "The higher you go in a company, the more important it is that you combine intuition and rationality, and see problems as interrelated" (Weintraub, Heinemann, 1998; Isenberg, 1984).

2.6. Review of Research on Intuition

During the behaviorist era, intuition was regarded as an unmeasurable and irrational process, thus not accessible to scientific study. But within the last two decades, there have been increasing demand to study intuition from a cognitive perspective (Greenwald, 1992; Kihlstrom, Barnhardt and Tataryn, 1992; Woolhouse and Bayne, 1999).

According to his studies, Bowers (1984) regards intuition as a distinct information processing mode, in which unconsciously stored information is used to guide decisions and problem solving. He further argued that when based on appropriate experience, this mode can be more effective than analytical thinking (Woolhouse and Bayne, 1999). Bowers' (1984) idea have been supported by Hammond, Hamm, Grassia and Pearson (1987). In their work, Hammond, Hamm, Grassia and Pearson (1987) showed that for certain tasks, when subjects are tested in an area in which they have relevant experience, a non-analytical or intuitive approach produces better performance than using a formal analytical method (Woolhouse and Bayne, 1999).

Lewicki, Hill and Bizot (1988) showed that 18 year old college students learned to predict a complex patterned sequence without conscious awareness of the rules defining the pattern. Because of the complexity of the factors underlying the pattern, attempts at conscious analysis of the sequence were unsatisfactory. According to this research, it can be said that, not only intuition can perform as well as or better than conscious analysis, but in some cases intuition is the only form of information processing that can yield a result (Woolhouse and Bayne, 1999).

Theorists' ideas about individual differences in implicit learning differ from each other. Reber *et al.* (1991) expected limited or no individual differences in implicit learning and hence intuition. Whereas Westcott (1968) and Bowers *et al.* (1990) agreed that there are individual differences in intuition. Bowers *et al.* (1990) agreed with Reber (1991) to the extent that he regarded everyone as intuitive, i.e. all the people can use the intuitive process (Woolhouse and Bayne 1999). However, Bowers and colleagues proposed that there will be differences in the speed and nature of the associative connections that underlie the intuitive process. The central view about individual differences in intuition is that everyone has access to intuition, but there are individual differences in the speed and accuracy of usage (Reber *et al.*, 1991).

2.7. Intuition in Science

Rational knowledge and rational activities constitute the major part of scientific research, but they are not all. As Capra (1976) said, the rational part of research would, in fact, be useless if it were not complemented by the intuition that gives scientists new insights and makes them creative. These insights tend to come suddenly, usually not when sitting at a desk working out the questions, but when relaxing, in the bath, during a walk in the garden etc. During these periods of relaxation, the intuitive mind works and can produce the sudden clarifying insights which give so much joy to scientific research.

Weintraub and Heinemann (1998) mentiones that innovation begins within the embryo of intuition, is nourished by imagination and takes its shape by hard working.

Lovelock (2000) states that science like art and music is a very intuitive thing. In his research, he asked many scientists how they made a discovery and he got the answer that it came to them in a flash. Scientists also added that, they spent at least two years trying to explain it first to themselves and then perhabs ten to forty years trying to explain it to their colleagues.

The invention of the "law of gravitation" happenned just in the same way. While Sir Isaac Newton was walking around the farm (1665), an apple fell at his feet. It was a usual event which has been superficially noticed by him thousands of times. But now it was different, like the click of some small switch which starts a great machine in operation, this event awoke his mind to action. He observed the apple falling from the tree and thought to himself why that apple always descend perpendicularly to the ground. Why doesn't it go sideways or upwards, but perpendicularly to the earth's center? He then answered that there must be a drawing power in the matter: and the sum of the drawing power in the matter of the earth must be in the earth's centre. That's why the apple falls perpendicularly, or towards the centre of the earth (Roberts, 1989). The commonplace event, falling of an apple from a tree, give birth to the invention of the law of gravitation. Newton published his discovery in his book Principia in 1687, some 20 years after the incident.

The Greek mathematician, Archimedes is another example to the people who make a discovery using his/her insights. Archimedes spent days thinking of the problem how to determine whether the king's crown is made up of pure gold or of a mixture of gold with other metals. He then realized that, if he could determine the volume of the crown, he would be able to tell whether that crown was made of pure gold or not. How to calculate the volume of an irregular object was the big question for this problem. While taking a bath, Archimedes suddenly realized that the volume of the water that run over the top of the tub was exactly equal to the volume of the part of his body that he placed in the water. He immediately ran from the bath to the streets shouting "Eureka, eureka!" "I found it!" (Roberts, 1989). The usual event, taking a bath, awakened Archiemedes intuition, and he discovered how to measure the volume of any irregular object.

Many other scientists emphasize the role of intuitive creative inspiration in their discoveries. For example, the Russian chemist Dmitri Mendeleev worked out for months to find a way to categorise the elements. One night, before falling asleep, he suddenly realized that he should compose "The Periodic Table of Elements" and can categorize the elements by this way (Intuition Magazine, 1995). Nicola Tesla said this of his insight that became the basis for the alternating current electrical system: "The idea came like a flash of lightining, and in an instant the truth was revealed" (Intuition Magazine, 1995).

Albert Einstein emphasizes the importance of intuition with these words: "The only valuable thing is intuition." Albert Einstein also described his theories as the "free invention of the imagination" (Intuition Magazine, 1995).

2.7.1. Senses of Intuitive Knowledge in Scientific Cognition

In the early discussions, the term intuitive is often regarded as standing in opposition to schooled or scientific knowledge (Wertsch and Polman, 2001). From this perspective, intuitive knowledge is understood in terms of being homegrown and not grounded in the principles of logical organization that underlie schooled thinking (Wertsch and Polman, 2001).

Recent studies, such as those concerning conceptual change, disclose some of the weaknesses of this earlier view. Investigators working from this perspective are against the tendency to view teachers as providing information through didactic instruction and students are viewed as absorbing correct (i.e., schooled) concepts (Wertsch and Polman, 2001). Instead, the focus has switched to the nature of conceptual change that starts with what are variously called intuitive concepts, misconceptions and preconceptions. These researches have suggested that the intuitive conceptions students bring to a learning situation are quite resistant to change through direct instruction (Confrey, 1989).

Several studies suggest that ignoring the intuitive concepts of students results in school knowledge about scientific phenomena that they are unable to apply in real-world settings (eg., Lewis, Stern and Linn, 1993; Reif and Larkin, 1991; Resnick, 1987).

Posner *et al.* (1982) suggest to design the learning environments and guide instruction taking into account the students' intuitive knowledge in various domains. For example, Dykstra *et al.* (1992) outlined ways that phyics teachers could diagnose students' differing conceptions about the relationship between force and motion and then induce them to transform these conceptions. Lewis and Linn (1994) state that educators should attempt to connect students' naive ideas in the domain to scientific concepts. They also add that the task of the educator is to create cognitive disequilibrium that forces accomodation of existing concepts through differentiation, class extension, or reconceptualization.

2.7.2. Research Findings About Students' Understanding of Force and Motion

A common research assumption is that students possess a system of beliefs and intuitions about physical phenomena mainly derived from their everyday experience (Jimoyiannis, Komis, 2000). Terms to describe these beliefs include; common sense beliefs (Champagne, Klopfer and Anderson, 1980), preconceptions (Arons, 1997; Dykstra, Boyle and Monarch, 1992), misconceptions or alternative conceptions (Halloun and Hestness, 1985) and misapplications (Elby, 2001). Students' system of beliefs and intuitions may either match the scientifically accepted concepts or may be incompatible with scientific theories and knowledge.

In recent years, a great deal of research in science education has been devoted to the study of the alternative conceptions of students. The results from various studies have shown that students have concepts of the natural world that are quite different from those of scientists (Berg and Brouwer, 1991).

There are many articles published on students' understanding of the force concept (for example; Clement, 1982; Hake, 1998; Halloun and Hestenes, 1985; Hestenes, Wells and Swackhamer, 1992; Minstrell, 1982; Watts, 1983), free fall, gravity and acceleration (for example; Cahyadi and Butler, 2004; Berg and Btouwer, 1991; Gunstone and White, 1981; Dall'Alba *et al.*, 1993), trajectory motion (for example; Jimoyiannis and Komis, 2000; Fischbein, Stavy and Ma-Naim, 1989; Maloney, 1988, McCloskey, 1983; McCloskey, Washburn and Felch, 1983), relative speed (for example; Walsh, Dall'Alba, Bowden, Martin, Marton; Masters, Ramsden and Stephanou, 1993), average velocity (for example; Andaloro, Bellomonte, Lupo, Sperandoe-Mineo, 1994), rotational motion (for example; Berg and Brouwer, 1991; McCloskey, Camarazza and Green, 1980; Gardner, 1984; Gunstone, 1984; Warren, 1979), Newton's Laws (for example; Savinainen, Scott, Viiri, 2004; Watts, 1983; Watts, 1981; Sjoberg and Lie, 1981; Peters, 1982; Viennot, 1979;

Langford and Zellman, 1982; Helm, 1981; Minstrell, 1982; Brown, 1989; Montanero *et al.*, 2002; Terry and Jones, 1986).

The findings of studies commonly indicate that most students experience difficulties in understanding Newton's laws, force and acceleration concepts in general. Halloun and Hestenes' (1985) and Whitaker's (1983) studies have suggested that students' beliefs about motion in the earth's gravitational field are usually based in Aristotelian ideas derived from limited first-hand experience of real-life phenomena (Jimoyiannis, Komis, 2000).

According to Stepans (1996), developing instruction which fails to acknowledge students' entry conceptions and ınderstanding can leave students' conceptions unchanged. Stepans also adds that developing instruction which fails to create the necessary conceptual conflict between students' intuitive conceptions and the scientific conception can leave students' conceptions unchanged. Stepans (1996) concludes that the topics are traditionally taught using expository methods, with the use of routine demonstrations. The role of the student is passive and they do not experience conflict between their views and the views that are being taught.

2.7.3. Students' Intuitive Conceptions About Force, Motion and Acceleration

<u>2.7.3.1. Students' Intuitive Conceptions About Newton's First Law.</u> A common intuitive rule among students is that "constant motion requires a constant force". 100 London students, who are 13, 14 and 17 years of age, are asked to discuss different situations in terms of their idea of force, such as a person sledging down a hill (Watts, 1983). Most of the responses include: "If he wanted to keep moving, he would have to keep pushing, otherwise he'll run out of force and stop" (Watts, 1983). Those students may believe that a net force is required to keep an object in motion at a constant velocity.

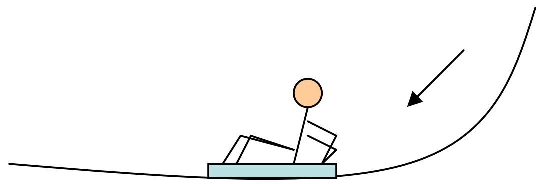


Figure 2.1. Many students intuitively believe that constant motion requires a constant force.

<u>2.7.3.2. Students' Intuitive Conceptions About Newton's Second Law.</u> In a study carried out in Greece by Jimoyiannis and Komis (2000), 90 (15-16 years old) students were asked to compare the final velocity of the two balls falling from the same height, one of which is twice the mass of the other. About 50 per cent of the students seemed to believe that the speed of the ball is proportional or correlated to its weight. Only 20 per cent of students in this group gave the correct answer, the two balls have the same velocity, because free fall depends only on the gravity constant.

Another common belief among youngsters is that, "force is always in the same direction as the velocity of the body" is revealed in Osborne's (1982) study. Osborne asked students to identify the total force acting on a thrown tennis ball, on the way up, at the top and on the way down. The table below shows the results of this study. The results of this study indicate that 66 per cent of the subjects believe that the net force exerting on the body is in the same direction of motion. Only 5,7 per cent of the subjects mentioned that the gravitational force would act downward in all three situations.

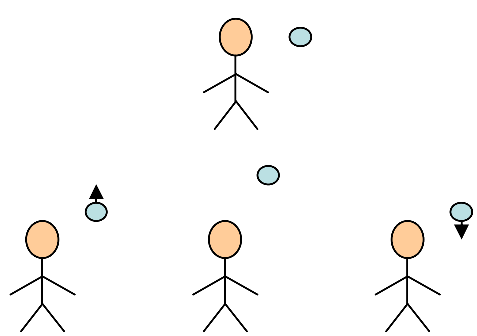


Figure 2.2. The total force on a ball while it is rising, at the top of its path, and while it is falling

Table 2.1. Osborne's (1982) study results table showing the percentage of student resposes about the direction of net force exerting on a body which is rising and free falling.

Student Response:	Percentage of Osborne (1982) Students 15 Years of Age:
On the way up..........Force up At the top..................No force At the top..................No force	66,1
On the way up..........Force down At the top..................No force On the way down......Force up	9,8
On the way up..........Force up At the top..................Force down On the way down......Force down	9,2
On the way up..........Force down At the top..................Force down On the way down......Force down	5,7
On the way up..........Force down At the top..................No force On the way down......Force down	5,2
Other responses	4,0

According to Stepans (1994), there are many students who intuitively believe that, if two objects were dropped from the same height, the heavier object would reach the ground earlier than the lighter object and their final velocity would be correlated with their mass.

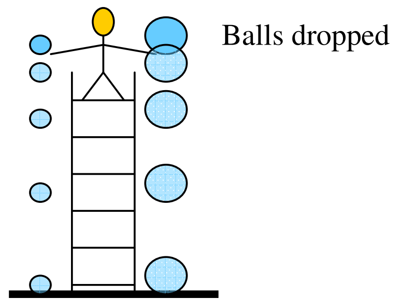


Figure 2.3. Many students intuitively believe that the heavier object would reach the ground earlier than the lighter one

If the motion of a ball that is dropped is compared with one that is thrown in the horizontal direction at the same time, it will be observed that the falling bodies will accelerate downward identically and will hit the ground at the same time. According to Stephans (1994), some students have intuitive conception that the object which has initial velocity at horizontal direction reaches to the ground earlier than the object which is dropped.

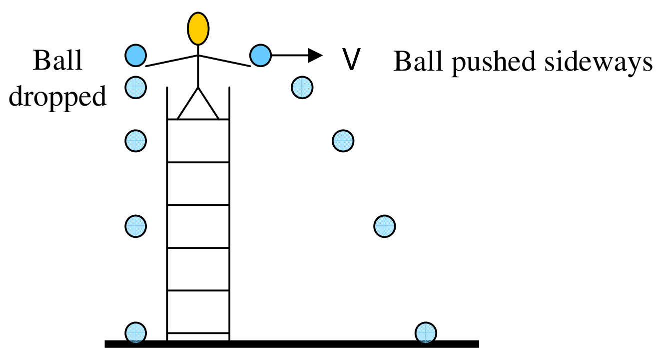


Figure 2.4. Many students have intuitive conception that the object which has initial velocity at horizontal direction reaches to the ground earlier than the object which free falls

<u>2.7.3.3. Students' Intuitive Conceptions About Newton's Third Law.</u> Newton's third law states that: "Wherever an object exerts a force on a second object, the second object exerts an equal and opposite force on the first." The research findings commonly indicate that most students have problems in understanding Newton's third law (Savinainen *et al.*, 2004).

Terry and Jones (1986) mention that students might think of forces as being things in themselves, as properties of objects. To think of force as an innate or acquired property of objects, not arising from an interaction between objects, is a common view among students (Brown, 1989; Savinainen *et al.*, 2004). In his study, Brown (1989) asked students to compare the forces a 200 gr. ball and a 20 gr. ball exert on each other when one of the balls crash to the other. The finding of this study showed that only 5 % of the students, who have taken traditional high school physics instruction, could answer the question correctly (stating that the forces will be equal). Most of the students seemed to think in terms of a "dominance principle", where the heavier ball is more able to cause damage than the lighter ball.

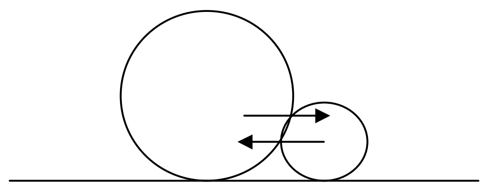
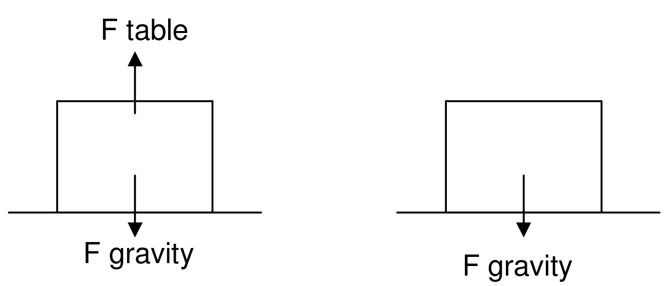


Figure 2.5. Students generally think that heavier object exerts greater force than the ligher object.

Another common belief among youngsters is that: "if a body is not moving, there is no force acting on it" (Gunstone and Watts, 1985). Minstrell (1982) asked a physics class at an American high school to use arrows on a drawing to represent the forces acting on a book stationary on a table. Approximately 50 % of the class believed that gravity and the table were exerting opposite forces. The other 50 % believed that only gravity was exerting a vertival force (Gunstone and Watts, 1985).



Physicist View
(Gravity and the table are exerting opposite forces on the object.)

Alternative View
(Gravity is the only vertical force acting on the object.)

Figure 2.6. Many students believe that there is no force acting on the object if it is not moving

<u>2.7.3.4. Students' Intuitive Conceptions Related with Projectile Motion.</u> In Eckstein and Shemesh's (1993) study, over 600 subjects in Grades 2.12 were asked to predict motion in a variety of circumstances. In the first situation, the subjects were asked to draw the path the ball follows after it reaches the edge of the table. In the second situation, the subjects were asked to draw the path of the ball, moving with higher velocity, after reaching the edge of the table.

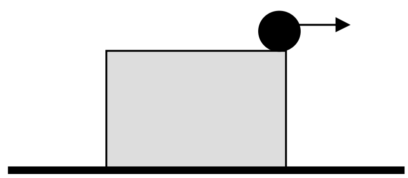


Figure 2.7. The figure used in Eckstein and Shemesh's (1993) study to assess subjects' predictions about projectile motion

Subjects' responses were categorized according to level of sophistication. Subjects in the first category drew both balls' motion path straightly downward. It is found that a large proportion of the subjects subscribe to the straight-down belief, that is they believe that if a transported object is released, then it falls straight down. Subjects in the second category drew the path of the slower ball straightly downward and the faster ball forward. Subjects in the third category drew the path of both slower and faster objects foreward. For subjects in this category, the law of support does not have validity; they understand that forward motion does not dissappear immediately when the object loses its support.

<u>2.7.3.5. Students' Intuitive Conceptions About Rotational Motion.</u> In McCloskey, Camarazza and Green's (1980) study, 14 and 15 year old 183 students were shown the top view of a ball being rotated in a circle, at the end of a string. The students were told that the string broke at a certain point A and were asked to draw in the path they expected the ball to travel.

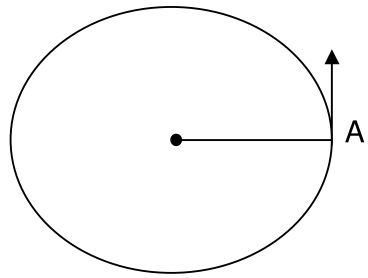


Figure 2.8. The figure used in McCloskey, Camarazza and Green's (1980) study to evaluate students' expectations about rotational motion

According to their responses, 53.6 per cent of them stated that the ball would continue in a curve, 18.6 per cent stated the path would be tangential (correct response), 13.7 per cent stated it would be angled outward, 3.8 per cent stated it would radially outward and 10.4 per cent gave other responses.

3. METHODOLOGY OF THE STUDY

3.1. Significance of the Study

According to the research findings stated above, it can be said that force and motion concept is one of the school topics, on which students have varying intuitive conceptions before and after the physics instruction. Research findings also suggest that conventional instruction is not effective in dealing with misconceptions (Jimoyiannis, Komis, 2000; Thornton, 1999). According to Thornton (1999), students may enter and leave the courses with fundamental misunderstandings of the world; their learning of facts about science remains within the classroom and has no effect on their thinking about the larger physical world. So, to be aware of students' existing intuitive notions about scientific concepts and to design instructional equipment considering their beliefs is important for educational settings.

Kılıç (1997) states that longer-lasting learning can be achieved by using visual educational materials in educational settings. He adds that in some circumstances, a well developed visual material may be more effective on the learner than tens of written pages may be. Also, according to William Glasser (1975), we remember 10 per cent of what we read, 20 % of what we hear, 30 per cent of what we see and 50 per cent of what we see and hear. Many authors have remarked that humans are highly visual creatures. According to some estimates, approximately 60 per cent of brain tissue is concerned with visual processing (Lambert, 2003). According to these views, it can be stated that using visual materials in lessons has an important role to enrich the instruction.

Visualization of phenomena through such techniques as computer-animations, simulations, video, demonstrations, models can contribute to students' understanding of physical concepts by attaching mental images to these concepts (Escalada and Zollman, 1996). Also Cadmus (1990) states that these visualization techniques not only allow the students to see first hand how things behave, but also provide them with visual associations that they may capture, and preserve the essence of physical phenomena more effectively than do verbal descriptions.

3.2. Sample

Two primary schools have participated in this research. One of them is Orbay Primary School which is located at Kasımpaşa and the other was Kami Saadet Güzey Primary School which is located at Etiler.

The aim of this study was to investigate students' intuitive notions about the motion of a free falling object from their drawings who do not have explicit information about the force and motion concept and who have studied this concept in the school years. For this aim, a large group of subjects for 5^{th}, 6^{th}, 7^{th} and 8^{th} grade from these two schools were selected.

The "force and motion" concept is studied at the end of first semester in the seventh grade in primary school. Because this study is conducted at the beginning of the first semester of 2005-2006 educational year in Orbay Primary School and in the second semester of 2005-2006 educational year in Kami Saadet Güzey Primary School, all 5^{th}, 6^{th}, 7^{th} graders of Orbay P.S. and 6^{th} graders of Kami Sadet Güzey P.S. were science naive in the sense of not studing the 'force and motion' concept in the school.

The study was carried out with the participation of 283 subjects in Grades 5-8 (ages 11-12 through 14-15). The subjects were chosen from two different state schools, which are Orbay İlköğretim Okulu (located at Kasımpaşa) and Kami Saadet Güzey İlköğretim Okulu (located at Etiler). From Orbay İlköğretim Okulu 197 students and from Kami Saadet Güzey İlköğretim Okulu 86 students have participated in the study. From Orbay School, 67 students from 5^{th} grade, 85 students from 6^{th} grade, 24 students from 7^{th} grade and 22 students from 8^{th} grade have participated in the study. From Kami Saadet Güzey Primary School, 43 students from 6^{th} grade, 26 students from 7^{th} grade, and 17 students from 8^{th} grade have participated in the study.

In the shools of the study, the science of motion is studied in Grade 7. Because this study is applied at the beginning of first semester in Orbay İlköğretim Okulu, the 5th, 6th and 7th grade subjects were all physics naive in the sense that they had not studied the science of motion formally. Similarly, because the study was applied at Kami Saadet Güzey İlköğretim Okulu at the beginning of the second semester, 7th grade subjects had just studied the science of motion and 6th grade subjects had not formal information about motion concept.

Table 3.1. Distribution of subjects participated in the study according to their schools and education levels

Name of School	Grade	N of Subjects	N of Girls	N of Boys
Orbay Primary School	5	66	24	42
	6	85	43	42
	7	24	12	12
	8	22	5	17
Kami Saadet Güzey P. School	6	43	37	6
	7	26	15	13
	8	17	5	12

3.3. Statement of the Problem

This study aims to investigate 5th, 6th, 7th and 8th grade students' intuitive conceptions about two different types of motion, namely constant velocity and accelerated motion, before and after watching a computer animation.

3.4. Research Questions

The research questions of this study are:

i. Can students discriminate between two types of the motion, namely accelerated and constant velocity motion, by estimating the position of the objects at each unit time?
ii. Does being exposed to computer animation have a significant effect on discriminating between accelerated and constant velocity motions?
iii. Is there a significant relationship between subjects' science achievement score and their pre and post "Locate the Position" scale results?
iv. Are there significant differences among students with respect to grades in so far as to tasks mentioned in the first and second questions?
v. Is there a significant correlation between subjects' science achievement grade and the score they obtained from the test related with the motions observed at the computer animation?
vi. Is there a significant relationship between the achievements in "Locate the Position" scale and the achievement in the "Animation Test" items?

3.5. Variables and Operational Definitions

Subjects' perception of the gravitational acceleration concept is the dependent variable of this study. It is operationalized in terms of the scores obtained from 'Locate the Position' scale and from the test which includes multiple-choice questions related with the motion of the objects presented in the animation section. Details for the 'Locate the Position' scale and the 'Animation Test' are presented in the 'Instrumentation' section.

Instructional procedure to improve subjects' notions about gravitational acceleration concept using computer animation is the independent variable of this study. Detailed information about the instructional procedure is given in the instrumentation part.

Subjects' age is one of the the moderator variable of this study. In this study, iy was investigated if there is a development of subjects' intuitions about the motion of a free falling object which can be determined by age.

Subjects' achievement in science lesson is the other moderator variable of this study. During the study it was investigated if those intuitions were superior in subjects who are successful in science or not. Subjects' success in science lesson is operationalized in terms of their previous year's science achievement score.

In order to eliminate possible different characteristics of each school, data analysis of the schools, participated in the study, is done seperately.

The number of times letting subjects to watch the computer animation is controlled and limited with 4 times for each subject. Also there is no maturation effect in this study since the pretest, treatment and posttest were all applied on the same day.

3.6. Instrumentation

The subjects' expectations about the motion of objects which moves with accelerated and constant velocity is measured by 'Locate the Position' scale. In this scale, the subjects were asked to express their expectations about two different motions by locating the position of the objects at each instant.

In the treatment part, the subjects observed the free falling apple and flying bird's real-event motions from a computer animation. The computer animation that is used in this study is developed by Volkan Bal using Macromedia Flash. The constant velocity motion of bird and gravitational acceleration motion of apple is demonstrated in the computer animation. In order to help students perceive how the displacement of two bodies differ in each unit time period, the various frames that project successive positions of the apple and bird are presented in the animation.

After watching the animation, the subjects were distributed the first screen of computer animation on a sheet of paper and were asked to plot six figures of apple and bird objects indicating the positions of those objects at each instant. The inter-judge reliability of the 'Locate the Position' instrument is analyzed by categorizing and evaluating LTP data by two different scorers and computed to be .793 for pretest and .822 for the posttest.

The subjects were asked to give answers to the "Animation Test" consisting of 8 multiple-choice items related with the motions of two objects which were observed from the computer animation. An example of this test can be seen in the Appendix A. A split-half reliability coefficient of .588 was computed for the entire group of 283 respondents.
In order to have information about the validity of the instrument that was used in this study, a group of science and mathematics teachers were interviewed and were asked their comments about each item of the instrument. Six teachers who are actively teaching to sixth, seventh and eight graders gave feedback about the validity of the test items.

