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EXPLORING EARLY CHILDHOOD CHILDREN'S COMPUTATIONAL THINKING SKILLS

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Abstract: *The current study has two purposes and within the context of the first purpose, the TechCheck-K (Relkin & Bers, 2021) instrument, which was developed to evaluate the computational thinking (CT) skills of children at the kindergarten level, was adapted into Turkish. Within the context of the second purpose of the study, the extent to which CT skill levels of Turkish children vary depending on the variables of gender and pre-school education status was investigated. To this end, the study employed the survey model, one of the quantitative methods. The study group is comprised of 106 early childhood children. As a result of the data analyses carried out in the study, the mean item difficulty index of the TechCheck-K instrument, which was adapted to Turkish in the study, was found to be 0.49 and the mean item discrimination index was found to be 0.32. The mean CT skill score of the children was found to be* $\bar{X}$*=7.42 out of 15 points. In addition, no significant difference was found between girls and boys and between the children who received and those who did not receive pre-school education in terms of CT skill level.*

Keywords: *Computational thinking skills, early childhood children, instrument adaptation, TechCheck-K*

Introduction

In the 21st century, the daily life of individuals is surrounded by more and more technology and technology helps people to do many things in their daily life (Bers, 2010; Silva, Dembogurski & Semaan, 2021). In addition to using technology, the importance given to producing it is increasing day by day and thus, a greater emphasis is put on training future generations as individuals who produce technology (Authors, 2021; Khoo, 2020). For future generations to produce technology, their computational thinking (CT) skills need to be developed (Silva, Dembogurski & Semaan, 2021). "Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science" (Wing, 2006, p. 33). At the heart of CT lies thinking like a computer scientist when faced with a problem (Grover & Pea, 2013). Moreover, CT is also defined as a general thinking skill set (for example, pattern recognition, abstraction, collaboration, or persistence) that includes both cognitive abilities and social-emotional dispositions (Gerosa et al., 2021).

Today, CT is seen as a basic skill set like reading, writing, and arithmetic that should be acquired by every child (Wing, 2006). Therefore, in recent years, more and more countries have included CT in their education policies and curricula to improve students' CT skills (Yang, Liu & Chen, 2020). In addition, countries such as the United States and the United Kingdom have updated their curricula to include CT from early childhood and have made CT a priority in early childhood learning environments (Bers, 2018; U.S. Department of Education, 2010). The reason for these policies of countries is the conviction that a solid foundation for learning CT can best be laid in early childhood (Wing, 2008). In this context, the investments made by countries in early childhood education are gaining more importance compared to their investments in other periods (Cunha & Heckman, 2007).

Many robots, online resources and platforms have been developed to support the development of children's CT skills (Gerosa et al., 2021). For example, Cargo-Bot, Codeable Crafts, Daisy the Dinosaur, Kodable, Lightbot Jr., PBS KIDS ScratchJr, Robozzle, Run Marco!, ScratchJr, Sushi Monsters, The Foos, Tynker (Ehsan, Beebe & Cardella, 2017); Cubetto, Bee-bot, Matatalab, Ozobot, KIBO, KUBO, Dash, Cue and Dot (Authors, 2021) are some of them. In addition to these applications and tools, STEM education (integration of science, technology, engineering and mathematics disciplines) is also used to develop children's CT skills because CT and STEM are in a symbiotic (complementary) relationship, science and math classes offer easy and effective daily life contexts for the learning and use of CT skills (Grover & Pea, 2018). Jeannette Wing, on the other hand, considers CT a vital component of STEM learning and argues that CT skills should be added to every child's analytical ability (Grover & Pea, 2013; Wing, 2011).

In addition to developing children's CT skills, it is also important to use tools to evaluate these skills (Bocconi et al., 2016). However, the number of tools for evaluating CT in the literature is very small (Bocconi et al., 2016). In the relevant literature, different tools and methods have been used to evaluate children's CT skills. In this regard, there are different tools proposed in the literature such as the interview method (Khoo, 2020), peer video interviews with ScratchJr (Portelance & Bers, 2015), observations and children's worksheets (Khoo, 2020), open-ended questions (Wang et al. 2014), projects produced by children through CHERP (Bers et al. 2014) and TACTIC-KIBO robotic activities (Relkin & Bers, 2019). In summary, in the literature, mostly interview protocols, observation and project-based coding assessments have been used to evaluate the CT skills of children in early childhood (Relkin, de Ruiter & Bers, 2020).