Four of the teachers reported that the questions were good and were appropriate for assessing the aimed objectives of this study. The other two teachers reported that the instrument was a good scale especially for the seventh and eight graders. They explained that it would be a difficult issue for sixth graders to grasp the meaning of 'the object's displacement in unit time'. They also mentioned that sixth graders were not so familiar with using < and > (smaller than and bigger than) symbols, so they stated that sixth graders may have some difficulties in dealing with questions that necessitates using these symbols.

One of the teachers mentioned that primary school students were not familiar with test items that have five choice alternatives. She stated that constructing multiple choice test items with four item alternatives would make primary school students more comfortable with the questionnaire.

3.7. Procedure of the Study

The study is organized in three stages. Stage I involves the modeling of students' intuitive notions about a real-world event. In this stage, the students are asked to express their ideas about the real-world event by using their drawings. The students are asked to work on a scenario and locate the positions of an apple free falling from a tree to the ground and of a bird flying to the tree for six

In stage II, the students watched a computer animation consisting of the real-event motion of the bird and the apple. The two bodies in the animation move according to the position-time and velocity-time graphs shown in the Figure 3.3 and Figure 3.4 (not shown to the students). The animation was shown to the students by using a projector and all students got the chance to watch it four times. They watched the animation firstly in the original speed. In nature, the movement of objects occur too fast that our eyes can not perceive the details of that movement. In order to comprehend the basic differences between the two motions, the students watch the animation firstly with original, then with slower motion and lastly with the slowest motion. In order to help students perceive how the displacement of two bodies differ in each unit time period, the various frames that project successive positions of the apple and bird are presented in the animation.

After watching the animation, in Stage III, the students are again wanted to animate the two moving bodies (bird and apple). Finally, the subjects are asked to answer the questions related with the motion of objects observed in the animation.

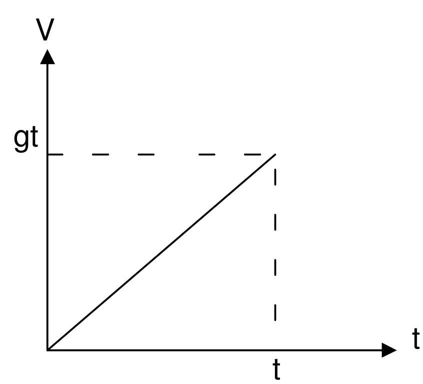


Figure 3.3. Velocity – time graph of the apple in the animation

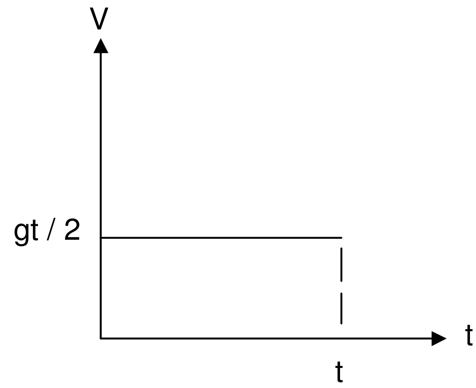


Figure 3.4. Velocity – time graph of the bird in the animation

4. DATA ANALYSIS

4.1. Categorization and Evaluation of Drawings

Categorization method was used in order to evaluate subjects' pre and post "Locate the Position" scale results. Since each figure in the drawings represents the position of the object at each unit time, the change in displacement is determined by measuring the distance between the figures.

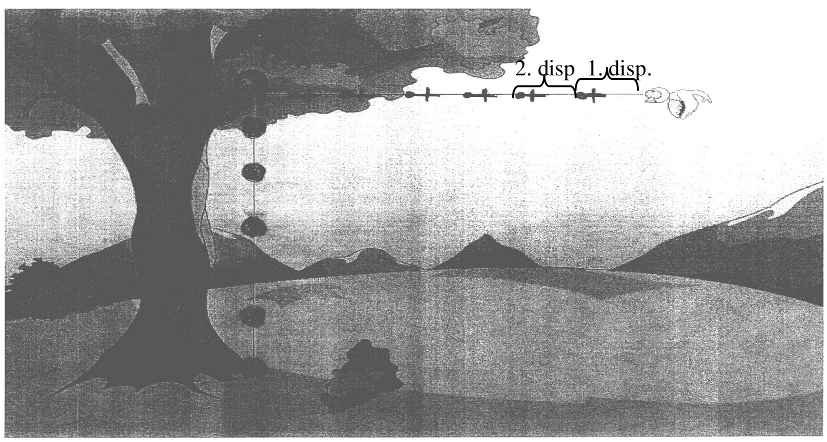


Figure 4.1 The method used for measuring the displacement between the figures

After measuring the distance between each figure, the data collected from each subject drawing is summarized in a table.

Category Name	**1. disp**	**2. disp**	**3. disp**	**4. disp**	**5. disp**	**6. disp**
Increasing	0.9	1.1	1.4	2.1	2.9	3.8
Constant	1.9	1.9	2	2	2	2
Decreasing	3	2.8	2.5	1.7	1.5	1.2
Other	2.8	1.6	1.5	2	1.1	2.8

Figure 4.2. An example to the table used in categorizing the drawings

By examining the data on the table composed for each subject, the drawings were categorized into four main categories. If the object's displacement in unit time increases, the drawing is categorized as 'increasing', if it doesn't change, categorized as 'constant', if it decreases, categorized as 'decreasing', and if it changes irregularly, it is categorized as 'other'. An example to the table used in categorizing the drawings is shown in Figure 4.2.

Table 4.1. The criteria for categorizing the subjects' drawings with respect to the change of object's displacement in unit time

Category No:	**Object's displacement in unit time:**
Category 1	increases
Category 2	constant
Category 3	decreases
Category 4	Others (No rational)

The drawings are scored taking into consider the motion of the objects presented in the computer animation. The subjects who took into consider the gravitational acceleration of free falling apple and increased the displacement of the object in their drawings, got 1 point from the evaluation of apple drawings. And the subjects who recognized the constant velocity and constant displacement of the bird observed in the animation and reflected this notion by drawing the motion of bird with constant displacements got 1 point from the evaluation of bird drawings. The drawings attributed to the other categories got 0 point from the evaluation part since other types of motion were excluded in this study.

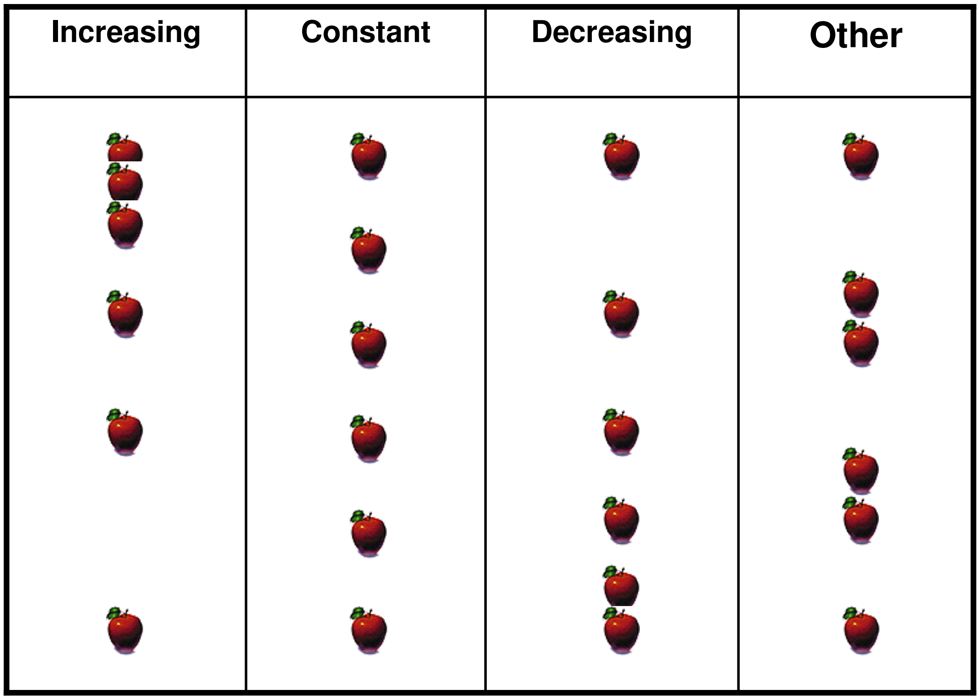


Figure 4.3 Figural representation of subject drawings categorization

4.2. Descriptive Characteristics of 'Animation Test' Items

'Animation Test' items were answered by the subjects after the treatment procedure and after the post application of 'Locate the Position' scale. The test is composed of 8 multiple choice items related with the motions of two objects observed in the animation. The number of items answered correctly by the subject is accepted to be that subjects' Animation Test score. The test is composed of 8 items related with the motions of two objects observed in the animation. So, each subject got a score out of eight points. The frequency and percentage of item alternative choice is given in Appendix B.

Table 4.2. Minimum, maximum, mean and standard deviation values of subjects' test results according to their grade levels.

School	Grade	N	Min	Max	Mean	Std. Dev.
Orbay Primary School	6	85	0	8	2,75	2,06
	7	25	0	6	1,80	1,35
	8	22	0	8	2,95	1,70
Kami Saadet G. Primary School	6	43	0	7	3,14	1,68
	7	25	1	8	4,92	2,60
	8	17	0	8	4,70	2,64

According to the Table 4.4., Kami Saadet Primary School students' test mean scores were higher than Orbay Primary School students at all levels. Mean score of AT was 2.75 for Orbay P.S. 6th graders, 1.80 for 7th graders, 2.95 for 8th graders, 3.14 for Kami Saadet P.S. 6th graders, 4.92 for seventh graders and 4.70 for eight graders. Kami Saadet seventh and eight graders are the groups which obtained highest mean score among the six groups.

4.3. Analysis of Item Difficulty and Item Discrimination Power

Table 4.3. Analysis of Item Difficulty and Item Discrimination Power

Item No:	Item Difficulty	Item Discrimination Power
1	0,39	0,49
2	0,58	0,39
3	0,49	0,59
4	0,35	0,30
5	0,42	0,57
6	0,34	0,39
7	0,25	0,27
8	0,33	0,38

According to the item difficulty analysis, the easiest questions for the subjects were 2., 3. and 5. items. The items which have highest discrimination power are 3., 5. and 1. items.

5. RESULTS AND FINDINGS

Research Question 1: Can students discriminate between two types of the motion, namely accelerated and constant velocity motion, by estimating the position of the objects at each unit time?

According to pretest apple positioning results, it is observed that 37.1 per cent of all subjects had intuitive conceptions to locate the positions of a free falling apple with constant displacement in unit time. Also another high tendency among students is to locate the positions of the free falling apple for each instant with irregularly changing displacement. 44.9 per cent of all subjects' pre positioning were in this 'other' category. 11.3 per cent of the subjects had intuitively thought that the displacement of free falling object decreases within time. The per cent of subjects who drew the motion of the apple with increasing displacement was rather low at the pretest. Only 6.7 per cent of subjects' apple drawings were in the 'increasing' category.

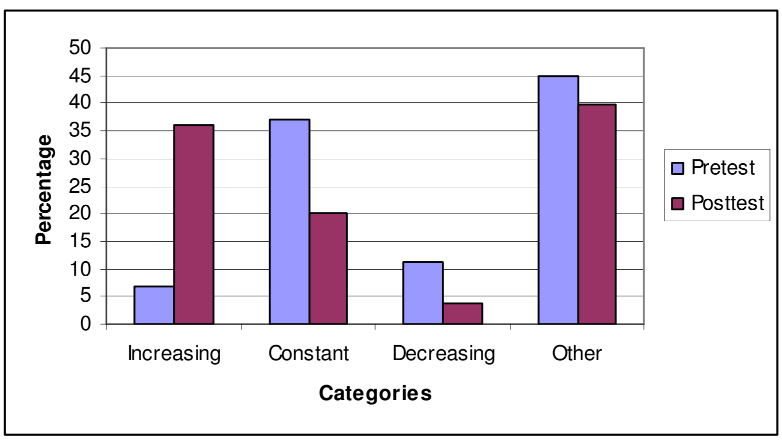


Figure 5.1. The percentage of all subjects (N=283) distributed into categories according to their pre and post apple drawings in 'Locate the Position' scale

Comparing the pretest and posttest percentages, it is observed that as the percentage of subjects in the 'constant', 'decreasing' and 'other' categories were decreasing, only the percentage of subjects in the 'increasing' category raised. After the treatment procedure, 36 per cent of all subjects have developed conceptions about the effect of gravitational force on falling objects and drew the motion of free falling object concerning these conceptions.

Table 5.1. The distribution of subjects according to their choices for the position of the 'apple' in pretest and posttest

Apple		Posttest				Total
		Increasing	Constant	Decreasing	Other	
Pretest	Increasing	13	0	0	6	19
	Constant	35	42	2	26	105
	Decreasing	5	4	3	20	32
	Other	49	11	6	61	127
Total		102	57	11	113	283

More detailed configuration representing the distribution of subjects into categories according to their pre and post apple positioning can be seen at Table 5.1. According to Table 5.1., only 19 out of 283 subjects, that is 6.71 per cent of all subjects had intuitive conceptions that direct them to locate free falling apple's position with increasing displacement in the pretest. 119 subjects had consistent intuitive conceptions that did not change after the treatment. 13 subjects positioned apple figures with increasing, 42 subjects positioned with constant, 3 subjects positioned with decreasing and 60 subjects positioned with irregularly changing displacement in both pre and posttest.

The percentage of subjects who located free falling apple's positions with increasing displacement raised from 6.71 to 36.04 per cent at the posttest. 35 out of 105 subjects who formerly indicated that the displacement would stay constant, 5 out of 32 subjects who indicated that it would decrease and 49 out of 127 subjects who indicated that it would irregularly change, located the apple positions with increasing displacement at the posttest. To sum up;

i. Students did not position the apple's motion randomly in the pretest
ii. Students did not position the apple's motion randomly in the posttest
iii. There is an association between the responses of students in pretest and posttest in locating the apple's position.

Figure 5.2. shows the change in the distribution of all subjects into categories according to their pre and post locations of bird positions. Most of the subjects had a high tendency to locate the positions of a flying bird with constant and with irregularly changing displacement. 40.3 and 43.5 per cent of all subjects' bird drawings were in 'constant' and in 'other' categories at the pretest respectively. The percentage of subject drawing in the 'decreasing' and 'increasing' category were rather low. They were 12 per cent and 4.3 per cent respectively.

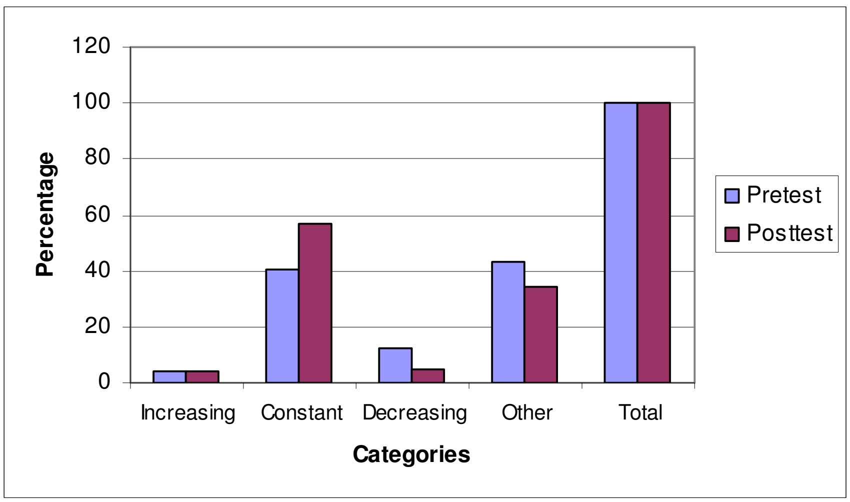


Figure 5.2. The percentage of all subjects (N=283) distributed into categories according to their pre and post bird drawings in 'Locate the Position' scale

After being exposed to the computer animation presenting the motion of a flying bird with constant velocity, most of the subjects, that is 57.2 per cent of all subjects drew the motion of bird with constant displacement. According to Figure 5.2., it is also observed that as the percentage of subject drawings in 'increasing', 'decreasing' and 'other' categories were decreasing, only the percentage of drawings in 'constant' category increased in the post test.

Table 5.2. The distribution of subjects according to their choices for the position of the 'bird' in pretest and posttest

Bird		Posttest				Total
		Increasing	Constant	Decreasing	Other	
Pretest	Increasing	1	4	0	7	12
	Constant	2	85	2	25	114
	Decreasing	0	13	4	17	34
	Other	8	60	7	48	123
Total		11	162	13	97	283

There is a tendency among subjects to represent the motion of flying bird with constant displacement in both pre and posttest. The frequency of subjects positioned bird figure with constant distance increased from 114 to 162 in the posttest. 4 subjects who formerly indicated that the bird's displacement in unit time would increase, 13 subjects who indicated that it would decrease and 60 subjects who indicated that it would irregularly change, positioned bird at the post test with constant displacements.

Shortly;

i. Students did not position the bird's motion randomly in the pretest.
ii. Students did not position the bird's motion randomly in the posttest.
iii. There is an association between the responses of students in pretest and posttest in locating the bird's position.

Table 5.3. Chi-Square test results for apple and bird positioning in pre and post applications of 'Locate the Position' scale

	Positions of the Apple in Pretest	Positions of the Apple in Posttest	Positions of the Bird in Pretest	Positions of the Bird in Posttest
Chi-Square	120.378	92.166	132.901	225.028
df	3	3	3	3
Sig.	.000	.000	.000	.000

Research Question 2: Does being exposed to computer animation have a significant effect on discriminating between accelerated and constant velocity motions?

The apple positioning results showed that, 6.71 per cent of the subjects had intuitive conceptions directing them to position free falling object with increasing displacement in the pretest. The percentage of subjects who represented the motion of apple with increasing displacement raised to 36.04 per cent in the posttest.

According to pretest bird positioning results, it is observed that 40.28 per cent of the subjects located the positions of a flying bird as it would move with constant displacement in unit time. The percentage of subjects in the 'constant' category raised to 57.24 after the treatment procedure.

McNemar test for significance of changes was used in order to analyze if the differences between pre and posttest scores obtained from LTP scale was significant or not. The reason for choosing McNemar test is that, two related samples, of before and after type, and nominal level measurement was used in that study.

McNemar test results for the significance of differences indicates that there is a significant difference between subjects' (N=283) pre and posttest scores obtained from 'Locate the Position' scale in terms of both apple (χ^2=70.779, p<.01) and bird positioning (χ^2=20.840, p<.01). According to that results, it can be concluded that being exposed to computer animation had a significant effect on subjects to discriminate between two types of motion, namely constant and accelerated motion.

Research Question 3: Are there significant differences among students with respect to grades in so far as to tasks mentioned in the first and second questions?

Figure 5.3. shows the distribution of fifth, sixth, seventh and eight grade subjects according to their choices for the position of the 'apple' in pretest. According to this figure, it can be said that most of the subjects have high tendency to represent that the displacement of free falling object stays constant or changes with no rational. In their first

positioning, 25.8 per cent of fifth graders, 37.5 per cent of sixth graders, 43.1 per cent of seventh graders and 47.4 per cent of eight graders have mentioned that free falling object's displacement in unit time stays constant. The tendency to mention in the pretest that the falling apple's displacement stays constant, increases with increasing age. Also 45.5 per cent of fifth graders, 44.5 per cent of sixth graders, 45.1 per cent of seventh graders and 44.7 per cent of eight graders' first apple drawings were found to be in the 'other' category which means that the object displacement in unit time changes differently with no rational. Beside these, it was observed that only 7.6 per cent of fifth graders, 6.3 per cent of sixth graders, 9.8 per cent of seventh graders and 2.6 per cent of eight graders have previously discovered that the free falling objects' displacement in unit time increases.

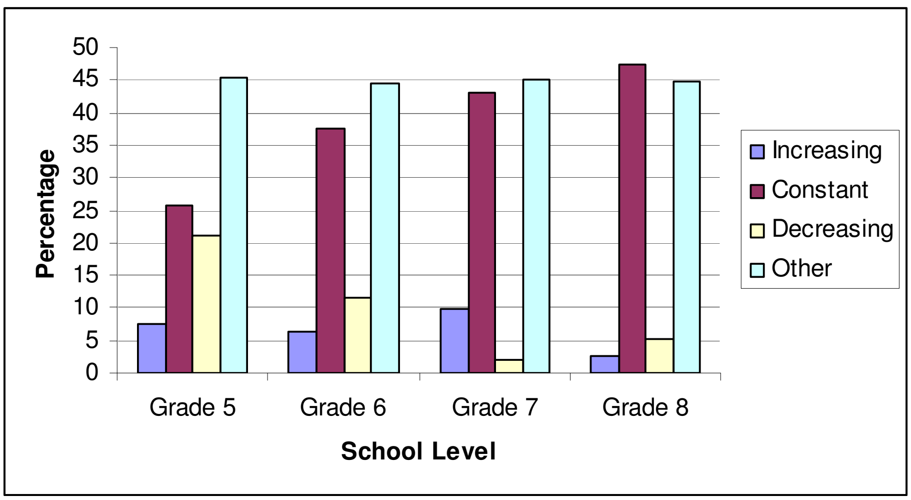


Figure 5.3. Fifth, sixth, seventh and eight grade subjects' distribution according to their choices for the position of the'apple' in pretest

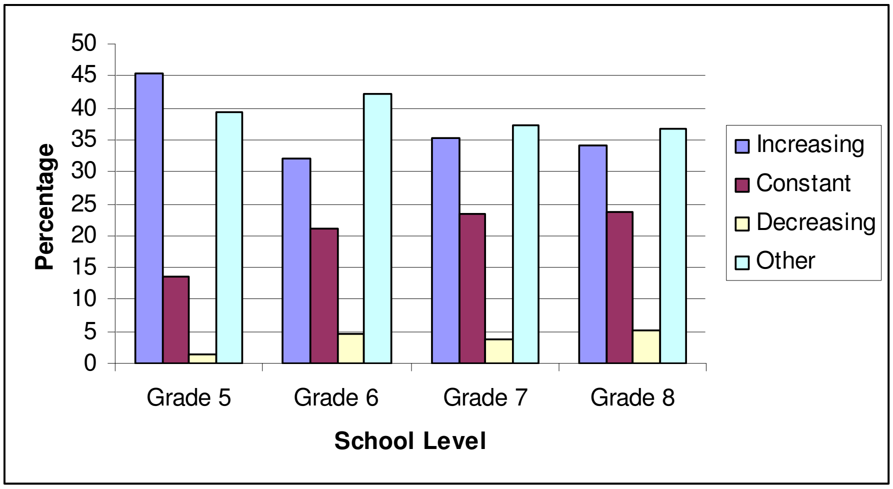


Figure 5.4. Fifth, sixth, seventh and eight grade subjects' distribution according to their choices for the position of the 'apple' in posttest

Figure 5.4. presents the distribution of fifth, sixth, seventh and eight grade subjects into categories according to their second apple drawings. If Figure 5.4. is compared with Figure 5.3., it can be concluded that the percentage of drawings attributed to 'increasing' category raised for all grades. Beside the increase in 'increasing' category, it is also observed that there is a decrease in the percentages of 'constant' and 'other' categories for all grades and in 'decreasing' category for fifth and sixth grades in the posttest.

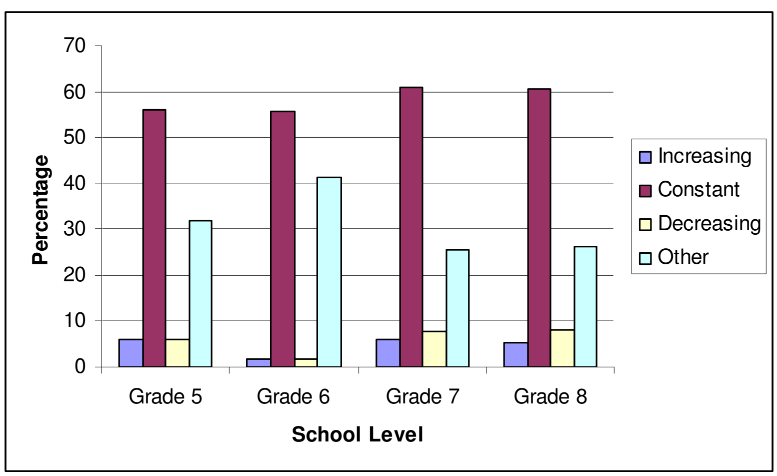


Figure 5.5. Fifth, sixth, seventh and eight grade subjects' distribution according to their choices for the position of the 'bird' in pretest

Resembling to the apple's case, it is observed in Figure 5.5. that the percentage of bird motion pretest drawings attributed to the 'constant' category increased with increasing age. The other high tendency among subjects from all grades is to locate the positions of bird with irregularly changing displacement.

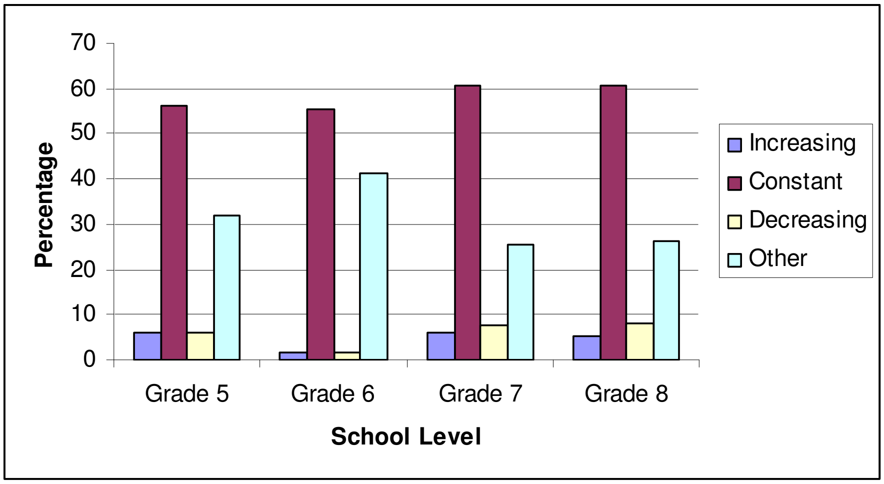


Figure 5.6. Fifth, sixth, seventh and eight grade subjects' distribution according to their choices for the position of the 'bird' in posttest

Comparing Figure 5.6. with Figure 5.5., it can be concluded that the percentage of subjects whose bird drawings were attributed to 'constant' category increased for all grades in the posttest. It should also be mentioned that the percentage of subject drawings attributed to the 'increasing', 'decreasing' and 'other' categories have decreased for almost all school levels in the posttest.

Table 5.4. McNemar test for significance of difference between Orbay P.S. 5th, 6th, 7th and 8th grade subjects' pre and posttest scores obtained from "Locate the Position" scale

Variables	School Level	N	Sig. (2-tailed)
Pre & Post Apple Positioning Scores	5	66	.000
Pre & Post Bird Positioning Scores	5	66	.002
Pre & Post Apple Positioning Scores	6	85	.000
Pre & Post Bird Positioning Scores	6	85	.010
Pre & Post Apple Positioning Scores	7	23	.070
Pre & Post Bird Positioning Scores	7	23	.344
Pre & Post Apple Positioning Scores	8	21	.125
Pre & Post Bird Positioning Scores	8	21	.021

The percentage of Orbay P.S. fifth graders who correctly made their estimations about the free falling apple's motion increased from 7.57 to 54.54 in the post test. Also the percentage of fifth graders who correctly made their estimations about the displacement (per unit time) of the bird, moving with constant velocity increased from 30.30 to 56.06 in the posttest. In order to analyze if the treatment procedure had a significant effect on changing students' previous estimations, McNemar test is used since the difference in two-related samples' pre and post test scores is investigated and at nominal level data is used.

According to the McNemar test results, there is a significant difference at .01 level between 5th grade subjects' pre and posttest scores obtained from 'Locate the Position' scale in terms of both apple and bird motion drawings.

The highest improvement is observed in fifth graders. Fifth graders are the group who benefited most from the computer- animation based, unstructured treatment procedure among the other groups, in spite of their younger age and lack of explicit knowledge related with force and motion concepts.

The percentage of Orbay P.S. sixth graders, who correctly estimated the positions of free falling object at each unit time increased from 8.23 to 37.64 in the posttest. Also the percentage of sixth graders who correctly made their estimations about the displacement of bird moving with constant velocity increased from 24.71 to 43.53. In order to analyze if there is a significant difference between the scores obtained from the pre and post applications of “Locate the Position” instrument, McNemar test is used.

According to McNemar test results presented in Table 5.4. it is concluded that there is a significant difference between 6th grade subjects’ pre and post scores obtained from scores obtained from the pre and post applications of “Locate the Position” Instrument. Treatment procedure has a significant effect on changing sixth graders’ intuitive notions into desired manner.

The percentage of Orbay P.S. seventh graders who drew the free falling apple’s motion in the desired way increased from 4.16 to 29.16 in the posttest. The percentage of seventh graders who correctly made their estimations about the displacement of bird moving with constant velocity increased from 20.83 to 37.5 in the posttest. The significance of difference between the scores obtained from pre and post applications of LTP scale is investigated by McNemar test. There is not a significant difference between the scores obtained from pre and post applications of LTP scale for seventh graders.

The percentage of eight grade subjects who discovered that the free falling apple’s displacement increases at each unit time, increased to 31.81 from 4.55 in the posttest. Also the percentage of subjects who discovered that the bird’s displacement stays constant within its motion, inreased to 50 from 13.63.

According to McNemar test results presented in Table 5.4., there is a significant difference between pre and posttest scores related with bird motion ($p<.05$) but there is not a significant difference between pre and post test scores related with apple motion for eighth graders ($p>.05$).

Table 5.5. McNemar test for significance of difference between Kami Saadet P.S. 6th, 7th and 8th grade subjects' pre and posttest scores obtained from "Locate the Position" scale

Variables	School Level	n	Sig. (2-tailed)
Pre & Post Apple Positioning Scores	6	43	.039
Pre & Post Bird Positioning Scores	6	43	1.000
Pre & Post Apple Positioning Scores	7	27	.016
Pre & Post Bird Positioning Scores	7	27	.125
Pre & Post Apple Positioning Scores	8	16	.031
Pre & Post Bird Positioning Scores	8	16	.250

The percentage of Kami Saadet P.S. sixth graders who correctly estimated free falling object's position at each unit time, increased from 2.33 to 20.93 in the posttest. Also the percentage of sixth graders who correctly made their estimations about the displacement of bird moving with constant velocity increased from 76.74 to 79.07. The significance of difference between pre and post drawings is investigated by McNemar test.

According to the test results presented in Table 5.5., there is a significant difference between pre and post apple scores ($p<.05$). There is not a significant difference between pre and post applications of LTPS in terms of bird scores. The treatment had a significant effect on forming conceptions about the motion of free falling object.

The percentage of subjects who discovered that the apple was moving under gravitational acceleration and who reflected this notion in their drawings increased from 14.81 to 40.74 in the posttest. And the percentage of seventh grade subjects who reflected bird's constant velocity motion in their drawings increased from 62.96 to 81.48. The significance of difference between pre and posttest results of the instrument is investigated with McNemar test. The treatment has a significant effect on apple drawings ($p<.05$) and has not a significant effect on bird drawings ($p>.05$).

According to the McNemar test results presented in Table 5.5., there is a significant difference between seventh graders pre and post apple scores obtained from LTPS. The treatment was effective in terms of changing intuitive notions about apple's motion ($p<.05$). According to the Table 5.5., there is not a significant difference between seventh graders' pre and post bird scores from LTPS ($p>.05$).

The percentage of eight graders who could reflect apple's accelerated motion in their drawings increased from 0 to 37.5 in the posttest. The percentage of eight graders who could reflect bird's constant velocity motion in their drawings decreased from 93.75 to 75 in the posttest. McNemar test is applied for investigating the difference between pre and posttest scores of LTP scale.

According to the McNemar test results presented in Table 5.5., there is a significant difference between eight graders' pre and post apple scores obtained from LTP ($p<.05$). But there is not a significant difference between eight graders' pre and post bird scores obtained from LTP scale. The treatment had a significant effect on changing eight graders' intuitive conceptions about the motion of a free falling object.

Research Question 4: Is there a significant relationship between subjects' science achievement score and their pre and post "Locate the Position" scale results?

Table 5.6. shows if the percentage of subjects, whose pretest apple positioning were attributed to specific categories, changes with the increasing science achievement grade or not. It is observed from Table 5.6. that none of the subjects, whose science achievement score is one, could correctly locate the positions of free falling object at pretest. It is also observed that the percentage of subjects whose pretest apple locations attributed to 'increasing' category increases as the science achievement score increases. Another point emphasized is that the percentage of drawings attributed to the 'constant' category decreases with the increasing science achievement score. It should also be emphasized that there are still many individuals who have high science grades and who have intuitive notions that the free falling object moves with constant, decreasing or irregularly changing displacement.

Table 5.6. The percentage of subjects with respect to their science achievement scores and choices for the position of the 'apple' in pretest

Science Achievement Score	Pretest				
	Increasing	Constant	Decreasing	Other	n
1	0	54.9	2	43.1	51
2	5.3	43.9	5.3	45.6	57
3	3.2	32.3	14.5	50	62
4	9.5	28.6	14.3	47.6	42
5	14.5	26.1	18.8	40.6	69
n	19	103	32	127	

Table 5.7. shows if the percentage of subjects, whose post test apple drawings attributed to specific categories, changes with increasing science achievement grade or not. According to the data presented in Table 5.7., it can be concluded that the percentage of subjects whose free falling apple drawings attributed to the 'increasing' category raises as the science achievement score raises. The individuals who have high science achievement scores are more likely to locate the positions of free falling object correctly in the post test. 9.8 per cent, 21.1 per cent, 30.6 per cent, 52.4 per cent and finally 62.3 per cent of subjects whose science achievement score is 1, 2, 3, 4 and 5 respectively could indicate the increase in object displacement within their drawings. It is also observed from the data presented in Table 5.6. that the percentage of subject drawings attributed to 'constant', 'decreasing' and 'other' categories decreases with increasing science achievement score. Among the subjects whose science achievement grade is five, the percentage of subject drawings attributed to the 'constant', 'decreasing' and 'other' categories were 1.4 per cent, 2.9 per cent and 33.3 per cent respectively.

Table 5.7. The percentage of subjects with respect to their science achievement scores and choices for the position of the 'apple' in posttest

Science Achievement Score	Posttest				
	Increasing	Constant	Decreasing	Other	n
1	9.8	41.2	3.9	45.1	51
2	21.1	28.1	7	43.9	57
3	30.6	19.4	3.2	46.8	62
4	52.4	14.3	2.4	31	42
5	62.3	1.4	2.9	33.3	69
n	101	56	11	113	281

Table 5.8. presents that most of the subjects at all science achievement levels drew the motion of flying bird to be either in the 'constant' or in the 'other' category in the pretest. The percentage of drawings attributed to the 'increasing' and to the 'decreasing' categories were rather low for all science achievement levels.

Table 5.8. The percentage of subjects with respect to their science achievement scores and choices for the position of the 'bird' in pretest

Science Achievement Score	Pretest				
	Increasing	Constant	Decreasing	Other	n
1	0	52.9	5.9	41.2	51
2	8.8	40.4	8.8	42.1	57
3	4.8	37.1	17.7	40.3	62
4	4.8	28.6	16.7	50	42
5	2.9	42	10.1	44.9	69
n	12	114	33	122	281

Comparing Table 5.8. with Table 5.9. results that the percentage of subject drawings attributed to be in 'constant' category increased for all groups at differing science achievement levels in the posttest. Also the percentage of subjects who positioned the bird with constant displacements was high for all groups of subjects at differing science achievement levels. Decrease in the percentages of other categories at almost all science levels is observed from the comparison of Table 5.8. with Table 5.9.

Table 5.9. The percentage of subjects with respect to their science achievement scores and choices for the position of the 'bird' in posttest

Science Achievement Score	Posttest				
	Increasing	Constant	Decreasing	Other	n
1	0	70.6	2	27.5	51
2	7	47.4	8.8	36.8	57
3	1.6	48.4	1.6	48.4	62
4	7.1	59.5	7.1	26.2	42
5	4.3	62.3	4.3	29	69
n	11	161	13	96	281

Pearson correlation coefficient were calculated in order to analyze the relationship between subjects' science achievement scores and their pre and post scores obtained from LTPS. Pearson correlation coefficients between subjects' science achievement score and the score obtained from LTPS in terms of apple and bird positioning are presented in Table 5.10.

According to the correlation analysis presented in Table 5.10., both pre apple positioning score ($r=.194$, $p<.01$) and post apple positioning score ($r=.406$, $p<.01$) had positive correlations with science achievement score, which means higher achievement levels of science was associated with higher performances on the LTPS in terms of apple positioning. The table also signifies that the correlation coefficient between science achievement score and the score obtained from the positioning of apple increases at the posttest.

Table 5.10. Pearson correlation coefficient for the relationship between science achievement score and the score obtained from pre and posttest results of LTP scale

		Pretest Apple Positioning Score	Posttest Apple Positioning Score	Pretest Bird Positioning Score	Posttest Bird Positioning Score
Science Achievement Score	Correlation Coefficient (r)	.194(**)	.406(**)	-.078	.000
	Sig. (2-tailed)	.001	.000	.190	.998
	N	281	281	281	281

** < .01

* < .05

According to the findings, neither the score obtained from pre bird positioning (r=-.078, p>.05) nor the score obtained from post bird positioning (r=.000, p>.05) had a significant correlation with science achievement scores. That is to say, many subjects had a tendency to locate the positions of flying bird with constant displacement regardless of their achievement in science lesson.

Pearson correlation coefficients between Orbay and Kami Saadet Primary School 5., 6., 7. and 8. grade subjects' science achievement score and the score they obtained from pre and post applications of LTP scale and the significance levels found are listed in Table 5.11. and Table 5.12.

Table 5.11. Pearson correlation coefficient for the relationship between Orbay P.S. 5th, 6th, 7th and 8th grade subjects' science achievement score and LTP pre and posttest scores

Variables	School Level	N	Pearson Correlation Coefficient	Sig. (2-tailed)
Science Achievement Score – Pre Apple Positioning Score	5	66	.154	.216
Science Achievement Score – Post Apple Positioning Score	5	66	.427(**)	.000
Science Achievement Score- Pre Bird Positioning Score	5	66	.145	.247
Science Achievement Score-Post Bird Positioning Score	5	66	.192	.121
Science Achievement Score – Pre Apple Positioning Score	6	85	-.052	.637
Science Achievement Score – Post Apple Positioning Score	6	85	.270(*)	.012
Science Achievement Score- Pre Bird Positioning Score	6	85	.201	.066
Science Achievement Score-Post Bird Positioning Score	6	85	.206	.058
Science Achievement Score – Pre Apple Positioning Score	7	23	.530(**)	.009
Science Achievement Score – Post Apple Positioning Score	7	23	.171	.435
Science Achievement Score- Pre Bird Positioning Score	7	23	.306	.156
Science Achievement Score-Post Bird Positioning Score	7	23	.064	.772
Science Achievement Score – Pre Apple Positioning Score	8	21	.438(*)	.047
Science Achievement Score – Post Apple Positioning Score	8	21	.453(*)	.039
Science Achievement Score- Pre Bird Positioning Score	8	21	.149	.520
Science Achievement Score-Post Bird Positioning Score	8	21	.499(*)	.021

** < .01

* < .05

According to the correlational analysis results shown in Table 5.12., it is observed that although there is not a significant correlation between 5th (r=.154, p>.05) and 6th (r=-.052, p>.01) grade Orbay P. S. subjects' science achievement score and their prettest scores obtained from apple positioning, there is a significant correlation between 5th (r=.427, p<.01) and 6th graders' (r=.270, p<.05) science achievement scores and the scores obtained from post apple positioning. The reverse case is observed for 7th graders. Although 7th graders' science achievement score is significantly correlated with their pretest apple positioning scores (r=.530, p<.01) , it is not correlated with the posttest scores (r=.171, p>.05). 8th graders' science achievement score is significantly correlated with the pre (r=.438, p<.05) and posttest scores obtained from the positioning of the apple (r=.453, p<.05). The significant correlation between science achievement scores and the scores obtained from bird positioning is only observed with 8th graders' posttest results (r=.499, p<.05). No significant correlation is observed between the rest of the subjects' science achievement scores and pre or post scores obtained from bird positioning.

Table 5.12. presents the correlation coefficients between Kami Saadet P.S. 6., 7., and 8. grade subjects' science achievement scores and the scores obtained from LTP scale. According to Table 5.12., there is a significant correlation between science achievement score and 6th graders' post (r=.425, p<.01), 7th graders' pre (r=.603, p<.01) and post (r=.844, p<.01) and finally 8th graders' posttest scores obtained from positioning of apple (r=.637, p<.01). It should be emphasized that the correlation coefficient between 7th graders science score and bird positioning score increased at the posttest. Similar to Orbay P.S. case, there is no significant correlation between any grade of Kami Saadet P.S.'s science achievement scores and the scores obtained from pre and post positioning of bird. The negative correlation is observed between 6th graders' post (r=-.171, p>.05), 7th graders' pre (r=-.219, p>.05) and post (r=-.106, p>.05) and 8th graders' pretest scores (r=-.138, p>.05) obtained for the positioning of bird and their science achievement scores although they were not significant. That means, the subjects who have lower science achievement scores were more successful at positioning the bird figures with constant displacements.

Table 5.12. Pearson correlation coefficient for the relationship between Kami Saadet P.S. 6th, 7th and 8th grade subjects' science achievement score and LTP pre and posttest scores

Variables	School Level	N	Pearson Correlation Coefficient	Sig. (2-tailed)
Science Achievement Score – Pre Apple Positioning Score	6	43	.106	.498
Science Achievement Score – Post Apple Positioning Score	6	43	.425(**)	.005
Science Achievement Score- Pre Bird Positioning Score	6	43	.061	.247
Science Achievement Score-Post Bird Positioning Score	6	43	-.171	.272
Science Achievement Score – Pre Apple Positioning Score	7	27	.603(**)	.001
Science Achievement Score – Post Apple Positioning Score	7	27	.844(**)	.000
Science Achievement Score- Pre Bird Positioning Score	7	27	-.219	.272
Science Achievement Score-Post Bird Positioning Score	7	27	-.106	.598
Science Achievement Score – Pre Apple Positioning Score	8	16	-	-
Science Achievement Score – Post Apple Positioning Score	8	16	.637(**)	.008
Science Achievement Score- Pre Bird Positioning Score	8	16	-.138	.609
Science Achievement Score-Post Bird Positioning Score	8	16	.062	.820

** < .01

* < .05

Research Question 5: Is there a significant correlation between subjects' science achievement grade and the score they obtained from the test related with the motions observed at the computer animation?

The fifth question aimed to investigate the relationship between subjects' science achievement score and the score they obtained from 'Animation Test' including questions related with the motions observed in the computer animation. The Pearson correlation coefficient between science achievement score and the score obtained from 'Animation Test' is calculated to be .194 which is significant at .01 level.

Research Question 6: Is there a significant relationship between the achievements in "Locate the Position" scale and the achievement in the "Animation Test" items?

The sixth question aimed to investigate the relationship between subjects' achievement in 'Locate the Position' scale and their achievement in 'Animation Test'. The Pearson correlation coefficient between the scores obtained from LTP scale and 'Animation Test' is found to be .236 ($p<.01$). It can be concluded that there is a significant correlation between subjects' achievement in 'Locate the Position' scale and their achievement in 'Animation Test'.

6. DISCUSSION

The first aim of this study was to identify if students could discriminate between two types of motion, namely constant and accelerated motion by using their intuitive conceptions and locating the positions of the objects at each unit time.

All 5th and 6th grade subjects who have no explicit knowledge about 'force and motion' concepts and 7th and 8th grade subjects who have studied this subject at school were asked to think of the motion of a flying bird and a free falling apple and estimate the positions of these two objects at each unit time and label a bird and an apple figure representing their positions at that instant. Subjects' positioning estimations were analyzed with the following procedure. Since each object figure subjects plotted on the papers were indicating the position of that object at that instant, the distance between the figures would indicate the displacement of the moving object. The distances between the figures were measured and subjects' estimations were categorized according to the objects' displacement changes.

Preexisting knowledge or knowledge structures that predispose individuals to think and act in particular ways without much conscious reflection are called intuitive conceptions. According to Torff and Sternberg (2001) even people who are trained in education hold powerful intuitive conceptions about teaching and learning, and these intuitive conceptions exert a great deal of influence on the way they think and act in classroom settings. According to the statistical analysis of this study, even the seventh and eight graders who have studied the 'force and motion' concept had intuitive conceptions to locate the positions of free falling object representing motion with constant or irregularly chanding displacement. 43.1 per cent of seventh graders and 47.4 per cent of eight graders formerly estimated that the free falling apple would move with constant displacement. The other high tendency among 7th and 8th graders was to view the motion of free falling object with irregularly changing displacement. 45.1 per cent of 7th graders and 44.7 per cent of 8th graders estimated that the free falling object's displacement in unit time would change irregularly. Beside these, only 9.8 per cent of 7th graders and 2.6 per cent of 8th graders could take into account what they have learnt about gravitational acceleration concept in 'force and motion' lesson and make their estimations related with the free falling object in correct way.

In this study, it was also investigated 5th and 6th graders' intuitive conceptions about the motion of an object under gravitational acceleration. Although 5th graders and 6th graders had not explicit knowledge related with acceleration concept, 7.6 per cent of fifth graders and 6.3 per cent of sixth graders could correctly positioned the figures in the pretest. 14 students could formerly discover the effect of gravitation on free falling object by intuition. The science achievement score of these 14 students was rather high. The mean science achievement score is calculated to be 3.93 for this group. Most of the 5th and 6th graders, 45.5 per cent of fifth graders and 44.5 per cent of sixth graders estimated that the free falling object's displacement would change irregularly. Second common tendency among 5th and 6th graders were the expectation of free falling object's motion with constant displacement. 25.8 per cent of 5th graders and 37.5 per cent of 6th graders made their estimations in that way.

Studies on intuitive physics have shown that people hold a set of naive beliefs (Chi and Slotta, 1993; diSessa, 1982, 1993; McCloskey, Camarazza and Green, 1980). According to Jimoyiannis and Komis (2000), there is a common research assumption that students' possess a system of beliefs and intuitions about physical phenomena mainly derived from everyday experience.The results presented so far also support these ideas and indicate students varying intuitive conceptions related with a specific phenomena, motion of an object under gravitational acceleration. Only 6.71 per cent of the subjects had correct intuitive conceptions about the phenomena. This study result is supported with the results of various studies which have shown that students have concepts of the natural world that are quite different from those of scientists (Berg and Brouwer, 1991). Recent studies, such as those concerning conceptual change, are against the tendency to view teachers as providing information through didactic instruction and students as absorving correct concepts (Wertsch and Polman, 2001). Instead, they focus on conceptual change that starts with intuitive conceptions. Those researches have suggested that the intuitive conceptions students bring to a learning situation are quite resistant to change through direct instruction (Confrey, 1989). There are also several studies which suggest that ignoring the intuitive concepts of students result in school knowledge about scientific phenomena that they are unable to apply in real-world settings (Lewis, Stern and Linn, 1993; Reif and Larkin, 1991); Resnick, 1987). An example of this situation can be observed in the results of study. Most of the subjects could not able to apply their school knowledge about scientific phenomena in a real-world setting even if they have studied the 'force and motion' subject. Most of the eight and seventh graders were unsatisfactory to use their school knowledge about the effects of gravitational force in making their estimations about the motion of a free falling object in the pretest.

It is resulted in this study that most of the subjects had wrong intuitive conceptions about the effects of gravitational force on free falling object although they were successful in science lesson. For example 40.6 per cent of the subjects whose science achievement score was 5, 47.6 per cent of the subjects whose science achievement score was 4 represented the free falling apple's motion with irregularly changing displacement. Also 26.1 per cent of the subjects whose sciece achievement score was 5 and 28.6 per cent of the subjects whose science achievement score was 4, expected that the free falling object would move with constant displacements. These results show that even the students who are successful in science lesson may experience some difficulties in dealing with abstract concepts, like gravity, and applying their knowledge in real-world settings. There are so many studies investifating why understanding complex information is difficult. Redish (1993) states that mastery of abstract scientific concepts requires building flexible and runnable mental models. Since gravity is one of the abstract concepts, trying to teach students the gravitational acceleration concept by presenting explicit information with rote manipulation of symbols and formulas may result in students' formations of those flexible mental models with no real-life experiences. And eventually the flexible mental models may turn into misconceptions that are resistant to change even after participating in courses. McDermott (1991) states that students learning science need to ba able to sift through complex information, identifying what is important and what is not and recognizing critical patterns and relationships.

In the light of these views, the second aim of this study was to investigate if subjects could change their wrong intuitive conceptions into correct ones without being presented the explicit information, theories or formulas but by observing two objects' different types of motion from a computer animation. In the treatment part, the subjects got chance to compare the displacements of two moving objects by observing the motion of two objects, firstly in natural and then in slower motion. After observing the accelerated motion of apple and constant velocity motion of bird from the computer animation, the subjects were again asked to locate the positions of two objects on the sheet of paper that is distributed to them. Posttest results have shown that the percentage of subjects who located the positions of free falling apple with increasing distances increased from 7.6 to 45.5 per cent for 5^{th} graders, from 6.3 to 32 per cent for 6^{th} graders, from 9.8 to 35.3 per cent for 7^{th} graders and 2.6 per cent to 34.2 per cent for eight graders. The interesting result is that 5^{th} graders are the group who benefitted most from the computer-animation based, unstructured treatment procedure inspite of their younger age and lack of explicit knowledge related with the subject. 5^{th} graders were more open to learn and more open to change their existing intuitive conceptions. 6^{th}, 7^{th} and 8^{th} graders could not benefitted from the treatment procedure as much as fifth graders. This may be because of having difficulties in changing misconceptions at older ages than at younger ages. Misconceived notions may become more resistant to change as time passes, so becoming aware of student misconceptions and developing learning environments that those misconceptions may be overcome is impostant for students' education.

McNemar test is used in order to analyze the significance of difference between 5^{th}, 6^{th}, 7^{th} and 8^{th} graders' pre and post LTPS resulta. Since two related samples, of before and after type, and nominal level measurement was used. McNemar test results indicate that, there is a significant difference between Orbay P.S. 5^{th} graders ($p<.01$), 6^{th} graders ($p<.01$), and Kami Saadet P.S. 6^{th} graders ($p<.05$), 7^{th} graders ($p<.05$) and 8^{th} graders' ($p<.05$) pre and posttest scores obtained from the positioning of apple. There is not a significant difference between Orbay P.S. 7^{th} graders' ($p>.05$) and 8^{th} graders' ($p>.05$) pre and posttest scores obtained from the location of apple positions.

There was a high tendency among students to represent bird's motion with constant or irregularly changing displacements regardless of their age. The tendency among students to position bird figure with constant displacements indicating its motion with constant velocity strengthened at the posttest. The percentage of subjects who positioned bird figures with constant distances increased from 30.3 to 56.1 for fifth graders, 42.2 to 55.5 for sixth graders, 43.1 to 60.8 for seventh graders and 47.4 to 60.5 for eight graders. The percentage of subjects who positioned bird figures with irregularly changing displacements decreases from 51.5 to 31.8 for 5th graders, 43 to 41.4 for 6th graders, 39.2 to 25.5 to 7th graders and 36.8 to 26.3 for 8th graders.

McNemar test results indicate that there is a sinificant difference between Orbay 5th graders' ($p<.01$), 6th graders' ($p<.01$) and 8th graders' ($p<.05$) pre and posttest scores obtained from the location of bird positions. Because many subjects had tendency to locate the bird positions with constant displacements in both pre and post test, no significance difference is observed between the rest of the subjects' pre and post bird positioning scores.

The mean science achievement score of the 15 subjects who had correct intuitive conceptions about the motion of falling apple was 3.93. It should be also emphasized that about 85 per cent of the subjects whose science achievement score was 5, wrongly made their predictions about the motion of free falling apple in the pretest.

The correlation coefficient ($r=.194$) between science achievement score and pretest apple positioning score increased to .406 at the posttest. As only 14.5 per cent of the subjects whose science grade 5 were successful at the pretest, 62.3 per cent of them could be successful at posttest. Similarly, the percentage of subjects whose science achievement grade was 4 and were successful in apple positioning increased from 9.5 to 52.4 at the posttest. So science achievement score is more associated with the posttest performance in LTPS then pretest performance.

Beside this, it should also be emphasized that there are some students who intuitively learnt gravity concept even if they were not successful in science lesson. 15 out of 102 students who located free falling object's positions correctly were students whose science achievement score was 1 or 2. The treatment had significant effect not only on higher achiever students. It helped to make the subject accessible to a wide range of students.

Since 5th and 6th grade subjects do not have explicit knowledge about gravitational acceleration, there is not a significant correlation between Orbay P.S. 5th (r=.154) and 6th (r=-.052) and Kami Saadet P.S. 6th grade subjects science achievement score and the pretest score obtained from LTPS.

Significant correlation is observed in all Orbay 5th (r=.427, p<.01), 6th (r=.270, p<.05) and Kami Saadet P.S. 6th graders' (r=.425, p<.01)science achievement score and 'Locate the position of apple' scale posttest score. There is a significant correlation between Orbay 7th graders' science achievement score and only 'Locate the position of apple' scale pretest score (r=.530, p<.01). There is a significant correlation between Orbay 8th graders' science achievement score and both LTPAS pretest (r=.438, p<.05) and posttest (r=.453, p<.05) scores. Kami Saadet 7th graders is one of the classes who have learnt 'force and motion' subject in the previous semester and it is found that there is a significant correlation between Kami Saadet 7th graders' science achievement score and their pre (r=.603, p<.01) and posttest LTPS scores for positioning of apple (r=.844, p<.01).

The relationship between subjects' responses to LTPS and their responses to animation test is investigated with Chi-Square test analysis. 89 out of 215 subjects showed in LTPS that the apple's displacement in unit time either increases, stays constant, decreases or changes irregularly and answered the related question in 'Animation Test' consistently. 27.7 per cent of subjects who positioned the of apple correctly in the post test, gave a wrong answer to the related item in the test. Also 51.03 per cent of the subjects who positioned the motion of apple wrongly, answered the question asking apple's displacement changes correctly. From this point, it can be said that there are some individuals who can visually understand and figurally explain an event but may have some difficulties in comprehending it verbally. Chi-Square test results (χ^2=8.870, df=1, p<.01) showed that there is a significant relationship between students' post apple positioning and answering to the question which asks how the apple's displacement changes within its motion.

83 out of 216 subjects showed LTPS that the bird's displacement in unit time either increases, stays constant, decreases or changes irregularly and answered the related

question in 'Animation Test' consistently. 54.4 per cent of subjects who positioned the apple correctly in LTPS post test, gave a wrong answer to the related item in the test. The ones who could visually understand the event but wrongly answered the question may have some difficulties on comprehending terminology like 'displacement in unit time'. Also 31.09 per cent of the subjects who drew the motion of apple wrongly, answered the question asking apple's displacement changes correctly. From this point, it can be said that there are some individuals who can visually understand and figurally explain an event but may have some difficulties in comprehending it verbally.

According to Chi-Square results, there is a significant relationship between students' post bird drawings and answering to the question which asks how the bird's displacement changes within its motion (χ^2=4.144, df=1, $p<.05$). 62.7 percent of the subjects who could answer verbal representation requiring question correctly, answered symbolic representation requiring question wrongly. Also 28.6 per cent of the subjects who answered verbal representation requiring question incorrectly could give correct answer to symbolic representation requiring question. This analysis shows that the students experience increasing difficulties as the task includes more abstract concepts and requires symbolic representations.

6.1. Recommendations For Further Study

The method used in this study can be an efficient starting point for instruction. Before the formal representations of abstract concepts are introduced, with the help of model used in this study the students can intuitively understand how the natural world functions. Fostering in students the ability to predict qualitatively the behavior of phenomena under investigation is a valuable method for teaching them to manipulate quantitative formulas. Students may use their experiences gained from computer-animation supported intruction to construct more accurate mental models and to form a bridge between real-world phenomena and scientific formalisms.

The method used in this study can also be used to get information about students' preexisting intuitive conceptions about other abstract concepts and to help them to construct a bridge between real-world phenomena and abstract formalisms. Only one-dimensional motion is concerned within this study. In further studies, students' intuitive conceptions about two-dimensional motions, such as trajectory motion, circular motion may be investigated. After investigating students' predictions, the students can compare their mental models with the operation of real-world phenomena.

6.2. Limitations of the Study

Although 36 per cent of the students were successful at the posttest of this study, it can not be said that the treatment procedure had caused mastery learning. Because the achievement in this study depends on students' observation and making comparison skills, and their ability to construct their own knowledge, the subjects who are used to lecture based traditional instruction, may not be ready for constructivist or discovery learning.

The limited time for instruction is another limitation of this study. Some of the students may have need extra time specified for the treatment procedure.

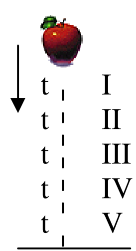
The crowded classes may have caused another limitation for this study. Some of the students' success in this study could have increased with individualized instruction.

APPENDIX A: ANIMATION TEST

1) Kuşun hareketinin başladığı noktadan ağaca varıncaya kadar birim zamanda aldığı yollar nasıl değişmiştir?
    A) Artmıştır
    B) Azalmıştır
    C) Sabit kalmıştır
    D) Bir müddet artmış, sonra azalmıştır
    E) Düzensiz değişmiştir

2) Elmanın hareketinin başladığı noktadan yere düşünceye kadar birim zamanda aldığı yollar nasıl değişmistir?
    A) Artmıştır
    B) Azalmıştır
    C) Sabit kalmıştır
    D) Bir müddet artmış, sonra azalmıştır
    E) Düzensiz değişmiştir

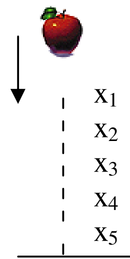
3)



Ağaçtan yere düşen bir elma harektini 5 birim zamanda tamamlamıştır.

Elmanın hareketi sırasında aldığı en uzun yol hangi zaman aralığındadır?
    A) I.
    B) II.
    C) III.
    D) IV.
    E) V.

4)



Ağaçtan yere düşen bir elma hareketini 5 birim zamanda tamamlamıştır.

Elmanın hareketi sırasında 1. 2. 3. 4. ve 5. zaman aralığında aldığı yollar sırasıyla x_1, x_2, x_3, x_4 ve x_5 ile gösterilmektedir.

Buna göre x_1, x_2, x_3, x_4 ve x_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

A) $x_1 > x_2 > x_3 > x_4 > x_5$

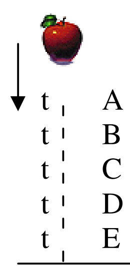
B) $x_1 = x_2 = x_3 = x_4 = x_5$

C) $x_1 < x_2 < x_3 < x_4 < x_5$

D) $x_1 < x_2 = x_3 = x_4 < x_5$

E) $x_1 < x_2 < x_5 < x_4 < x_3$

5)



Şekildeki elma düşüş hareketinin 1. 2. 3. 4. ve 5. anında sırasıyla A, B, C, D ve E noktalarından geçmektedir.

Buna göre elma hangi konumdayken en fazla hıza sahiptir?

A) A

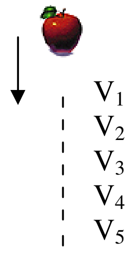
B) B

C) C

D) D

E) E

6)



Elma yere düşüş hareketini 5 birim zamanda tamamlamıştır. Elmanın hareketi sırasında 1. 2. 3. 4. ve 5. anlarda ulaştığı hızlar sırasıyla V_1, V_2, V_3, V_4, V_5 ile gösterilmektedir.

Buna göre V_1, V_2, V_3, V_4, V_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak verilmiştir?

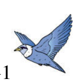
A) $V_1 < V_2 < V_3 < V_4 < V_5$

B) $V_1 > V_2 > V_3 > V_4 > V_5$

C) $V_1 = V_2 = V_3 = V_4 = V_5$

D) $V_1 < V_2 = V_3 = V_4 < V_5$

E) $V_1 < V_2 < V_5 < V_4 < V_3$

7) x_5 x_4 x_3 x_2 x_1 

....

Kuşun hareketinin 5 birim zamanlık bölümünde, 1. 2. 3. 4. ve 5. zaman aralığında aldığı yollar sırasıyla x_1, x_2, x_3, x_4 ve x_5 ile gösterilmiştir.

Buna göre x_1, x_2, x_3, x_4 ve x_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

A) $x_1 < x_2 < x_3 < x_4 < x_5$

B) $x_1 = x_2 = x_3 = x_4 = x_5$

C) $x_1 > x_2 > x_3 > x_4 > x_5$

D) $x_1 > x_2 = x_3 = x_4 > x_5$

E) $x_5 < x_4 < x_1 < x_2 < x_3$

8) V_5 V_4 V_3 V_2 V_1 

....

Kuşun hareketinin 5 birim zamanlık bölümünde, 1. 2. 3. 4. ve 5. anlarda ulaştığı hızlar sırasıyla V_1, V_2, V_3, V_4, V_5 ile gösterilmektedir.

Buna göre V_1, V_2, V_3, V_4, V_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak verilmiştir?

A) $V_1 > V_2 > V_3 > V_4 > V_5$

B) $V_1 < V_2 < V_3 < V_4 < V_5$

C) $V_1 > V_2 = V_3 = V_4 > V_5$

D) $V_1 = V_2 = V_3 = V_4 = V_5$

E) $V_5 < V_4 < V_1 < V_2 < V_3$

APPENDIX B: THE FREQUENCY AND PERCENTAGE OF SUBJECTS SELECTING EACH ALTERNATIVE OF 'ANIMATION TEST'

B.1. ITEM 1

Kuşun hareketinin başladığı noktadan ağaca varıncaya kadar birim zamanda aldığı yollar nasıl değişmiştir?

A) Artmıştır
B) Azalmıştır
C) Sabit kalmıştır
D) Bir müddet artmış, sonra azalmıştır
E) Düzensiz değişmiştir

				Item Alternatives					
School	Grade	N of Subjects	f / p	A	B	**C**	D	E	Omit
Orbay Primary School	6	85	f	25	13	26	19	2	0
			%	29	15	31	22	2	0
	7	25	f	2	4	6	13	0	0
			%	8	16	24	52	0	0
	8	22	f	5	6	7	4	0	0
			%	23	27	32	18	0	0
Kami Saadet Güzey Primary School	6	43	f	12	2	20	8	1	0
			%	28	5	47	19	2	0
	7	25	f	6	1	16	2	0	0
			%	24	4	64	8	0	0
	8	17	f	2	4	11	0	0	0
			%	12	24	65	0	0	0

Table B.1. The distribution of subjects according to the selected alternative of item 1

B.2. ITEM 2

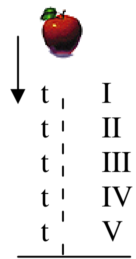
Elmanın hareketinin başladığı noktadan yere düşünceye kadar birim zamanda aldığı yollar nasıl değişmistir?

A) Artmıştır
B) Azalmıştır
C) Sabit kalmıştır
D) Bir müddet artmış, sonra azalmıştır
E) Düzensiz değişmiştir

				Item Alternatives					
School	Grade	N of Subjects	f / p	**A**	B	C	D	E	Omit
Orbay Primary School	6	85	f	41	14	16	9	5	0
			%	48	16	19	11	6	0
	7	25	f	11	3	3	7	1	0
			%	44	12	12	28	14	0
	8	22	f	17	0	2	2	0	1
			%	77	0	9	9	0	5
Kami Saadet Güzey Primary School	6	43	f	29	4	6	2	2	0
			%	67	9	14	5	5	0
	7	25	f	16	1	4	2	2	0
			%	64	4	16	8	8	0
	8	17	f	12	1	1	2	1	0
			%	71	6	6	12	6	0

Table B.2. The distribution of subjects according to the selected alternative of item 2

B.3. ITEM 3



Ağaçtan yere düşen bir elma harektini 5 birim zamanda tamamlamıştır.

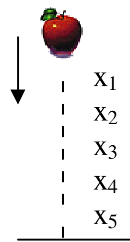
Elmanın hareketi sırasında aldığı en uzun yol hangi zaman aralığındadır?

A) I.
B) II.
C) III.
D) IV.
E) V.

				Item Alternatives					
School	Grade	N of Subjects	f / p	A	B	C	D	**E**	Omit
Orbay Primary School	6	85	f	12	6	14	16	34	3
			%	14	7	16	19	40	4
	7	25	f	5	3	4	4	9	0
			%	20	12	16	16	36	0
	8	22	f	2	1	3	3	13	0
			%	9	5	14	14	59	0
Kami Saadet Güzey Primary School	6	43	f	4	2	7	7	23	0
			%	9	5	16	16	53	0
	7	25	f	4	2	1	1	17	0
			%	16	8	4	4	68	0
	8	17	f	2	0	3	1	10	1
			%	12	0	18	6	59	6

Table B.3. The distribution of subjects according to the selected alternative of item 3

B.4. ITEM 4



Ağaçtan yere düşen bir elma hareketini 5 birim zamanda tamamlamıştır.
Elmanın hareketi sırasında 1. 2. 3. 4. ve 5. zaman aralığında aldığı yollar sırasıyla x_1, x_2, x_3, x_4 ve x_5 ile gösterilmektedir.

Buna göre x_1, x_2, x_3, x_4 ve x_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

A) $x_1 > x_2 > x_3 > x_4 > x_5$

B) $x_1 = x_2 = x_3 = x_4 = x_5$

C) $x_1 < x_2 < x_3 < x_4 < x_5$

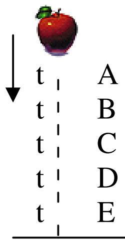
D) $x_1 < x_2 = x_3 = x_4 < x_5$

E) $x_1 < x_2 < x_5 < x_4 < x_3$

				Item Alternatives					
School	Grade	N of Subjects	f / p	A	B	**C**	D	E	Omit
Orbay Primary School	6	85	f	15	13	25	19	10	3
			%	18	15	29	22	12	4
	7	25	f	9	5	5	5	1	0
			%	36	20	20	20	4	0
	8	22	f	9	2	5	3	3	0
			%	41	9	23	14	14	0
Kami Saadet Güzey Primary School	6	43	f	8	7	15	10	2	1
			%	19	16	35	23	5	2
	7	25	f	3	4	16	1	1	0
			%	12	16	64	4	4	0
	8	17	f	4	1	9	1	1	1
			%	24	6	53	6	6	6

Table B.4. The distribution of subjects according to the selected alternative of item 4

B.5. ITEM 5



Şekildeki elma düşüş hareketinin 1. 2. 3. 4. ve 5. anında sırasıyla A, B, C, D ve E noktalarından geçmektedir.

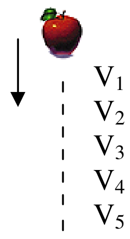
Buna göre elma hangi konumdayken en fazla hıza sahiptir?

A) A
B) B
C) C
D) D
E) E

School	Grade	N of Subjects	f / p	Item Alternatives A	B	C	D	**E**	Omit
Orbay Primary School	6	85	f	11	14	15	9	34	2
			%	13	16	18	11	40	2
	7	25	f	4	4	6	6	5	0
			%	16	16	24	24	20	0
	8	22	f	2	1	3	6	10	0
			%	9	5	14	28	45	0
Kami Saadet Güzey Primary School	6	43	f	10	3	8	7	15	0
			%	23	7	19	16	35	0
	7	25	f	4	0	1	5	15	0
			%	16	0	4	20	60	0
	8	17	f	1	1	0	3	12	0
			%	6	6	0	18	71	0

Table B.5. The distribution of subjects according to the selected alternative of item 5

B.6. ITEM 6



Elma yere düşüş hareketini 5 birim zamanda tamamlamıştır.

Elmanın hareketi sırasında 1. 2. 3. 4. ve 5. anlarda ulaştığı hızlar sırasıyla V_1, V_2, V_3, V_4, V_5 ile gösterilmektedir.

Buna göre V_1, V_2, V_3, V_4, V_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak verilmiştir?

A) $V_1 < V_2 < V_3 < V_4 < V_5$

B) $V_1 > V_2 > V_3 > V_4 > V_5$

C) $V_1 = V_2 = V_3 = V_4 = V_5$

D) $V_1 < V_2 = V_3 = V_4 < V_5$

E) $V_1 < V_2 < V_5 < V_4 < V_3$

				Item Alternatives					
School	Grade	N of Subjects	f / p	**A**	B	C	D	E	Omit
Orbay Primary School	6	85	f	23	23	16	16	1	3
			%	27	27	19	19	1	4
	7	25	f	1	9	6	1	1	7
			%	4	36	24	4	4	8
	8	22	f	10	1	5	3	0	3
			%	45	5	23	14	0	14
Kami Saadet Güzey Primary School	6	43	f	17	4	8	11	2	1
			%	40	9	19	26	5	2
	7	25	f	13	1	5	5	1	0
			%	52	4	20	20	4	0
	8	17	f	9	2	1	1	4	0
			%	53	12	6	6	24	0

Table B.6. The distribution of subjects according to the selected alternative of item 6

B.7. ITEM 7

x_5 x_4 x_3 x_2 x_1 

....

Kuşun hareketinin 5 birim zamanlık bölümünde, 1. 2. 3. 4. ve 5. zaman aralığında aldığı yollar sırasıyla x_1, x_2, x_3, x_4 ve x_5 ile gösterilmiştir.

Buna göre x_1, x_2, x_3, x_4 ve x_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

A) $x_1 < x_2 < x_3 < x_4 < x_5$

B) $x_1 = x_2 = x_3 = x_4 = x_5$

C) $x_1 > x_2 > x_3 > x_4 > x_5$

D) $x_1 > x_2 = x_3 = x_4 > x_5$

E) $x_5 < x_4 < x_1 < x_2 < x_3$

				Item Alternatives					
School	Grade	N of Subjects	f / p	A	**B**	C	D	E	Omit
Orbay Primary School	6	85	f	24	19	21	16	2	2
			%	28	22	25	19	23	2
	7	25	f	1	4	3	6	4	7
			%	4	16	12	24	16	8
	8	22	f	7	1	1	8	5	0
			%	32	5	5	36	23	0
Kami Saadet Güzey Primary School	6	43	f	10	7	8	8	9	1
			%	23	16	19	19	21	2
	7	25	f	6	15	1	0	3	0
			%	24	60	4	0	12	0
	8	17	f	3	9	2	2	1	0
			%	18	53	12	12	6	0

Table B.7. The distribution of subjects according to the selected alternative of item 7

B.8. ITEM 8

$V_5 \quad V_4 \quad V_3 \quad V_2 \quad V_1$ 

....

Kuşun hareketinin 5 birim zamanlık bölümünde, 1. 2. 3. 4. ve 5. anlarda ulaştığı hızlar sırasıyla V_1, V_2, V_3, V_4, V_5 ile gösterilmektedir.

Buna göre V_1, V_2, V_3, V_4, V_5 arasındaki ilişki aşağıdakilerden hangisinde doğru olarak verilmiştir?

A) $V_1 > V_2 > V_3 > V_4 > V_5$

B) $V_1 < V_2 < V_3 < V_4 < V_5$

C) $V_1 > V_2 = V_3 = V_4 > V_5$

D) $V_1 = V_2 = V_3 = V_4 = V_5$

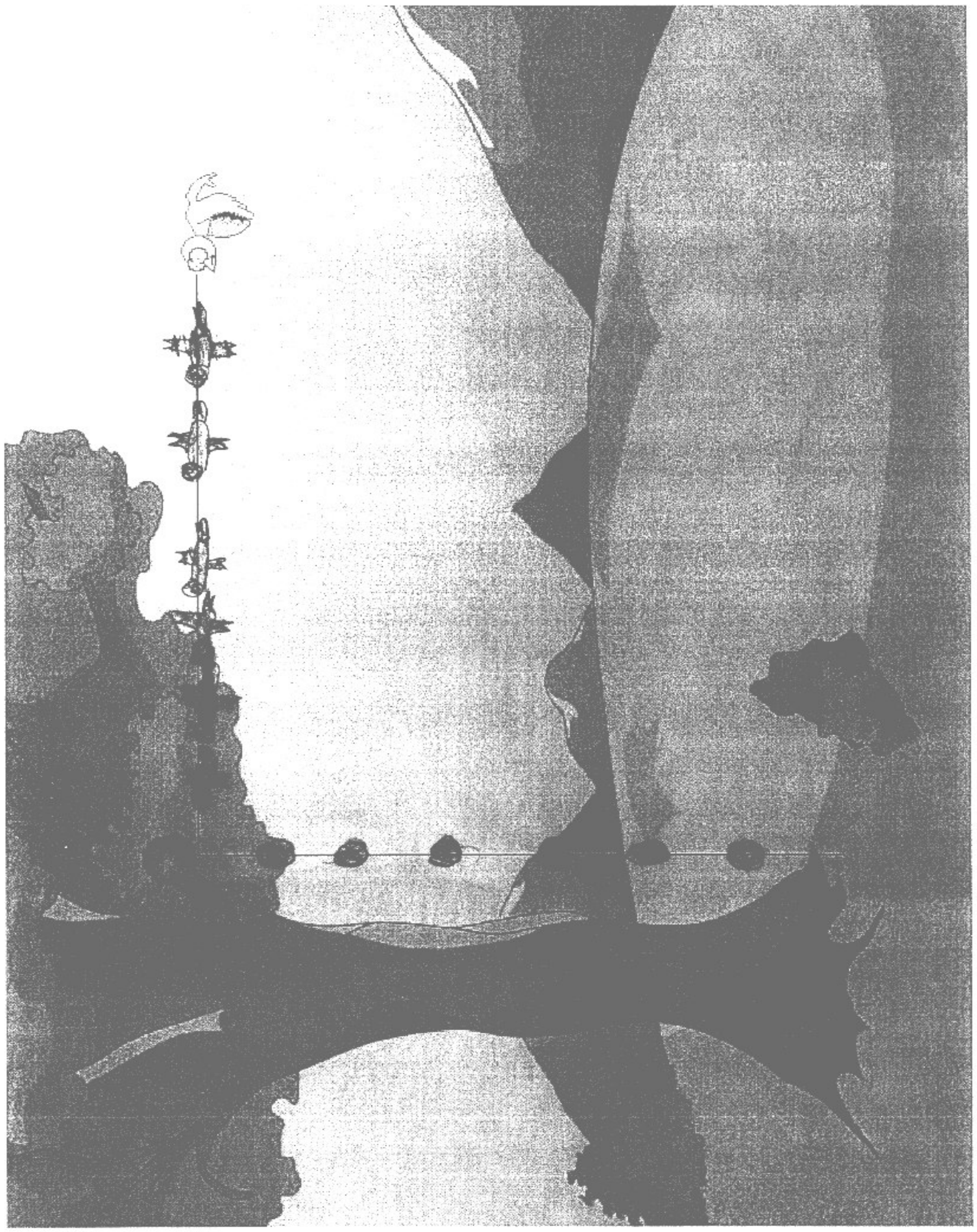
E) $V_5 < V_4 < V_1 < V_2 < V_3$

				Item Alternatives					
School	Grade	N of Subjects	f / p	A	B	C	**D**	E	Omit
Orbay Primary School	6	85	f	14	17	10	32	10	2
			%	16	20	12	38	12	2
	7	25	f	1	5	4	4	4	7
			%	4	20	16	16	16	28
	8	22	f	0	8	3	3	5	3
			%	0	36	14	14	23	14
Kami Saadet Güzey Primary School	6	43	f	8	11	7	9	7	1
			%	19	26	16	21	16	2
	7	25	f	2	4	2	15	2	0
			%	8	16	8	60	8	0
	8	17	f	2	4	3	8	0	0
			%	12	24	18	47	0	0

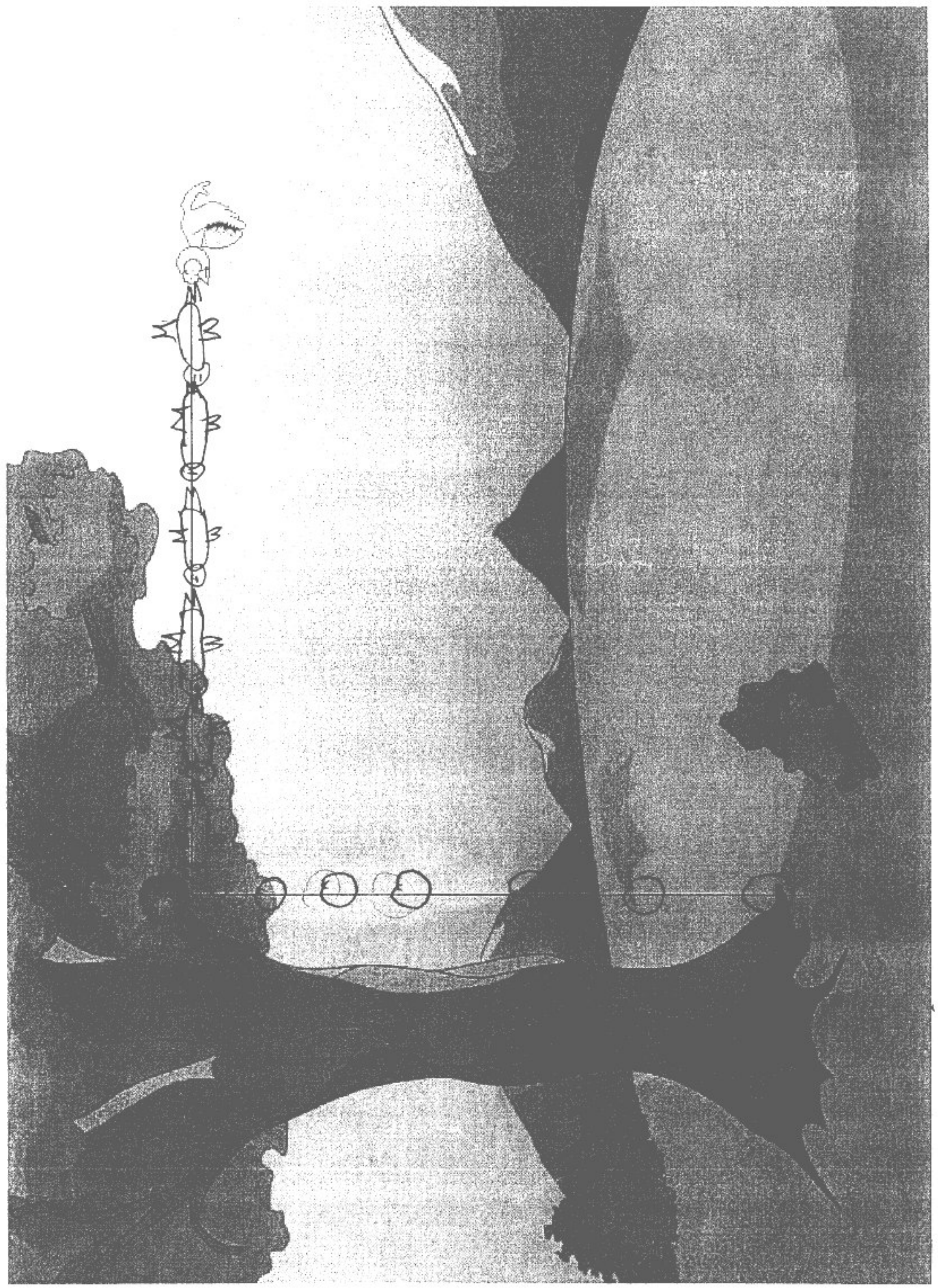
Table B.8. The distribution of subjects according to the selected alternative of item 8

APPENDIX C: LOCATE THE POSITION SCALE

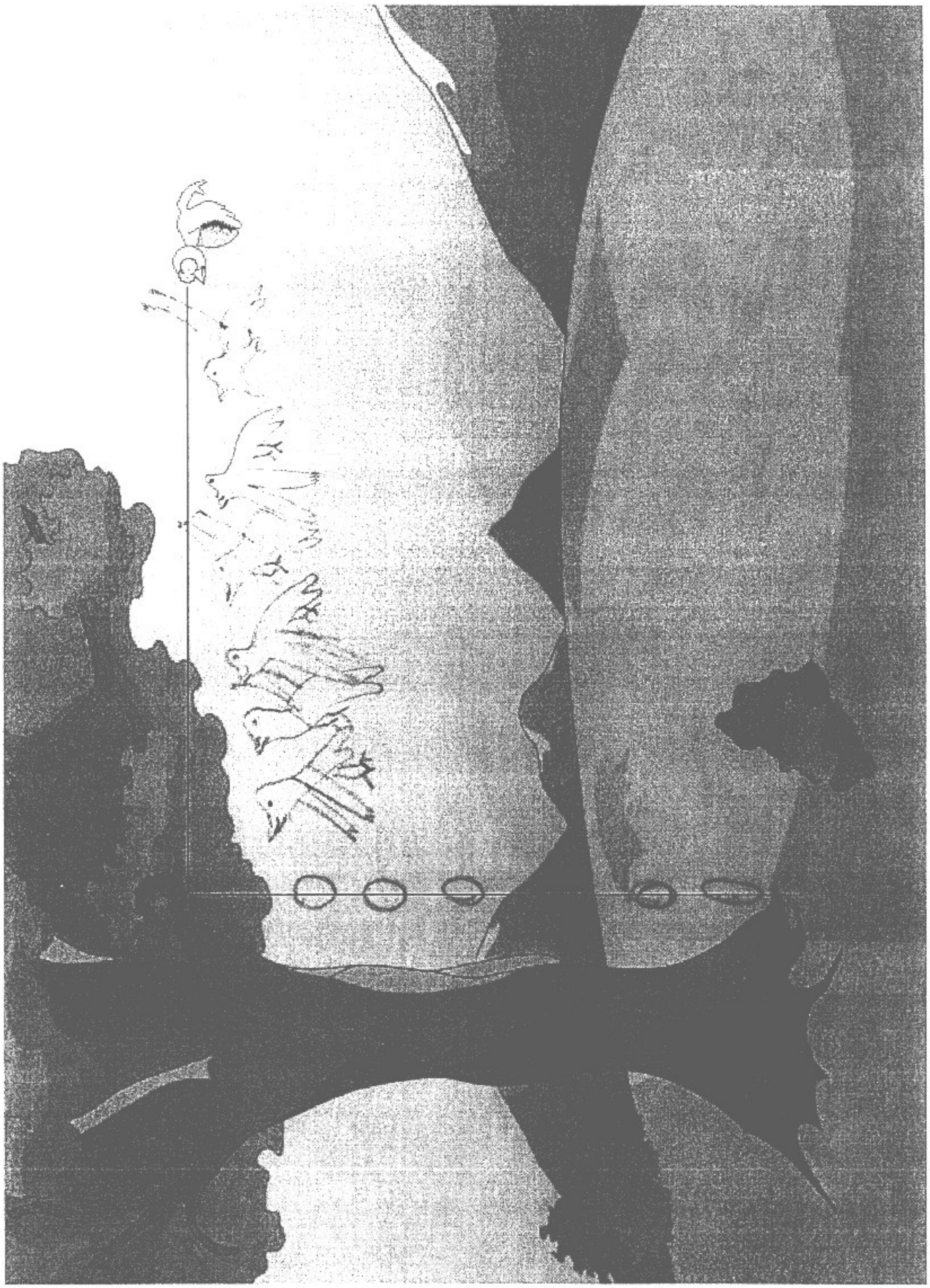
APPENDIX D: EXAMPLES TO DTM SCALE PRE AND POST DRAWINGS



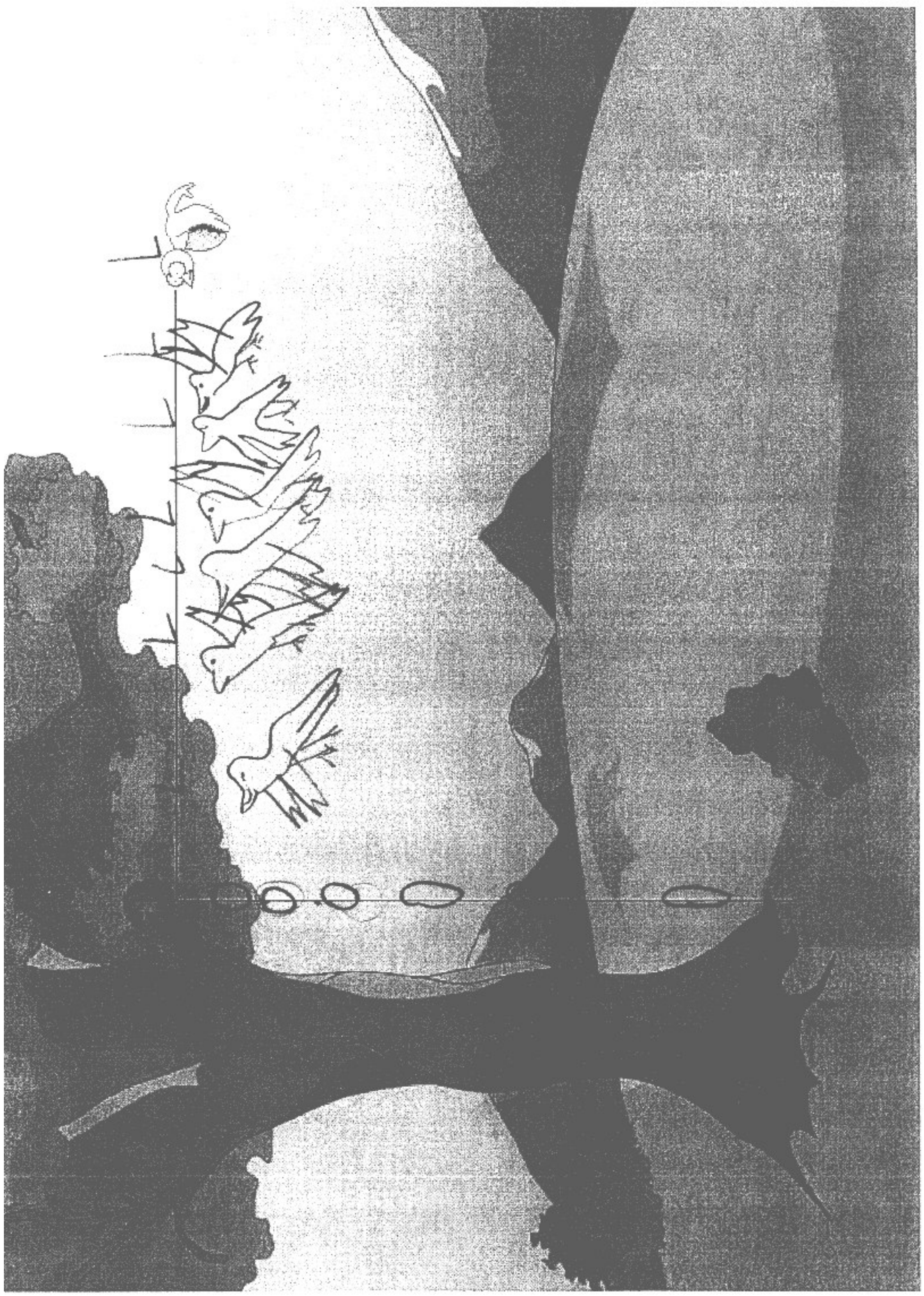
Student 1, Female, 5th Grade, pretest



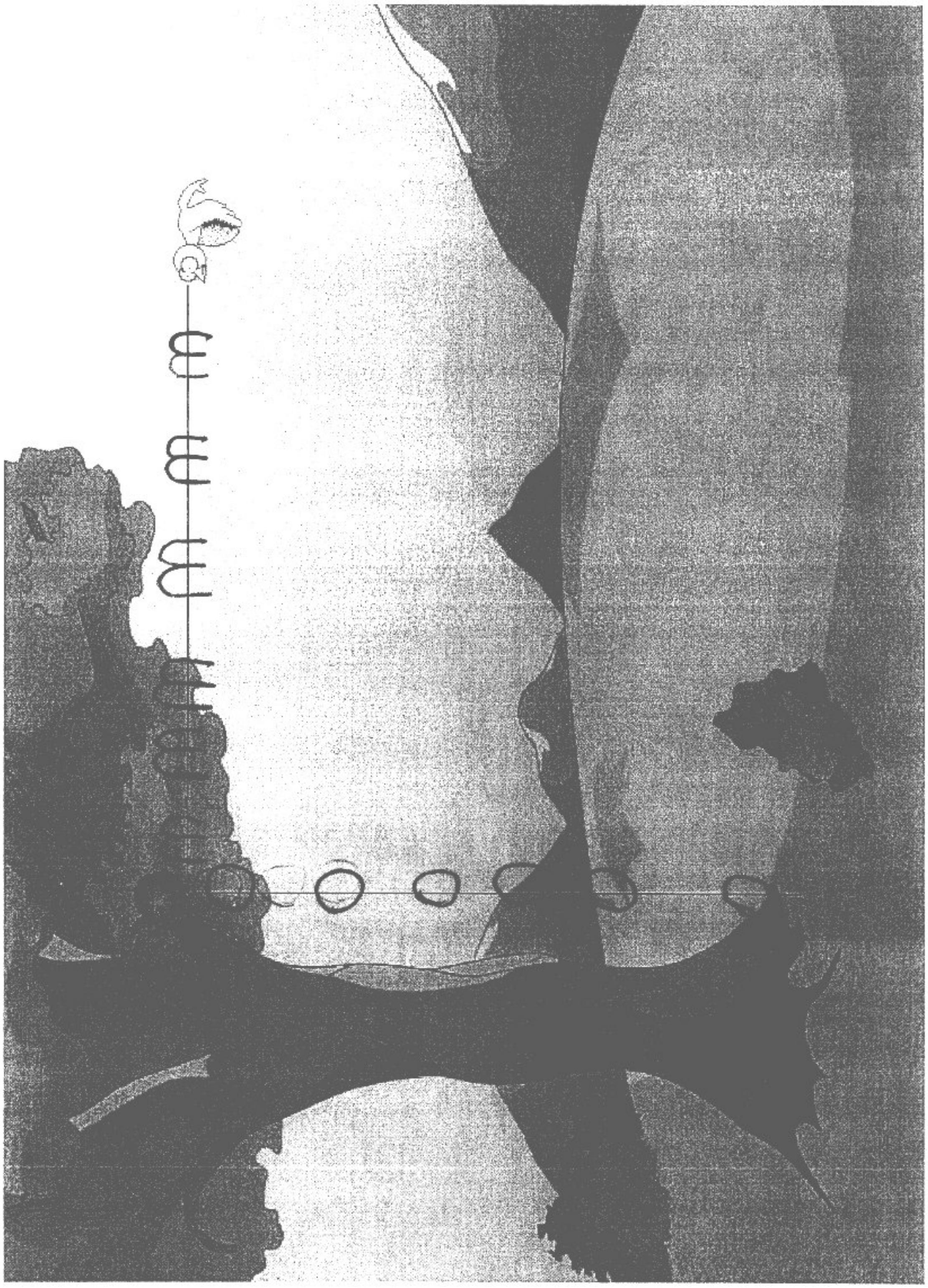
Student 1, Female, 5th Grade, posttest



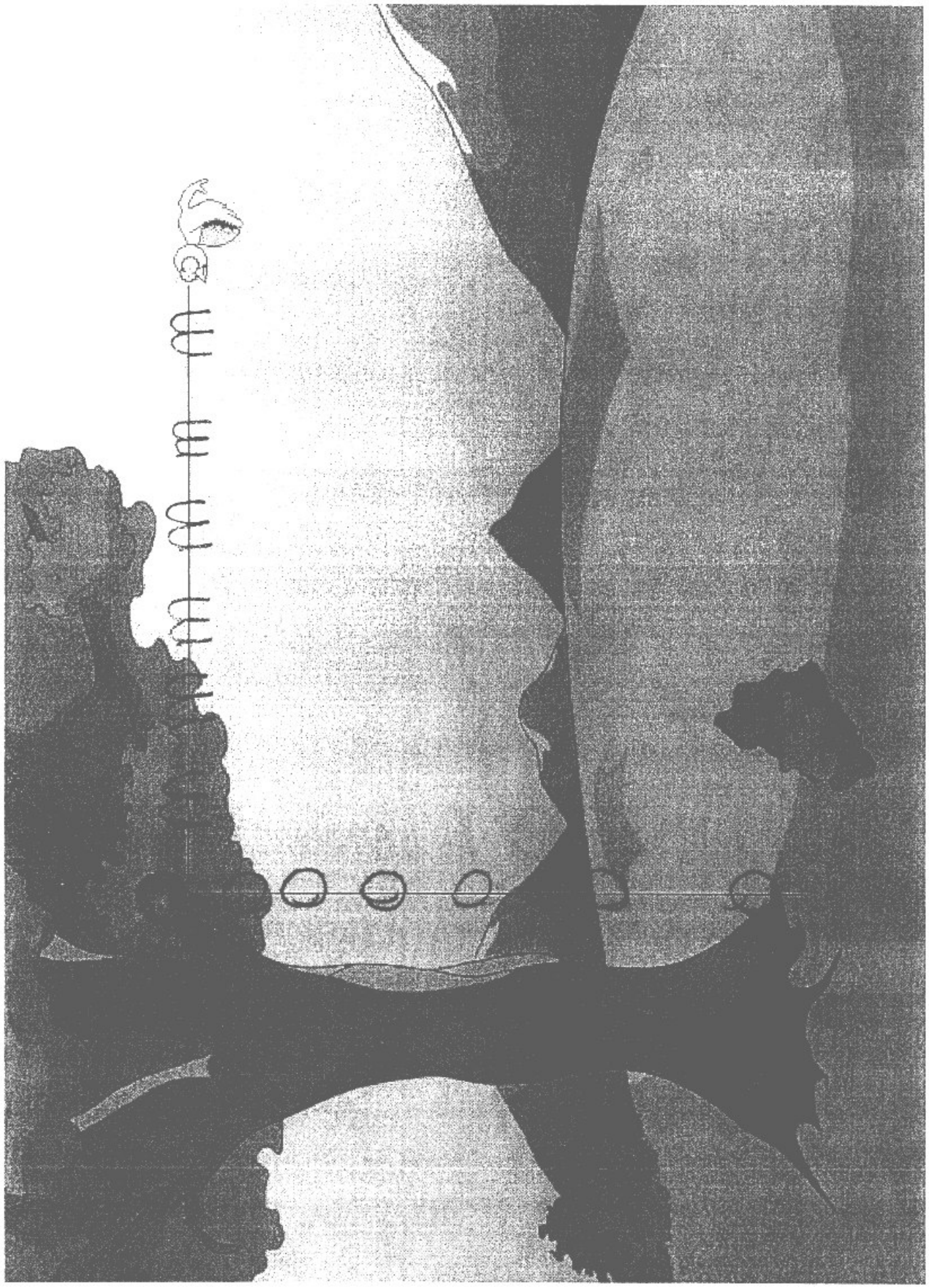
Student 2, Female, 5th Grade, pretest



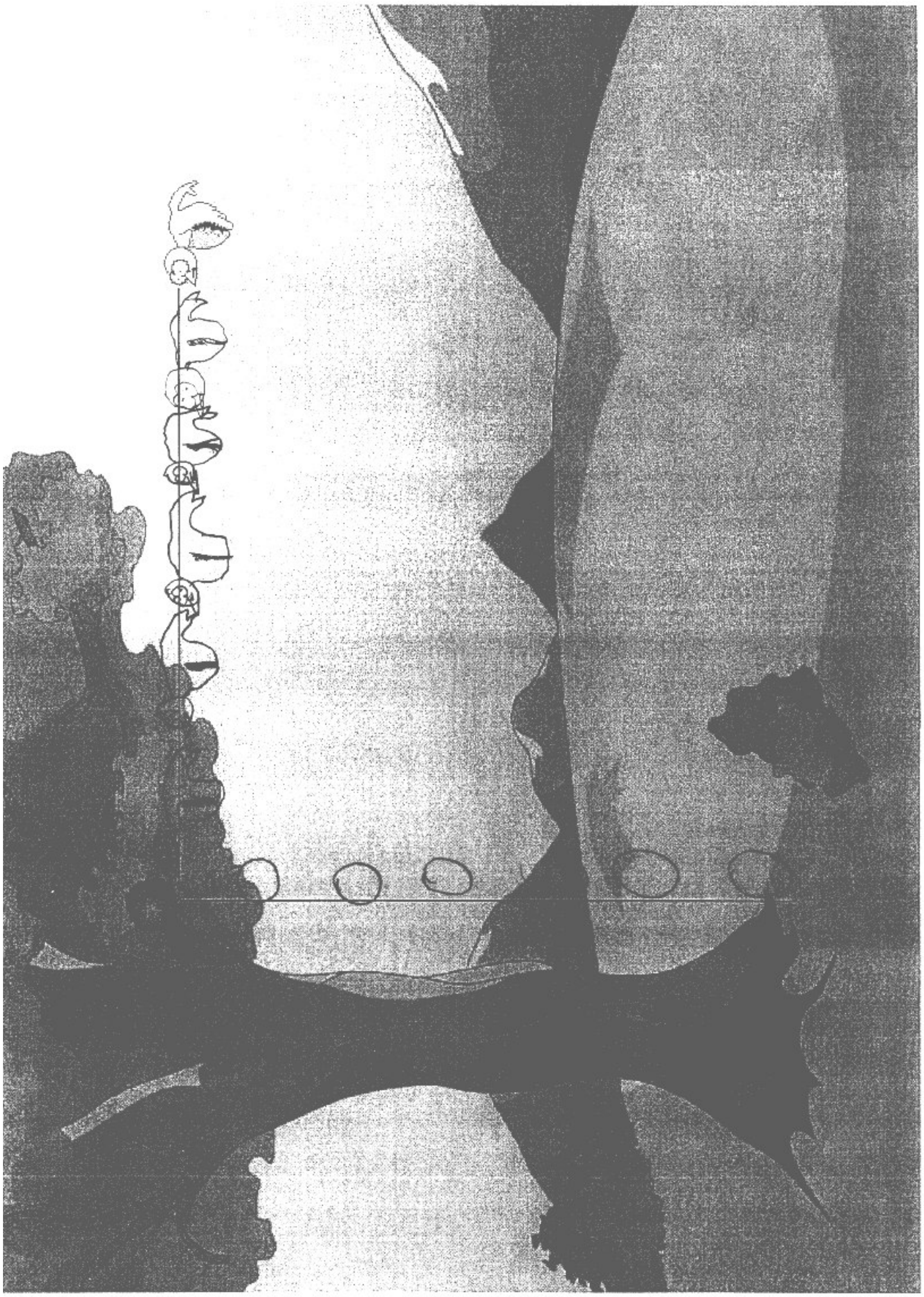
Student 2, Female, 5th Grade, posttest



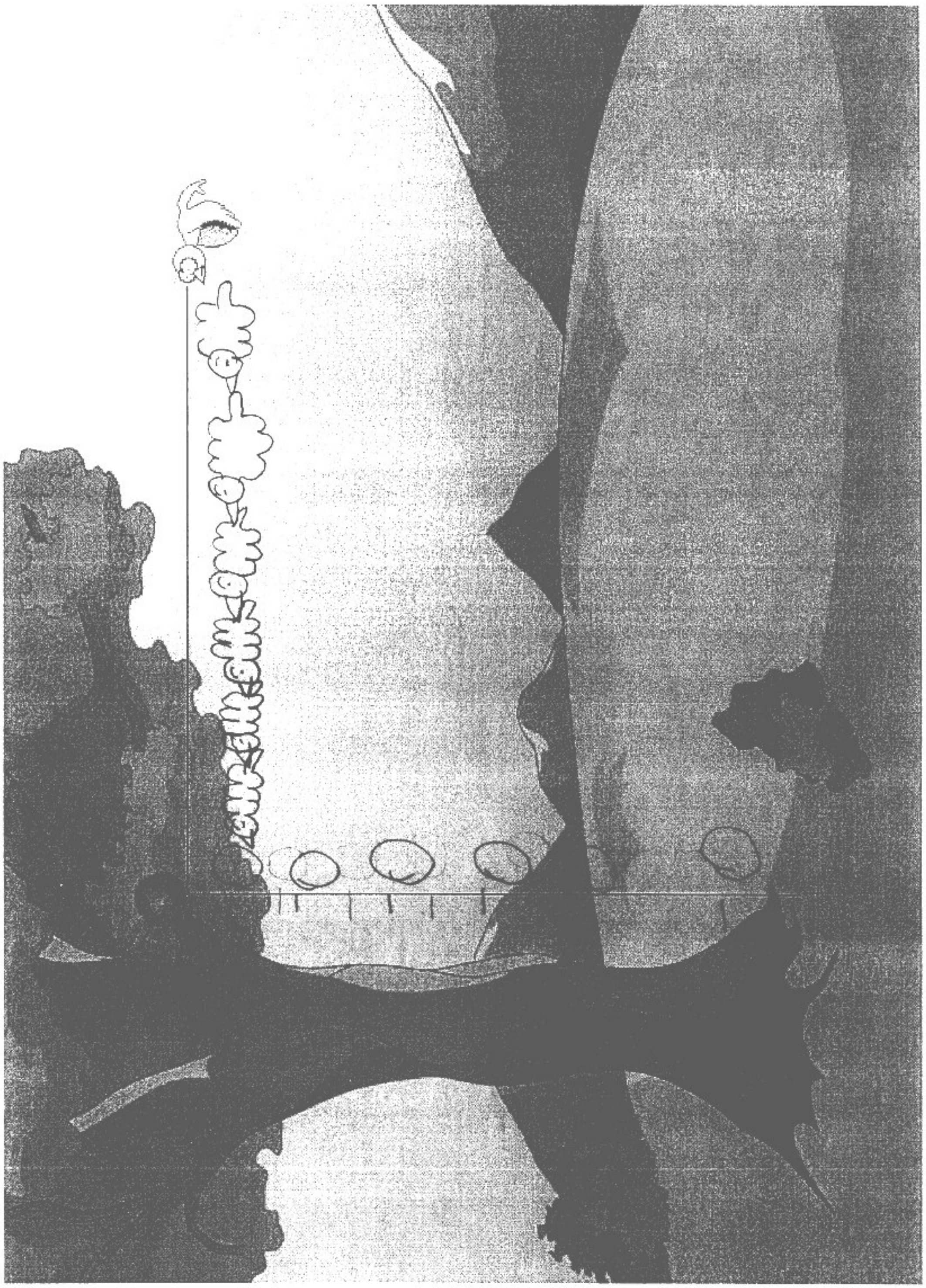
Student 3, Male, 5th Grade, pretest



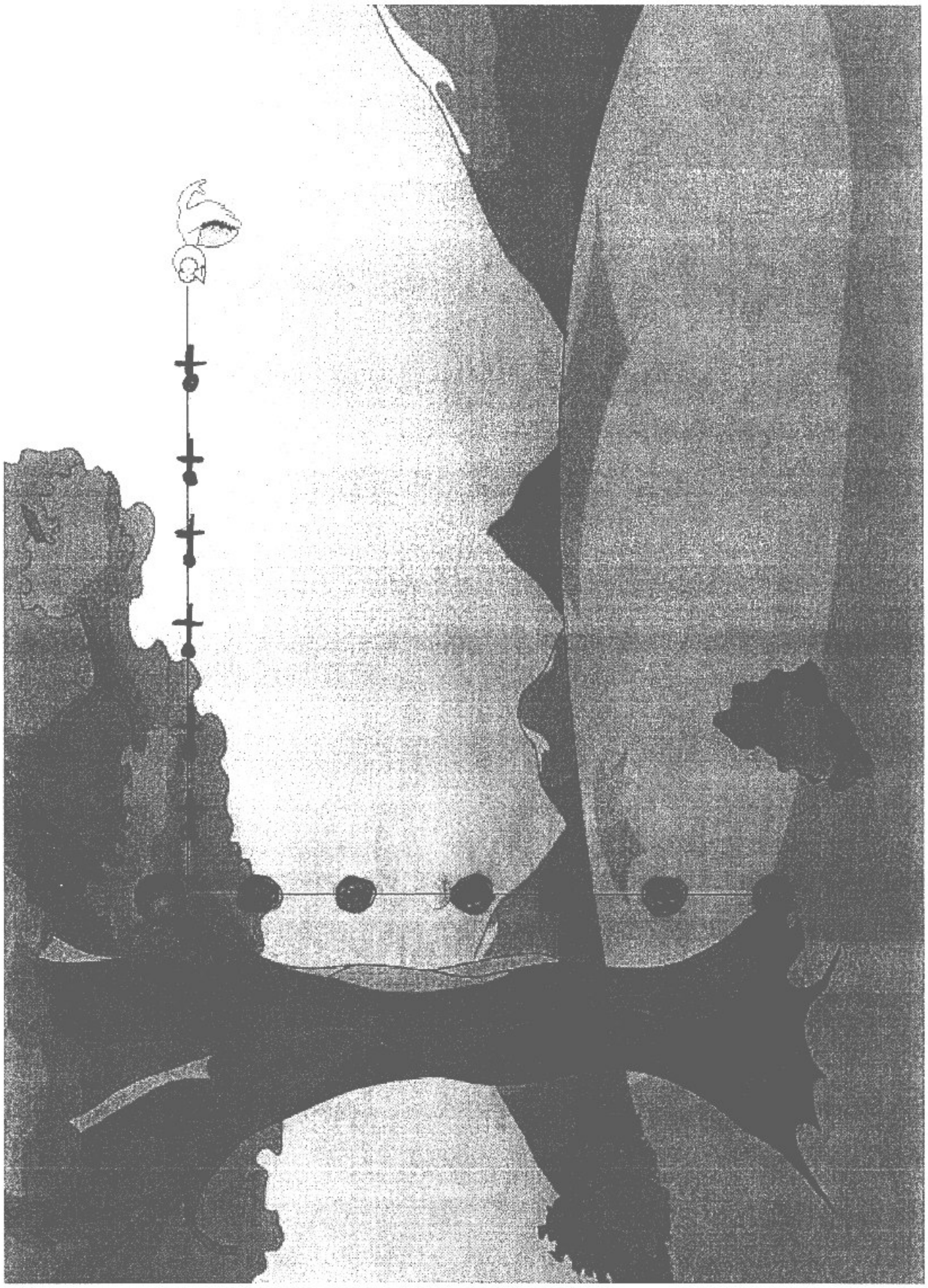
Student 3, Male, 5th Grade, posttest



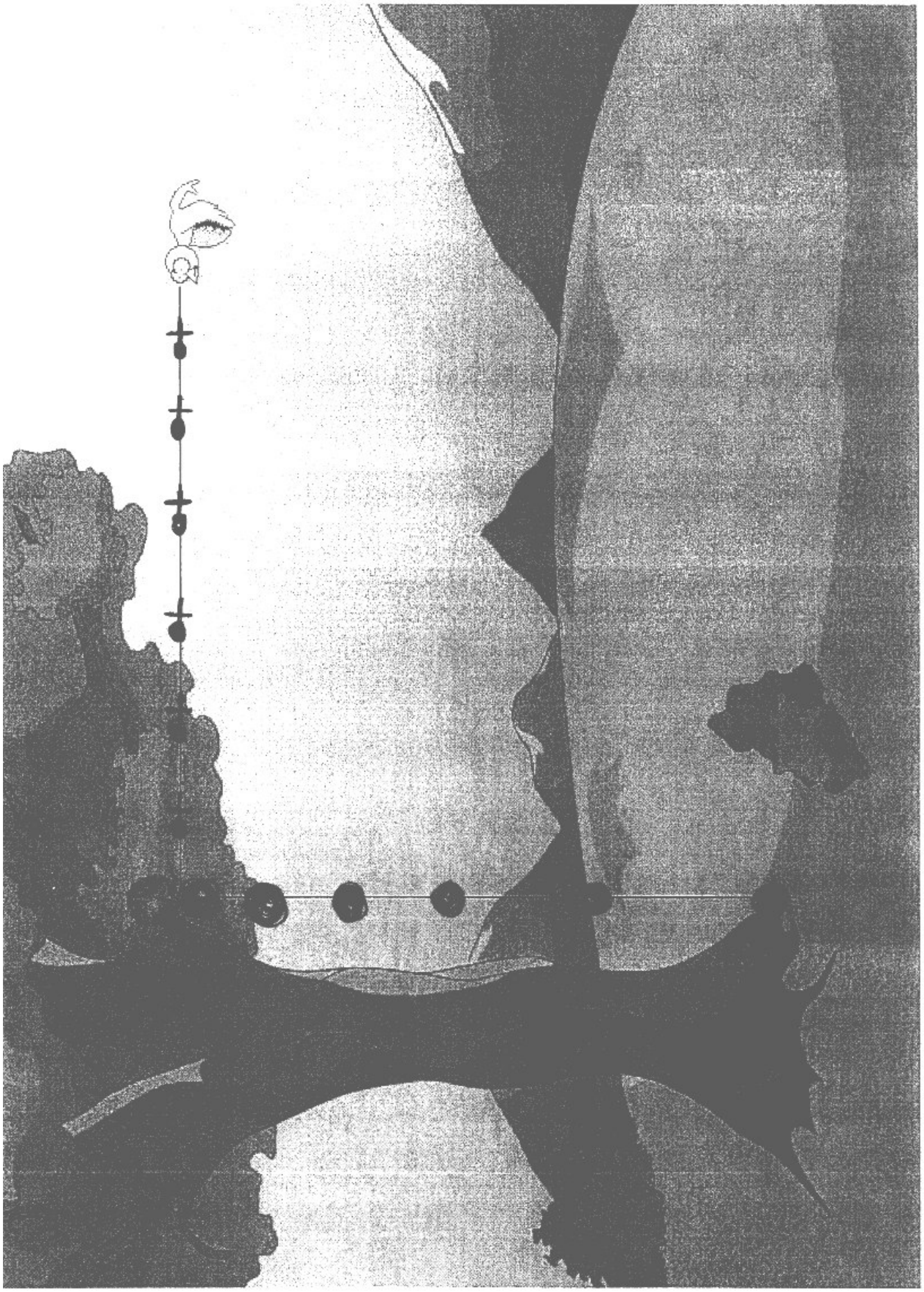
Student 4, Male, 6th Grade, pretest



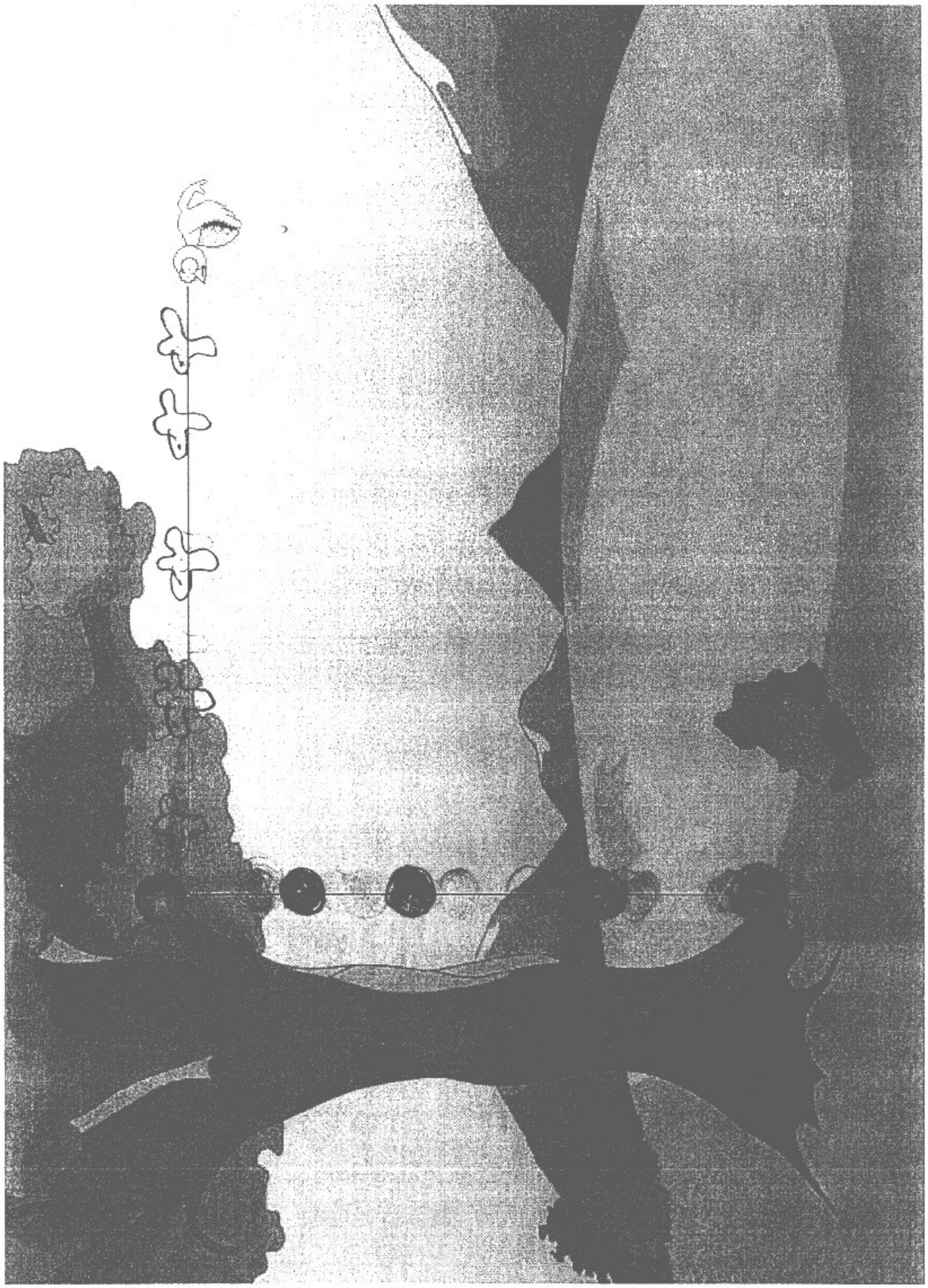
Student 4, Male, 6th Grade, posttest



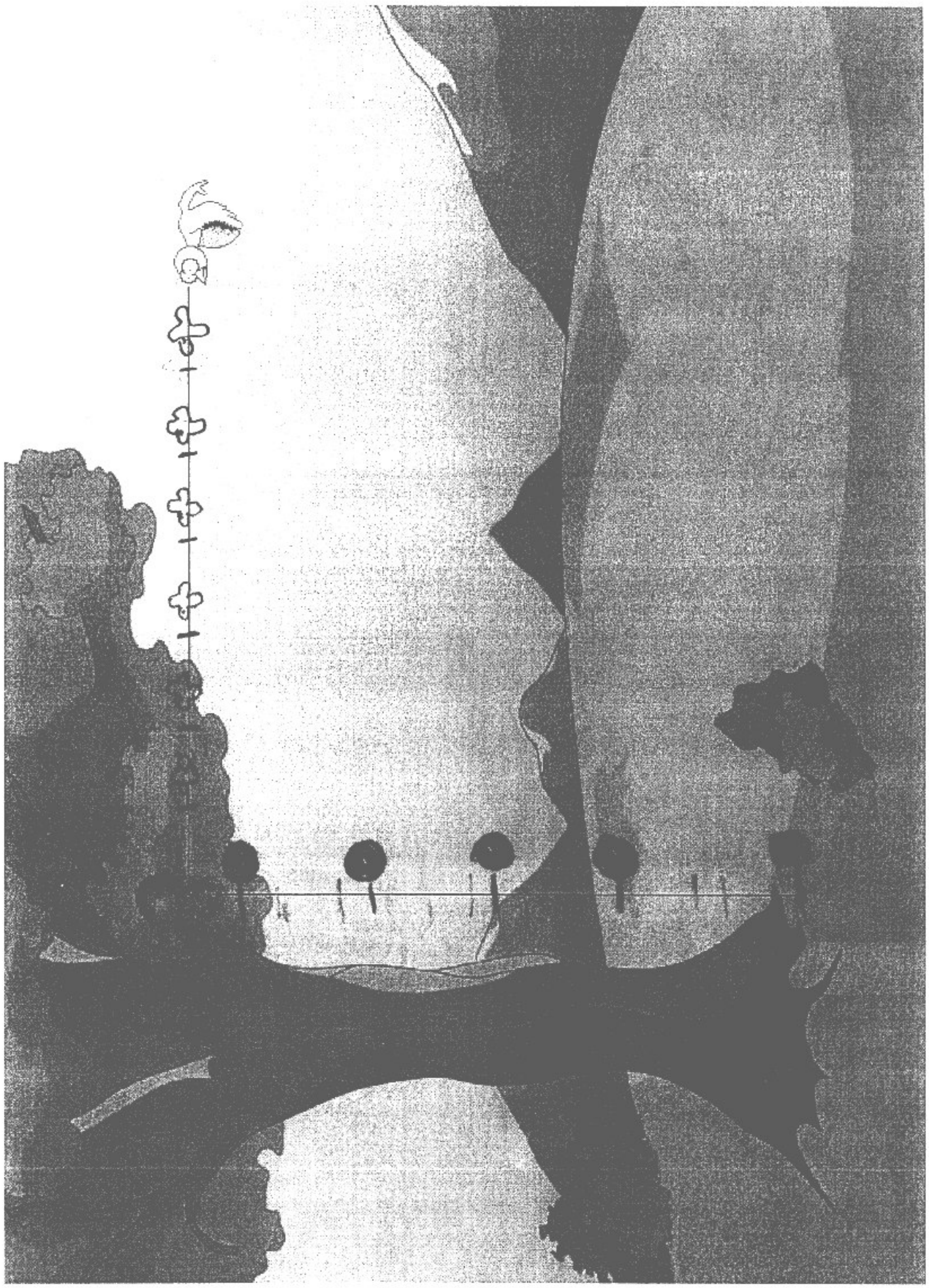
Student 5, Female, 6th Grade, pretest



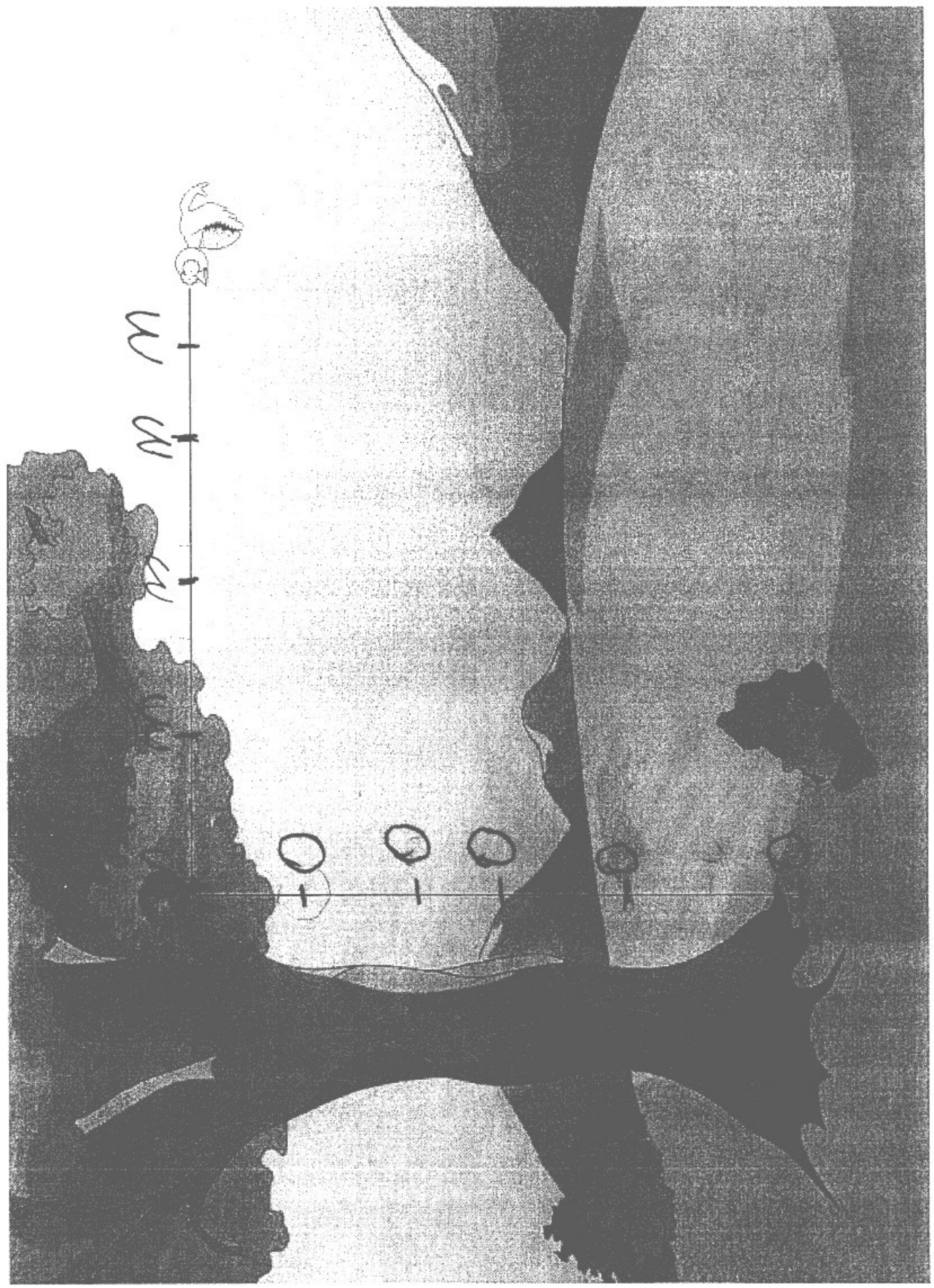
Student 5, Female, 6th Grade, posttest



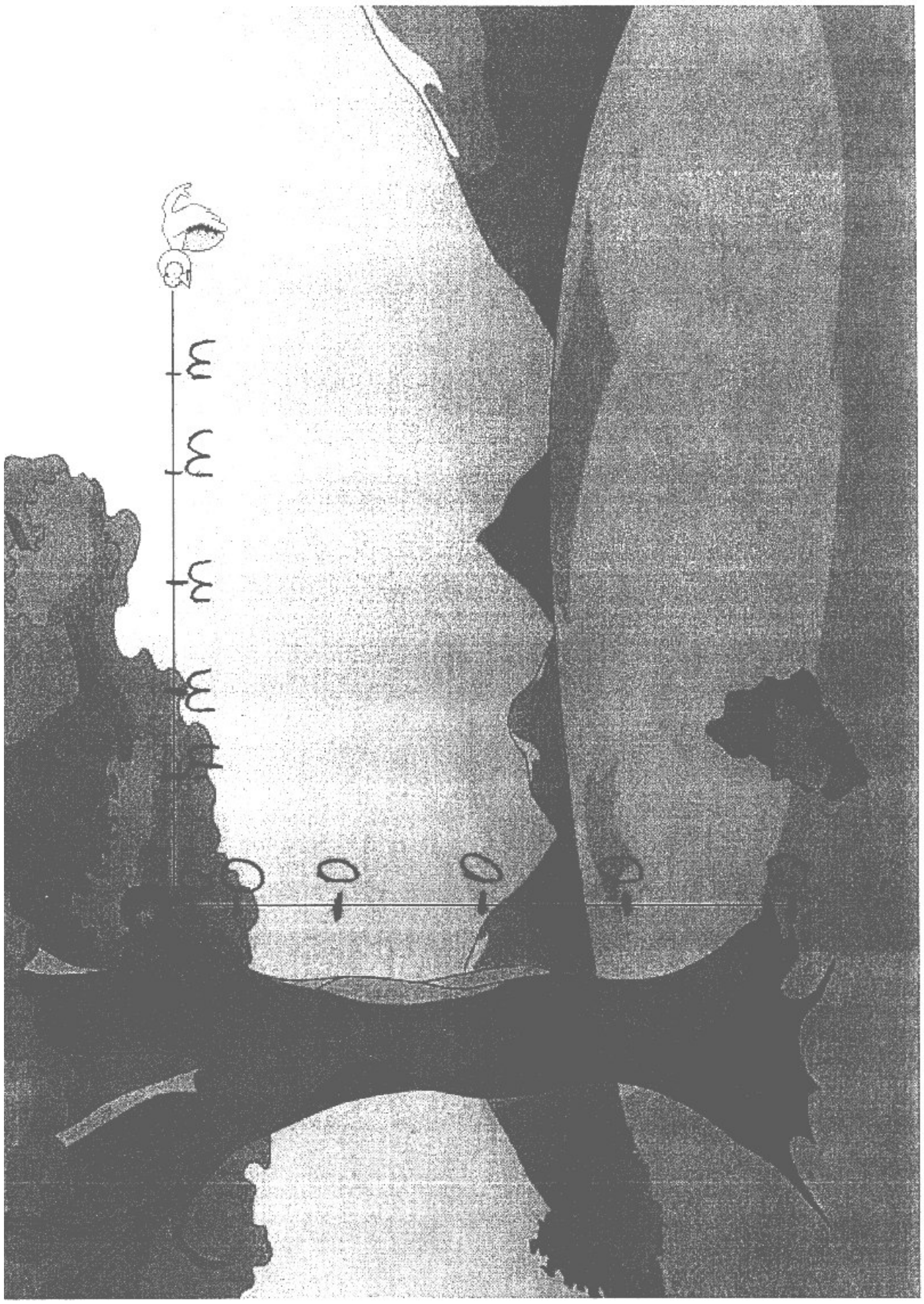
Student 6, Male, 6th Grade, pretest



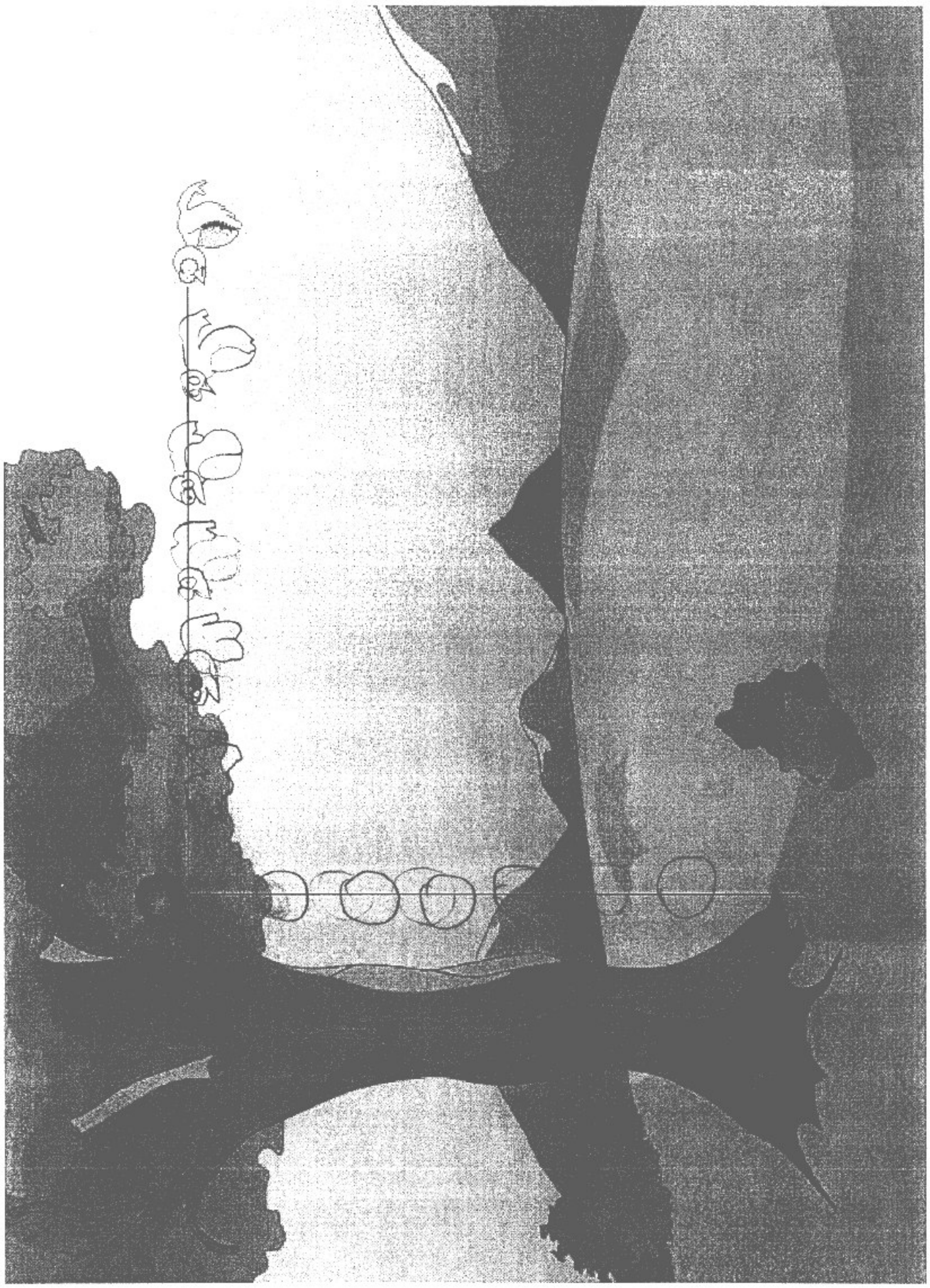
Student 6, Male, 6th Grade, posttest



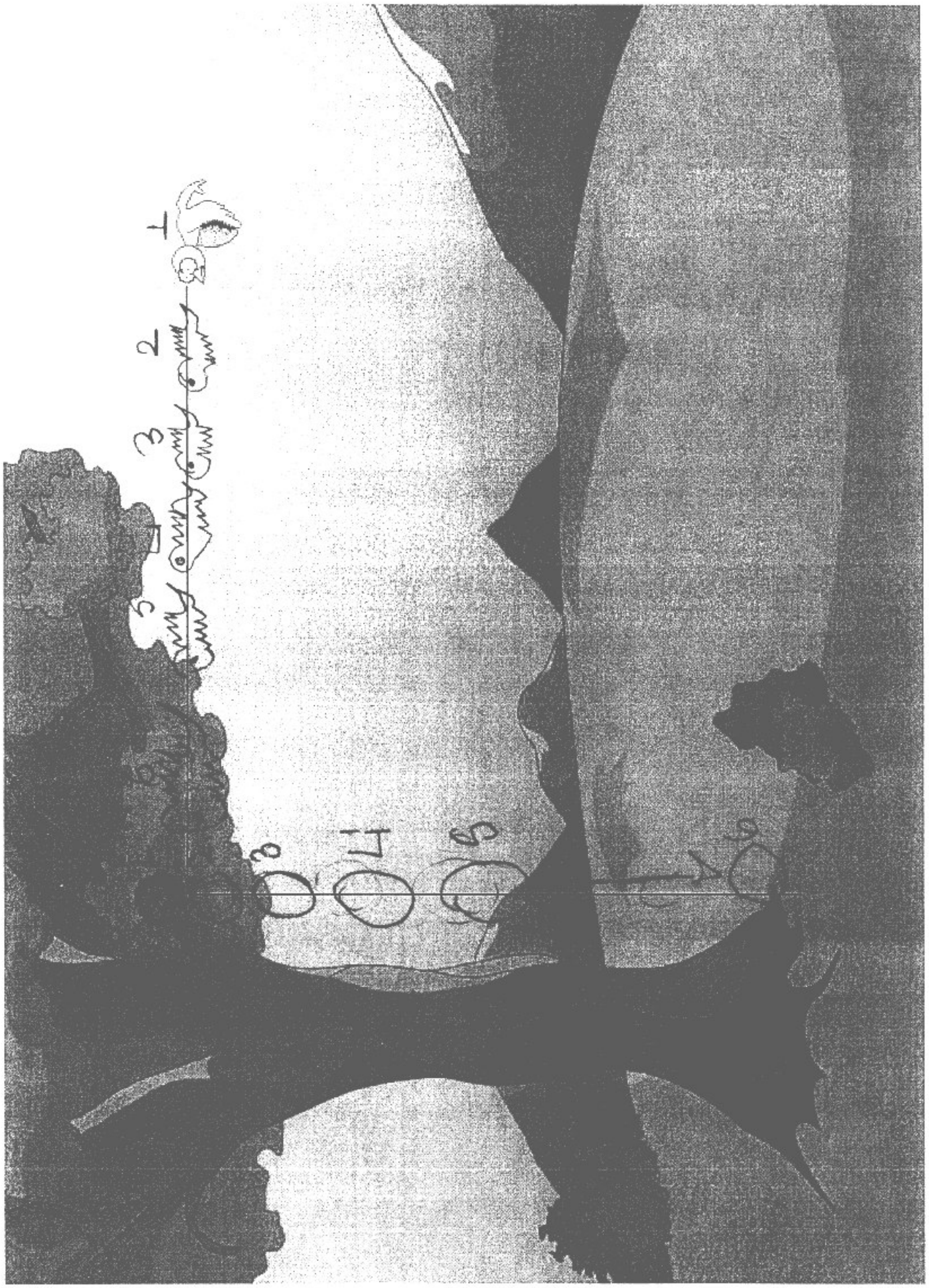
Student 7, Male, 6th Grade, pretest



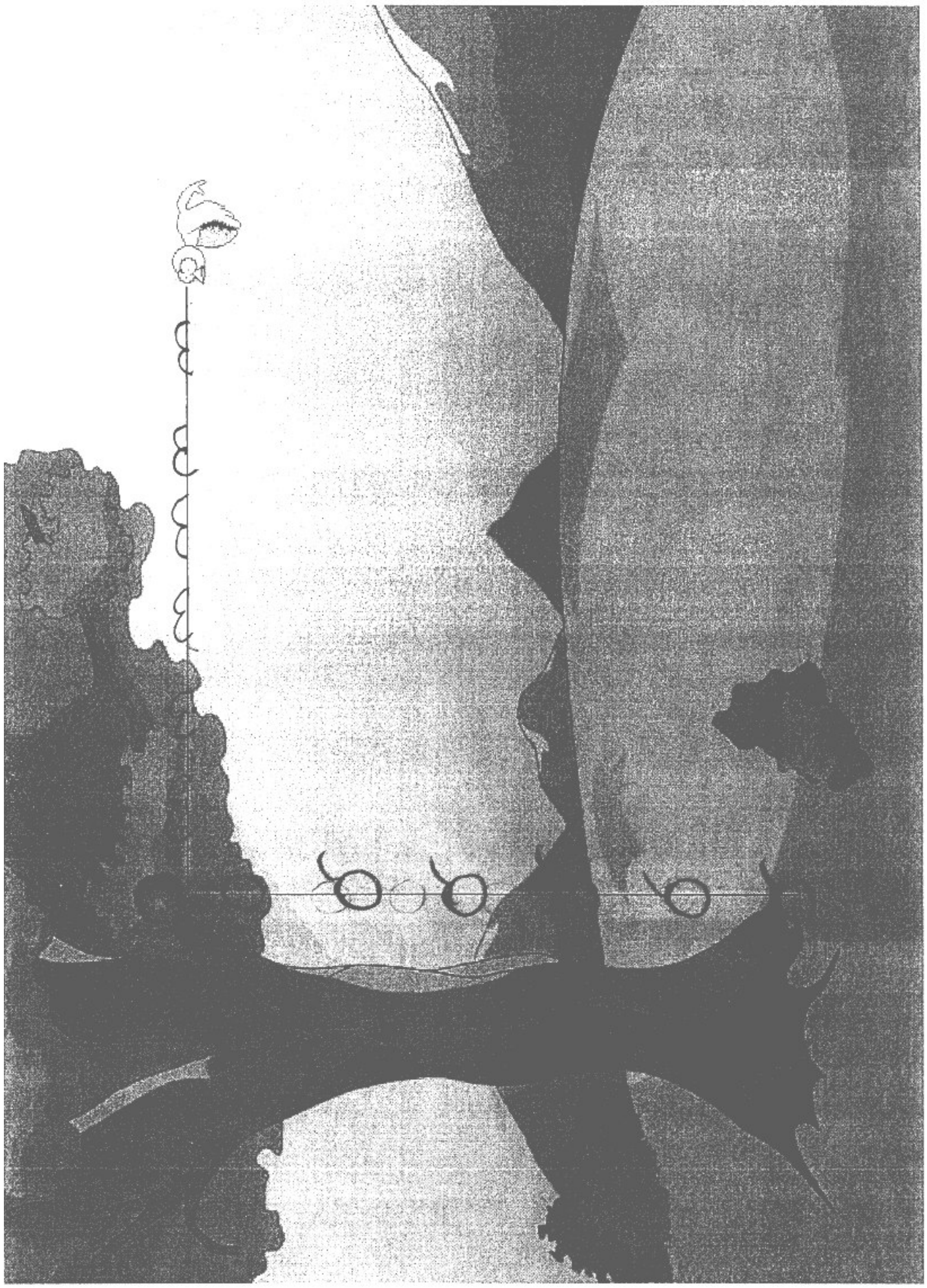
Student 7, Male, 6th Grade, posttest



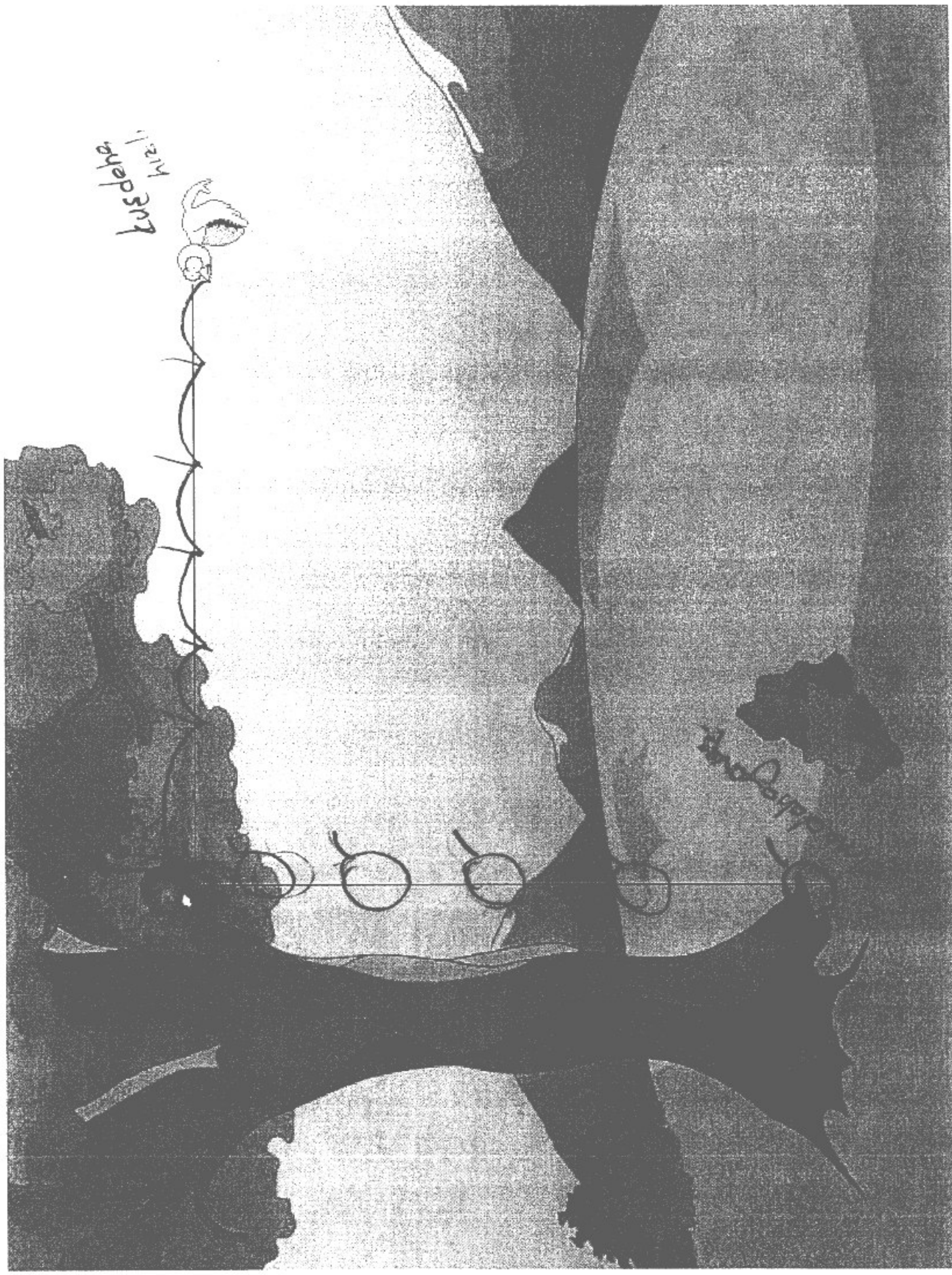
Student 8, Female, 6th Grade, pretest



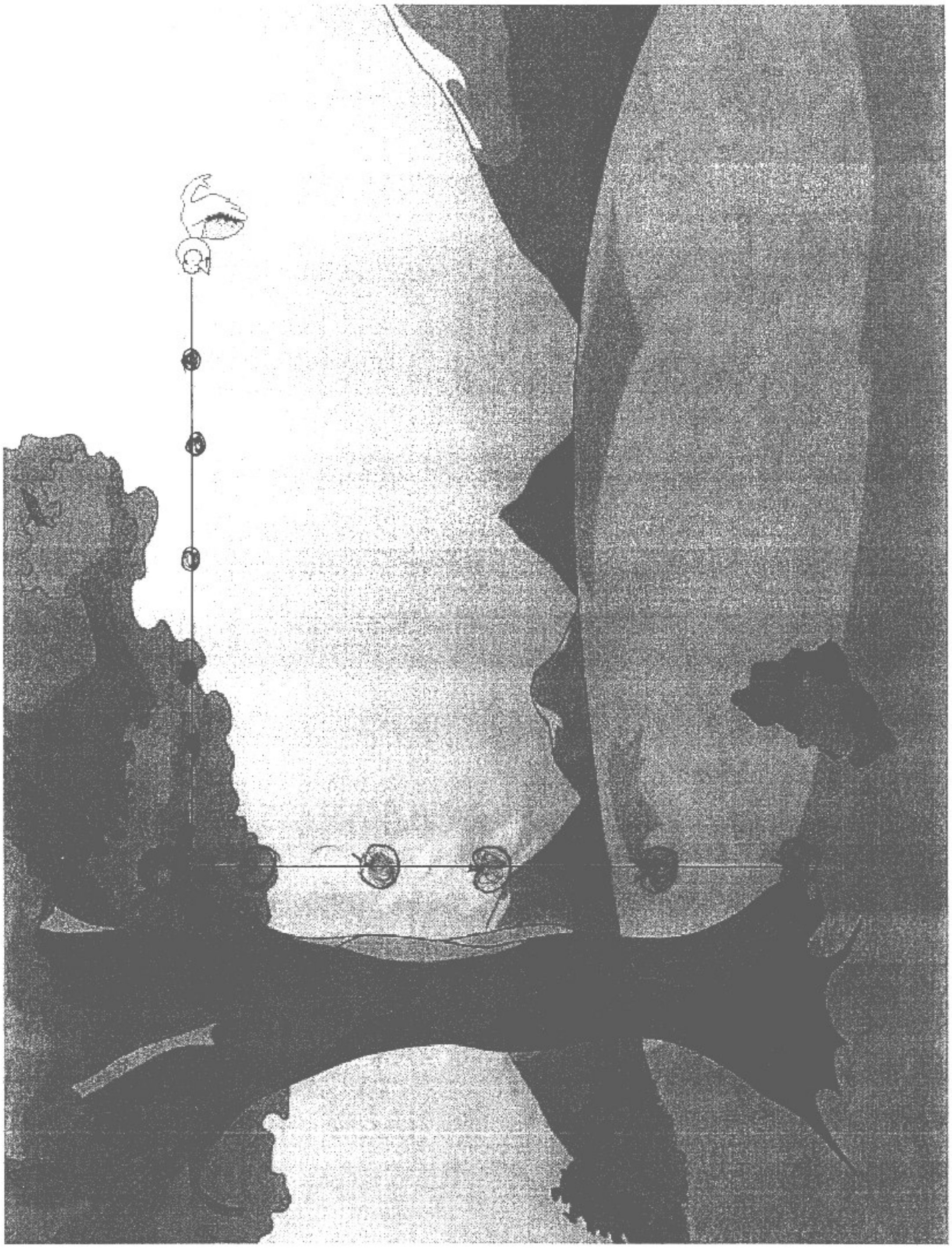
Student 8, Female, 6th Grade, posttest



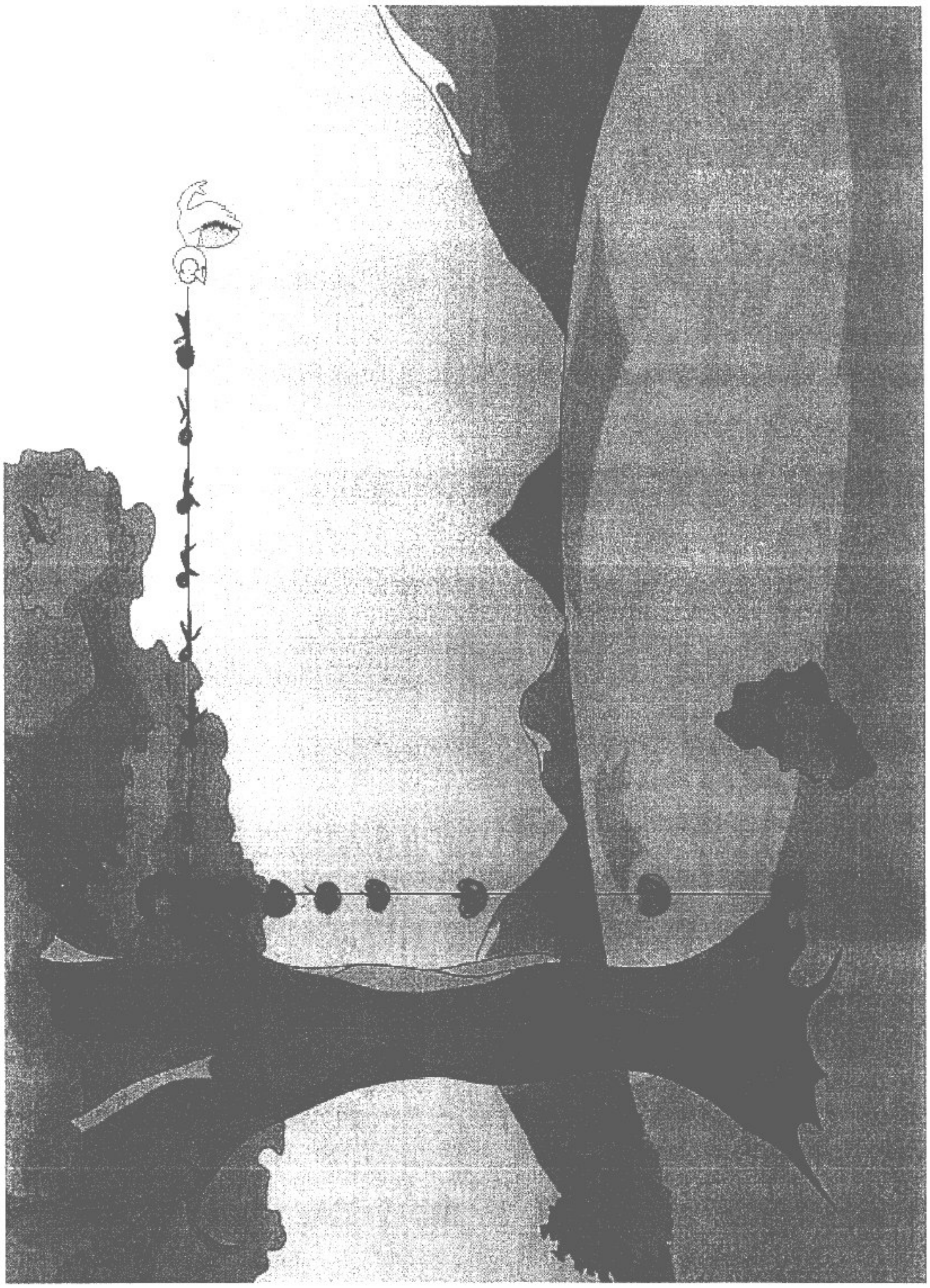
Student 9, Female, 6th Grade, pretest



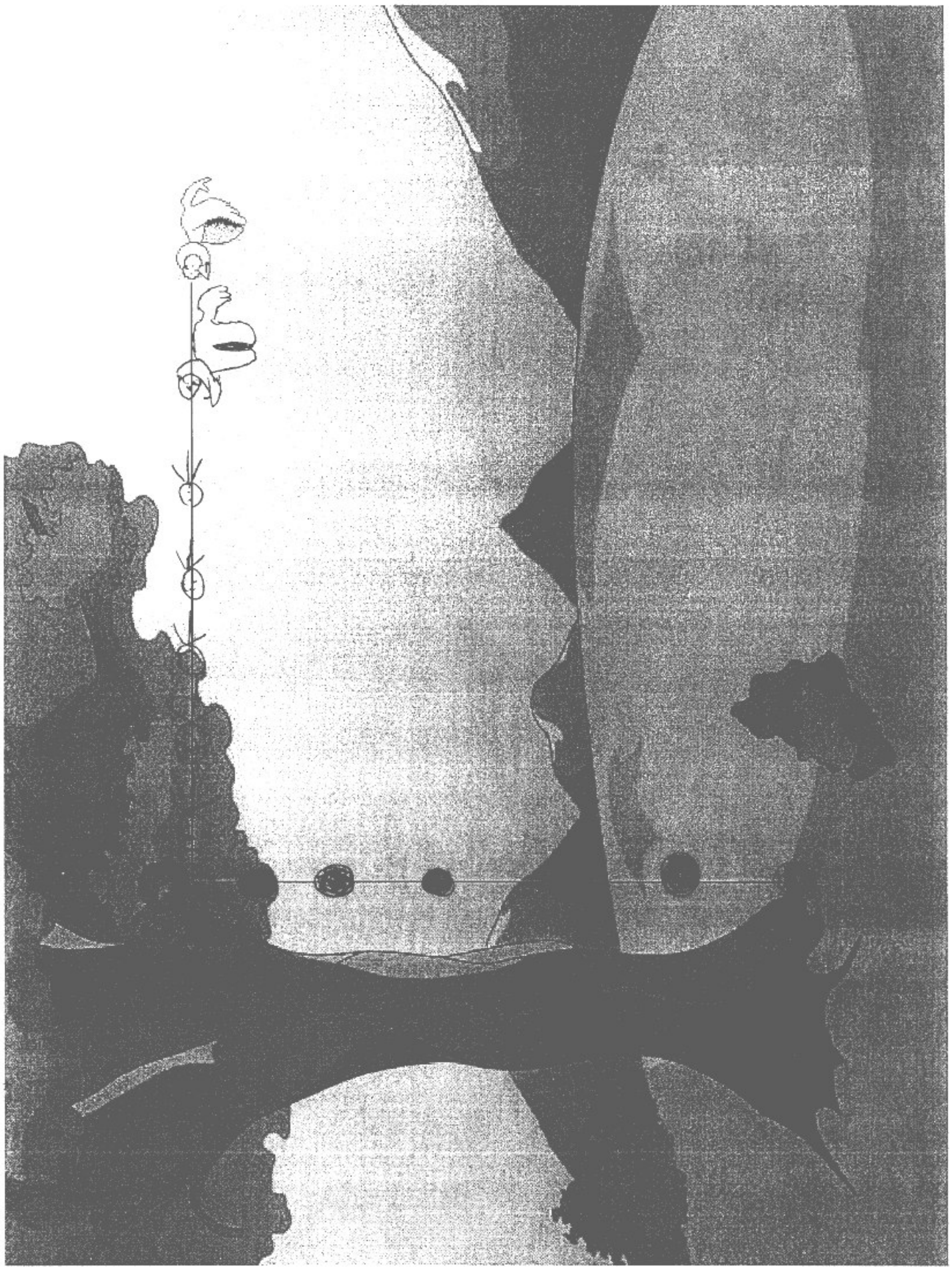
Student 9, Female, 6th Grade, posttest



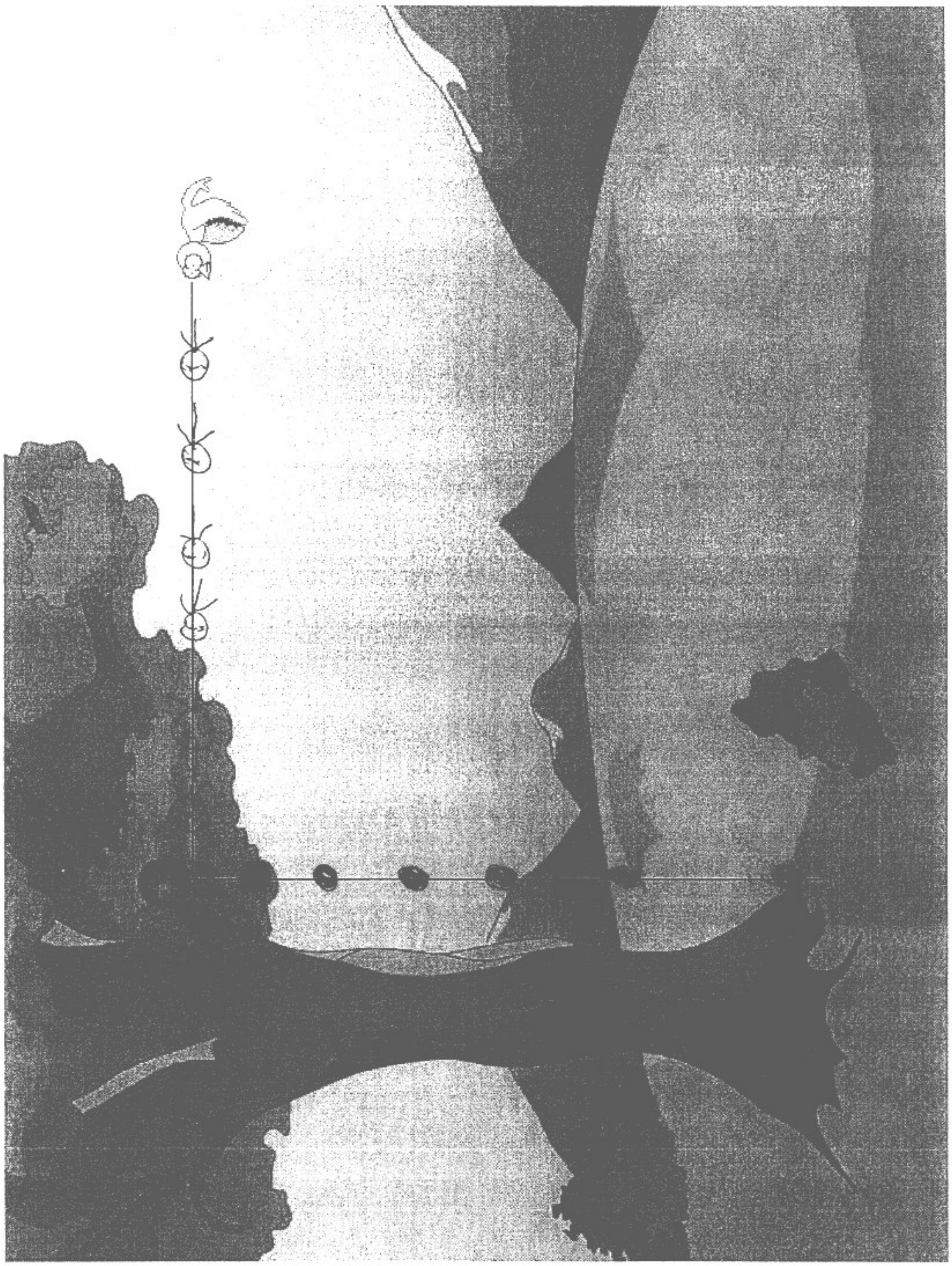
Student 10, Female, 6th Grade, pretest



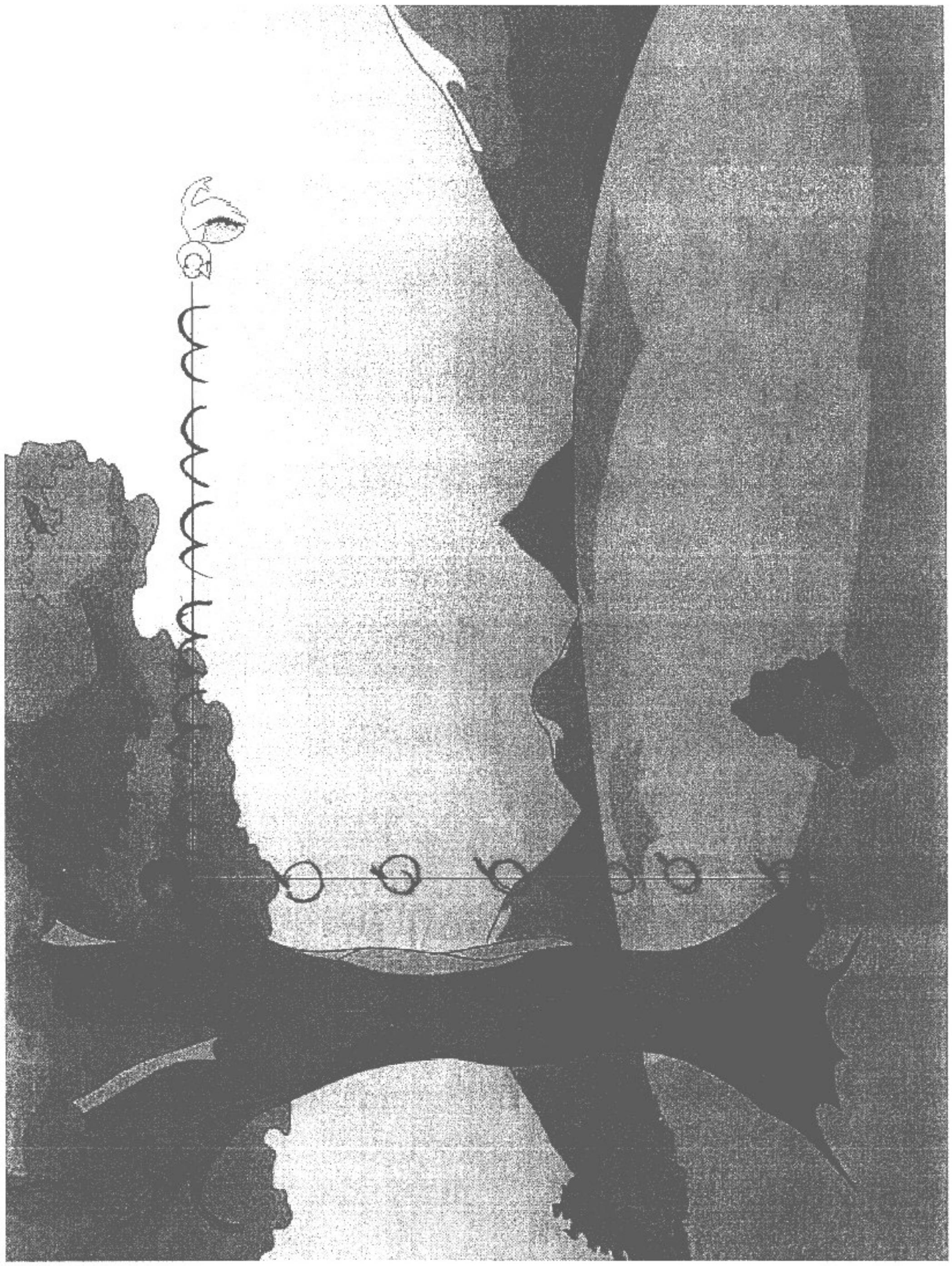
Student 10, Female, 6th Grade, posttest



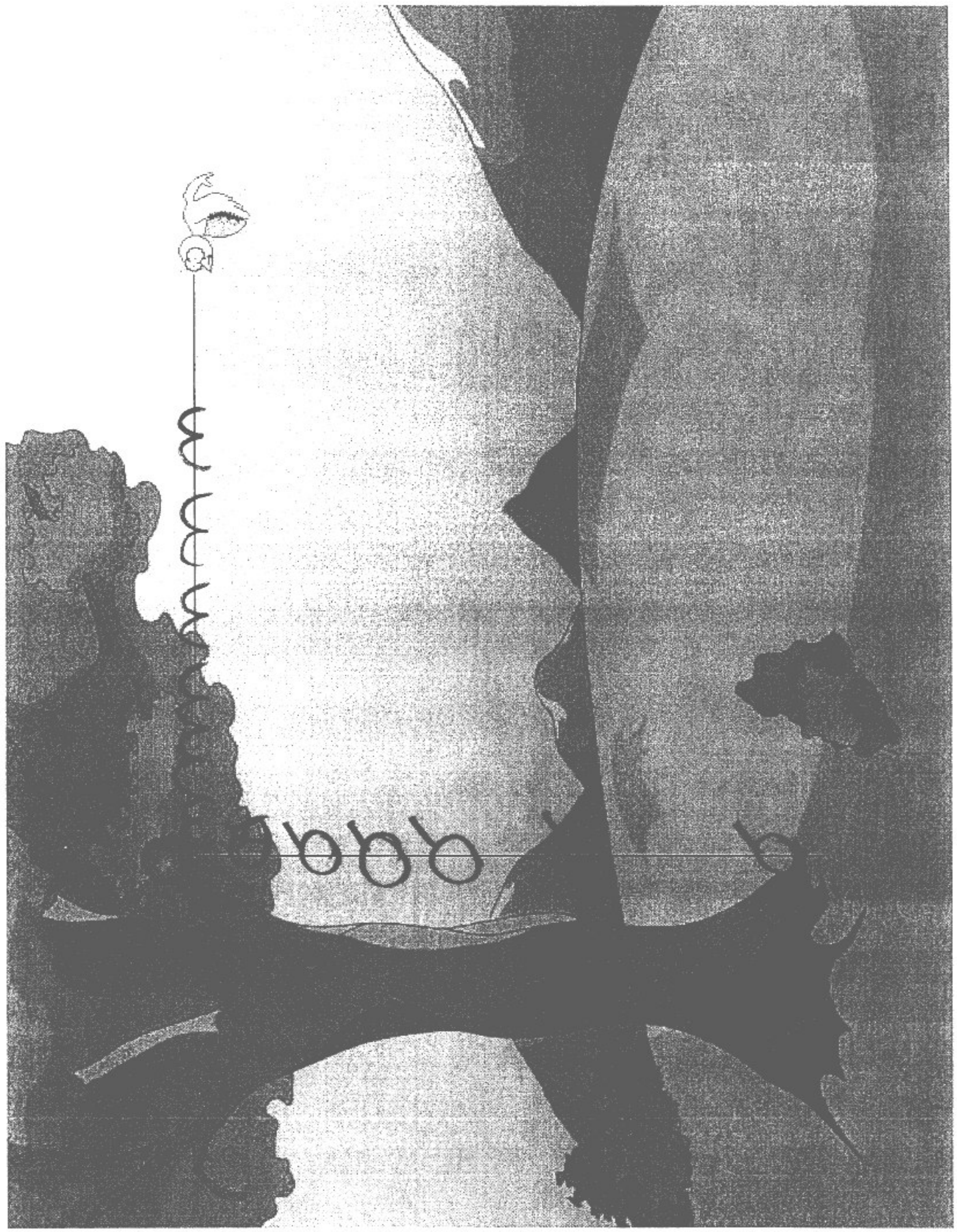
Student 11, Male, 8th Grade, pretest



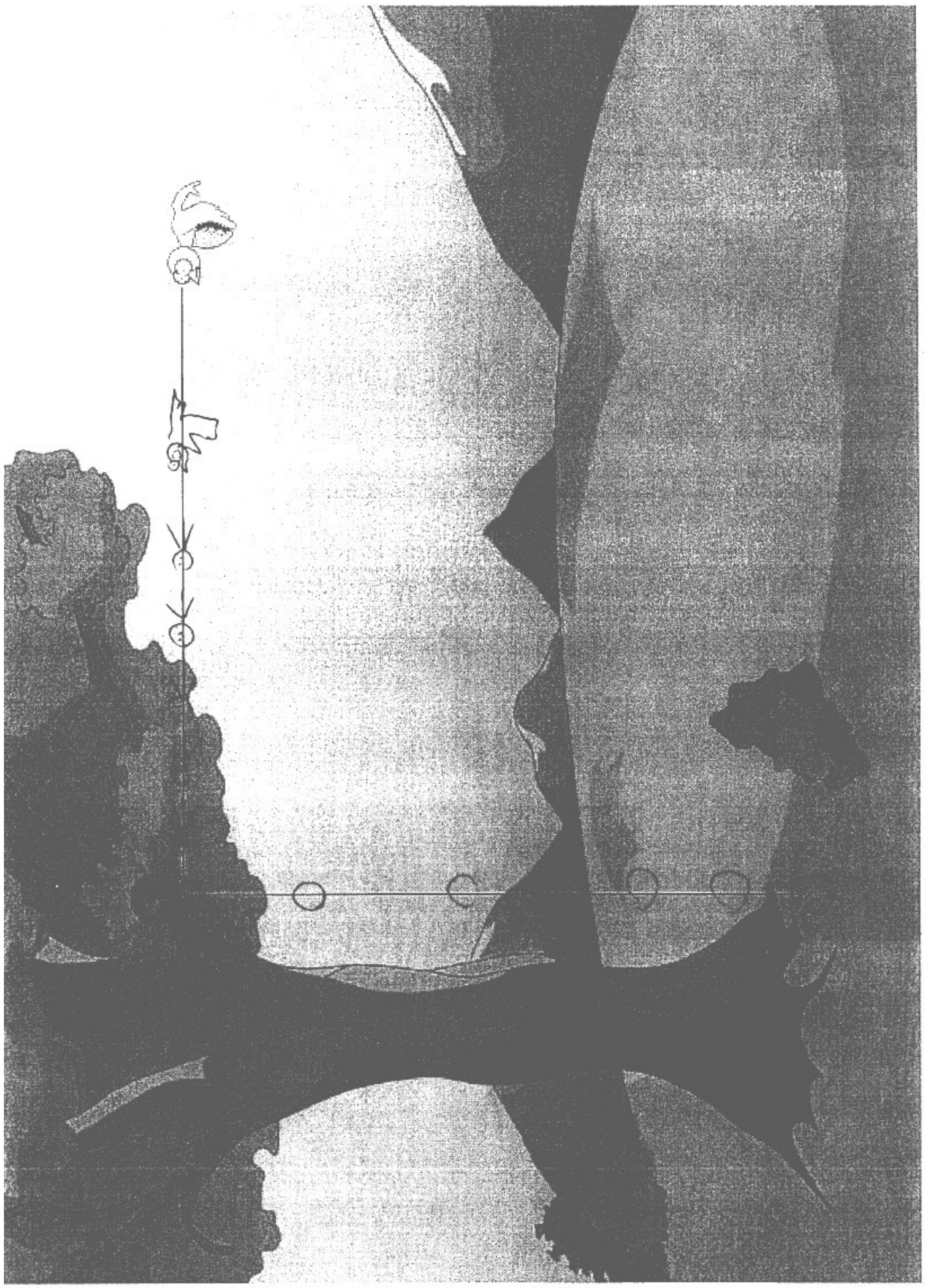
Student 11, Male, 8th Grade, posttest



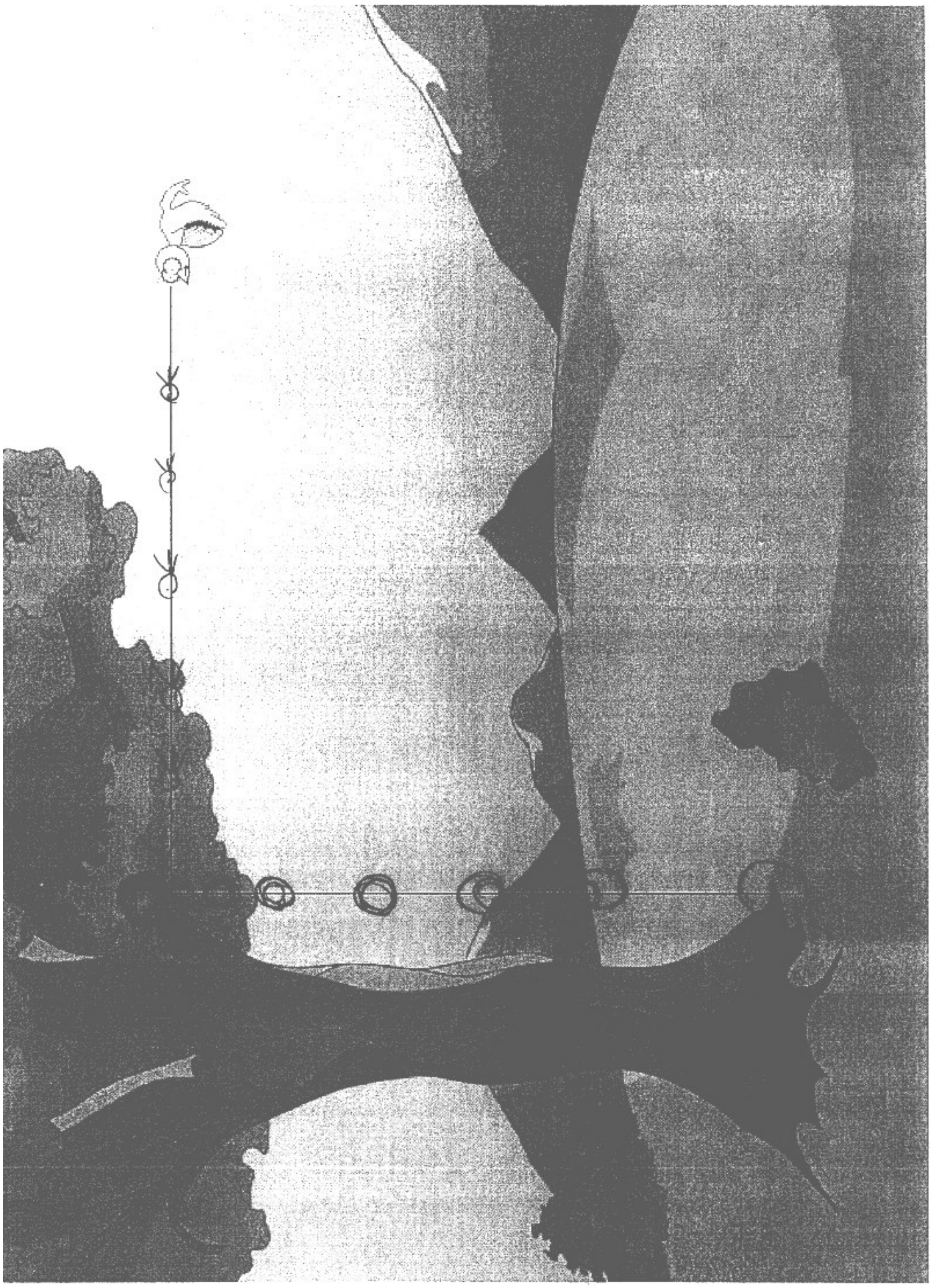
Student 12, Female, 8th Grade, pretest



Student 12, Female, 8th Grade, posttest



Student 13, Male, 8th Grade, pretest



Student 13, Male, 8th Grade, posttest

7. REFERENCES

Andaloro, G., L. Bellomonte, L. Lupo and R. M. Sperandoe- Mineo, 1994, "Construction and Validation of a Computer-Based Diagnostic Module on Average Velocity", *Journal of Research in Science Teaching*, Vol. 31, No. 1, pp. 53-63.

Arons, A.B., 1997, *Teaching introductory physics,* Wiley, New York.

Bastick, T., 1982, *Intuition: How we think and act*, Wiley, New York.

Berg, T. and W. Brouwer, 1991, "Teacher Awareness of Student Alternate Conceptions About Rotational Motion and Gravity", *Journal of Research in Science Teaching,* Vol.28, No. 1, pp. 3-18.

Bergson, H., 1954, *Creative Evolution*, Translated by A. Mitchell, Macmillan and Co. Lyd, First Edition, London.

Ben-Zeen, T. and J. Star, 2001, "Intuitive Mathematics: Theoretical and Educational Implications", in B. Torff and R. J. Sternberg, 2001, *Understanding and Teaching the Intuitive Mind: Student and Teacher Learning*, Lawrence Erlbaum Associates, New Jersey, pp. 29-55.

Berry, D. and Z. Dienes, 1993, *Implicit Learning: Theoretical and empirical issues,*Hillsdale, Lawrence Erlbaum Associates, New Jersey.

Beth, E.W. and J. Piaget, 1966, *Mathematical Epistemology and Psychology*, Reidel, Dordrecht.

Bowers, K., 1984, "On being uncounsciously influenced and informed", in K. Bowers and D. Meichenbaum (Eds), *The uncounscious reconsidered*, Wiley, New York.

Bowers, K., G. Regehr, C. Balthazard and K. Parker, 1990, “Intuition in the Context of Discovery”, *Cognitive Psychology*, Vol. 22, pp. 72-110.

Brown, D.E., 1989, “Students’ Concept of Force: The Importance of Understanding Newton’s third law”, *Physics Education*, Vol. 24, pp. 353-358.

Cadmus, R. R., Jr., 1990, “A Video Technique to Facilitate the Visualization of Physical Phenomena”, *American Journal of Physics*, Vol. 58, pp. 397-399.

Cahyadi, M. V. and P. H. Butler, 2004, “Undergraduate students’ understanding of falling bodies in idealized and real-world situations”, *Journal of Research in Science Teaching*, Vol. 41, No. 6, pp. 569-583.

Capra, F., 1976, “An Exploration of the Parallels Between Modern Physics and Eastern Mysticism, The Tao of Physics, http://www.intuition-in-service.org/main/intuition/quotations/science.html

Champagne, A. B., L. E. Klopfer and J. H. Anderson, 1980, “Factors Influencing the Learning of Classical Mechanics”, *American Journal of Physics*, Vol. 48, pp. 1074-1079.

Chi, M. T. H. and J. D. Slotta, 1993, “The Ontological Coherence of Intuitive Physics”, *Cognition and Instruction*, Vol. 10, pp. 249-260.

Clement, J., 1982, “Students’ Preconceptions in Introductory Mechanics”, *American Journal of Physics*, Vol. 50, pp. 66-71.

Confrey, J., 1989, “A Review of the Research on Student Conceptions in Mathematics, Science and Programming”, in C. Cazden (Ed.) *Review of research in educatio,* pp. 3-56, American Educational Research Association, Washington.

Dall'Alba, G., E. Walsh, J. Bowden, E. Martin, G. Masters, P. Ransden and A. Stephanou, 1993, "Textbook Treatments and Students' Understanding of Acceleration*", Journal of Research in Science Teaching*, Australia, Vol. 30, No. 7, pp. 621-635.

diSessa, A. A., 1982, "Unlearning Aristotelian Physics: A Study of Knowledge-Based Learning", *Cognitive Science*, Vol. 6, pp. 37-75.

diSessa, A., 1983, "Phenomenology and Evolution of Intuition, in D. Gentner and A. Stevens (Eds.), *Mental models*, Lawrence Erlbaum Associates, Hillsdale, New Jersey.

diSessa, A. A., 1993, "Toward an Epistemology of Physics", *Cognition and Instruction*, Vol. 10, pp. 105-225.

Dykstra, D. I., C. F. Boyle and I. A. Monarch, 1992, "Studying Conceptual Change in Learning Physics", *Science Education*, Vol. 76, No. 6, pp. 615-652.

Eckstein, S. G. and M. Shemesh, 1993, "Stage Theory of the Development of Alternative Conceptions", *Journal of Research in Science Teaching*, Vol. 30, No. 1, pp. 45-64.

Elby, A., 2001, "Helping Physics Students Learn How to Learn", Physics Education Research, *American Journal of Physics*, pp. 54-69.

Escalada, L. T. and D. A. Zellman, 1997, "An Investigation on the Effects of Using Interactive Digital Video in a Physics Classroom on Student Learning and Attitudes", *Journal of research in science teaching*, Vol. 34, No. 5, pp. 467-489.

Fischbein, E., 1987, *Intuition in Science and Mathematics an Educational Approach*, D. Reidel Publishing Company, Boston.

Fischbein, E., R. Stavy and H. Ma-Naim, 1989, "The Pschological Structure of Naive Impetus Conceptions", *International Journal of Science Education*, Vol. 11, pp. 71-81.

Gardner, P.L., 1984, "Circular Motion: Some Post-Instructional Alternative Frameworks", *Research in Science Education*, Vol. 14, pp. 136-145.

Glasser, W., 1975, Schools Without ailure, Harper and Row, Publishers, New York.

Greenwald, A.G., 1992, "Unconscious Cognition Reclaimed", *American Psychologist*, Vol. 47, pp. 766-779.

Gunstone, R.F. and R. T. White, 1981, "Understanding of Gravity", *Science Education*, Vol. 65, pp. 291-299.

Gunstone, R.F., 1984, "Circular Motion: Some Pre-Instructional Alternative Frameworks", Reseach in Science Education, Vol. 14, pp. 125-135.

Gunstone, R. and M. Watts, 1985, "Force and Motion", in R. Driver, E. Guesne and A. Tiberghien, 1985, *Children's Ideas in Science,* Open University Press, Philadelphia, pp. 84-104.

Hake, R., 1998, "Interactive-Engagement vs Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses", *American Journal of Physics*, Vol. 66, pp. 64-74.

Halloun, I.A. and D. Hestenes, 1985, "Common Sense Concepts About Motion", *American Journal of Physics*, Vol. 53, pp. 1056-1065.

Hammond, K. R., R. H. Hamm, J. Grassia and T. Pearson, 1987, "Direct Comparison of Efficacy of Intuitive and Analytical Cognition in Expert Judgement", *IEEE Transactions on Systema. Man and Cybernetics*, Vol. 17, pp. 753-770.

Helm, H., 1981, "Conceptual Misunderstandings in Physics", in *Perspective 3. School of Education*, University of Exeter, Exeter.

Hestenes, D., M. Wells and G. Swackhamer, 1992, "Force Concept Inventory", *The Physics Teacher*, Vol. 30, pp. 141-158.

Hiebert, J. and P. Lefevre, 1986, "Conceptual and Procedural Knowledge in Mathematics: An Introductory Analysis", in J. Hiebert (Eds), *Conceptual and Procedural Knowledge: The case of Mathematics*, pp. 1-27, Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Intuition Magazine, December (1995), http://www.intuition-in-service.org/main/intuition/quotations/science.html

Jimoyiannis, A. and V. Komis, 2000*, Computer Simulations in Physics Teaching and Learning: a Case Study on Students' Understanding of Trajectory Motion*, Greece, http://www.ecedu.upatras.gr/komis/Pdf_Total/Jimoyiannis_Komis_C&E_V34_2001.pdf.

Kılıç, R., 1997, "Görsel Öğretim Materyalleri Tasarım İlkeleri", *Milli Eğitim Dergisi*, No. 136, p. 74.

Kihlstrom, J. F., T. M. Barnhardt and D. J. Tataryn, 1992, "The Psychological Uncounscious: Found, Lost, and Regained", *American Psychologist*, Vol. 47, pp. 788-791.

Lambert, T., 2003, "Visual Orienting, Learning and Conscious Awareness", in L. Jimenes, 2003, *Attention and Implicit Learning*, pp. 253 – 275, John Benjamin Publishing Company, Spain.

Langford, J.M. and D. Zollman, 1982, "Conceptions of Dynamics Held by Elementary and High School Students", Paper Presented at the Annual Meeting of the *American Associations of Physics Teachers*, San Francisco.

Larkin, J., 1983, "The Role of Problem Representation in Physics, in D. Gentner and A. Stevens (Eds.), *Mental models*, Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Lewicki, P., T. Hill and E. Bizot, 1988, "Acquisition of Procedural Knowledge", *Cognitive Psychology*, Vol. 20, pp. 24-37.

Lewis, E. L., J. L. Stern and M. C. Linn, 1993, "The Effect of Computer Simulations on Introductory Thermodynamics Understanding", *Educational Technology*, Vol. 14, pp. 45-58.

Lewis, E.L. and M. C. Linn, 1994, "Heat Energy and Temperature Concepts of Adolescents, Adults and Experts: Implications for Curricular Improvements", *Journal of Research in Science Teaching*, Vol. 31, No. 6, pp. 657-677.

Lovelock, J., 2000, *Goi Peace Foundation Report*, p.18, http://www.intuition-in-service.org/main/intuition/quotations/science.html

Maloney, D. P., 1988, "Novice Rules for Projectile Motion", *Science Education*, Vol. 72, pp. 501-513.

McCloskey, M., A. Camarazza and B. Green, 1980, "Curvilinear Motion in Absence of External Forces: Folk Beliefs About the Motion of Objects", *Science*, Vol. 210, pp. 1149-1151.

McCloskey, M., 1983, "Intuitive Physics", *Scientific American*, Vol. 248, pp. 114-122.

McCloskey, M., A. Washburn and L. Felch, 1983, "Intuitive Physics: The Straightdown Belief and its Origin", J*ournal of Experimental Psychology: Learning, Memory and Cognition*, Vol. 9, pp. 636-649.

McDermott, L.C., 1991, "Millikan Lecture 1990: What We Teach and What is Learned – Closing the Gap", *American Journal of Physics*, Vol. 59, pp. 301-315.

Minstrell, J., 1982, "Explaining 'at Rest' Condition of an Object", *The Physics Teacher*, Vol. 20, pp. 10-14.

Montanero, M., M. I. Suero, A. L. Perez and P. J. Pardo, 2002, "Implicit Theories if Statics Interactions Between Two Bodies", *Physics Education*, Vol. 37, pp. 318-323.

Osborne, R., 1982, "Science Education: Where do We Start?", *Australian Science Tearchers Journal*, Vol. 28, No. 1, pp. 21-30.

Parikh, J., 1994, *Intuition*, The New Frontier of Management, Blackwell Publisher S, Malden, M. A.

Peters, P.C., 1982, "Even Honuors Graduates Have Conceptual Difficulties with Physics", *American Journal of Physics*, Vol. 50, No. 6, pp. 501-508.

Poincare, H. L., 1920, *The Value of Science*, Dover Publications Inc, New York.

Posner, G.J., K. A. Strike, P. W. Hewson and W. A. Gertzog, 1982, "Accomodation of a Scientific Conception: Toward a Theory of Conceptual Change", *Science Education*, Vol. 66, No. 2, pp. 211-227.

Reber, A. S., 1989, "Implicit Learning and Tacit Knowledge", *Journal of Experimental Psychology*, General, Vol. 118, pp. 219-235.

Reber, A.S., F. F. Walkefeld and R. Hernstadt, 1991, "Implicit and Explicit Learning: Individual Differences and IQ", *Journal of Experimental Psychology Learning, Memory and Cognition*, Vol. 17, pp. 888-896.

Reber, A., 1993, *Implicit Learning and Tacit Knowledge*, Oxford University Press, New York

Redish, E., 1993, "The Implications of Cognitive Studies for Teaching Physics", *American Journal of Physics*, Vol. 62, No. 9, pp. 796-803.

Reif, F. and J. H. Larkin, 1991, "Cognition in Scientific and Everyday Domains: Comparison and Learning Implications", *Journal of Research in Science Teaching*, Vol. 28, No. 89, pp. 733-760.

Resnick, L., 1986, "The Development of Mathematical Intuition", in M. Perlmutter (Eds), *Perspectives on Intellectual Development: The Minnesota Symposia on Child Psychology*, Vol. 19, pp. 159-194, University of Minnesota Press, Minneapolis.

Resnick, L.B., 1987, "Learning in School and Out", *Educational Researcher*, Vol. 16, pp. 13-20.

Resnick, L.B., 1989, "Developing Mathematical Knowledge", *American Psychologist*, Vol. 44, No. 2, pp. 162-169.

Roberts, R. M., 1989, *Serendipity, Accidental Discoveries in Science*, Wiley Science Editions, New York, pp. 1-15.

Savinainen, A., P. Scott and J. Viiri, 2004, *Using a Bridging Representation and Social Interactions to Foster Conceptual Change: Designing and Evaluating an Instructional Sequence for Newton's Third Law*, Wiley InterScience, Finland.

Sjoberg, D. and S. Lie, 1981, *Ideas About Force and Movement Among Norweigian Pupils and Students: Centre for School Science*, Universiy of Oslo, Oslo.

Spinoza, B., 1967, *Ethics and Treatise on the Correction of the Understanding* (Translated by A. Boyle), Everyman's Library Dent, London.

Stepans, J., 1996, *Targeting Students' Science Misconceptions Physical Science Concepts Using the Conceptual Change Model*, Idea Factory, pp. 89-104.

Sternberg, R., 1988, *The TriarchicMind: A New Theory of Human Intelligence*, Viking, New York.

Sternberg, R., 1997, *Successful Intelligence*, Viking, New York.

Sternberg, R. and J. Horvath (Eds.), 1999, *Tacit Knowledge in Proffessional Practice*, Lawrence Erlbaum Associates, Mahmah, New Jersey.

Sternberg, R., B. Torff and E. Grigorenko, 1998a, May, *Teaching for Successful Intelligence Improves School Achievement*, Phi Delta Kappan.

Sternberg, R., B. Torff and E. Grigorenko, 1998b, September, "Teaching Triarchically Improves School Achievement", *Journal of Educational Psychology*.

Sternberg, R., R. Wagner, W. Williams and J. Horvath, 1995, "Testing Commonsense", *American Psychologist*, Vol. 50, No. 11, pp. 901-912.

Terry, C. and G. Jones, 1986, "Alternative Frameworks: Newton's Third Law and Conceptual Change", *European Journal of Science Education*, Vol. 8, pp. 291-298.

Torff, B., 1997, "Into the Wordless World: Implicit Learning and Instructor Modeling in Music", in V. Brummet (Eds), *Music as Intelligence*, Ithaca College Press, Ithaca. New York.

Torff, B., 1999, “Tacit Knowledge in Teaching: Folk Pedagogy and Teacher Education”, in R. Sternberg and J. Horvath (Eds.), *Tacit Knowledge in Professional Practice*, Lawrence Erlbaum Associates, Mahmah, New Jersey.

Torff, B. and R. J. Sternberg, 2001, *Understanding and Teaching the Intuitive Mind: Student and Teacher Learning*, Lawrence Erlbaum Associates, Publishers, New Jersey, pp. 3-26.

Viennot, L., 1979, “Spontaneous Learning in Elementary Dynamics”, European *Journal of Science Education*, Vol. 1, No. 2, pp. 205-221.

Walsh, E., G. Dall’Alba, J. Bowden, E. Martin, F. Marton, G. Masters, P. Ramsden and A. Stephanou, 1993, “Physics Students’ Understanding of Relative Speed: A Phenomenographic Study”, Journal of Reserch in Science Teaching, Vol. 30, No. 9, pp. 1133-1148.

Warren, J.W., 1979, *Understanding Force*, John Murray, London.

Watts, D.M. and A. Zylbersztajn, 1981, “A Survey of Some Children’s Ideas About Force”, *Physics Education*, Vol. 15, pp. 360-365.

Watts, D. M., 1983, *A Study of Alternative Frameworks in School Science*. Unpublished PhD thesis, University of Surrey, Guilford.

Watts, D.M., 1983, “A Study of School Children’s Alternative Frameworks of the Concept of Force”, *European Journal of Science Education*, Vol. 5, No. 2, pp. 217-230.

Weintraub, S., B. Heinemann, 1998, *The Hidden Intelligence, Innovation Through Intuition*, Boston.

Wertsch, J. V. and J. L. Polman, 2001, “Intuitive Mind and History Knowledge”, in B. Torff, R. J. Sternberg, 2001, *Understanding and Teaching the Intuitive Mind: Student and Teacher Learning*, Lawrence Erlbaum Associates, Publishers, New Jersey, pp. 58-72.

Westcott, M. R., 1968, *Towards a Contemporary Psychology of Intuition*, Hott, Rinehart and Winston, New York.

Westcott, M, 1961, “On the Measurement of Intuitive Leaps”, *Psychological Reports*, Vol. 9, pp. 267-274.

Woolhouse, L. S.,and R. Bayne, 1999, *Personality and the Use of Intuition: Individual Differences in Strategy and Performance on an Implicit Learning Task*, John Wiley and Sons, United Kingdom.