Tools and methods used to evaluate CT in early childhood in the current literature require prior knowledge of online programming platforms, robotics, programming and CT (Relkin, de Ruiter & Bers, 2020). Moreover, children can be distracted because the application of these tools and methods requires a lot of time (Relkin, de Ruiter & Bers, 2020). This indicates that there is a need for developmentally appropriate tools for the assessment of CT in early childhood (Portelance & Bers, 2015). In order to assess children's CT skills more easily and effectively, criteria such as the appropriateness of assessment tools for children's age, their ease of administration, the short attention span of children and teachers' lack of time for long-term assessments should be taken into account (Relkin & Bers, 2019).

In line with the aforementioned deficiencies and the need for an assessment tool suitable for the development of children in examining CT skills, Relkin, de Ruiter, and Bers (2020) developed the TechCheck instrument to assess the CT skills of 5-9-year-old children. Later, Relkin and Bers (2021) adapted the same instrument to be suitable for the level of kindergarten children (5-6 years old) and named it TechCheck-K. This instrument includes unplugged assessment (assessments for which there is no need for programming knowledge), which does not require prior knowledge of CT or coding and can be applied in a short time and easily (Relkin & Bers, 2021). At the same time, this instrument was developed by considering 6 of Bers's (2018)' developmentally appropriate seven powerful ideas of CT' (Algorithms, Modularity, Control Structures, Representation, Hardware and Software, Debugging).

In the literature review conducted, though some studies existed on technology, computer-integrated preschool teaching (Kabadayı, 2005; Kabadayı, 2006; Demir & Kabadayı, 2008; Kabadayı & Doğan Kirişçigil, 2021) no assessment tool was developed to examine the CT skills of early childhood children in Turkey could be found. However, CT skills need to be identified at an early stage for more effective planning of CT-based activities (Chongo, Osman & Nayan, 2020). Elicitation of the present CT skill levels of children in Turkey can guide policy makers and curriculum developers to revise the country's education policies and curriculums. For this reason, TechCheck-K instrument developed by Relkin and Bers (2021) was adapted to Turkish in the current study, due to the advantages it provides in assessment (for example, it does not require prior knowledge of programming, does not require literacy, can be applied easily in a short time, is based on an unplugged assessment).

Computational Thinking in terms of Gender and Pre-school Education Status

In addition to adapting TechCheck-K to Turkish, comparing the CT skills of girls and boys in the context of Turkey is another purpose of the current study. In the literature, it is generally stated that boys' CT ability is better than girls (Chongo, Osman & Nayan, 2020) and girls need more training time to reach the same CT skill level as boys (Atmatzidou & Demetriadis, 2016). Moreover, in previous studies conducted in the context of early childhood, CT skills of children in the United States were compared depending on the gender variable and no statistically significant difference was found (Relkin, de Ruiter & Bers, 2020). In the literature review, we could not find any study examining the CT skills of girls and boys in the early childhood period in the context of Turkey. In the current study, the absence of a significant gender difference between the

CT skills of male and female children educated in the USA was examined in Turkey in order to determine whether it is an observable situation in the context of Turkey. These reasons and deficiencies reveal the importance of the present study in terms of examining the CT skills of early childhood children in Turkey according to the gender variable.

Evaluating CT skills depending on the variable of pre-school education status is also among the aims of the current study. Pre-school education in Turkey is supported by the state and the number of children receiving preschool education is increasing day by day, yet this increase is not at the desired level (The World Bank, 2013). Evaluating whether the existing preschool education affects children's CT skills is important in terms of showing the effectiveness of preschool education in developing CT skills in Turkey. Furthermore, no research has been found that examines children's CT skills depending on their pre-school education status. The reason for the comparison of CT skills according to the status of receiving pre-school education in the current study is to reveal the situation of the current pre-school curriculum and early childhood learning environments in our country in terms of developing CT skills.

Powerful Ideas of Computational Thinking

Seymour Papert, known as the 'father of educational computing', used CT for the first time in the context of K-12 education in 1980 by teaching children mathematical concepts with the LOGO programming language (Czerkawski and Lyman 2015; Stager, 2016). LOGO supports children's learning to think (Papert, 2005). Papert saw LOGO's greatest potential as the 'incubator of powerful ideas' (Bers, 2018). Papert gave importance to powerful ideas of computational thinking and emphasized that children could develop their CT skills by using their powerful ideas (Bers, 2020). Bers (2020) explains in what sense Papert (1980) uses powerful ideas as follows: What is referred to by the term powerful idea is a central concept or skill of a discipline that is personally useful, has connections with other disciplines, and is based on intuitive knowledge internalized by a child over a long period. In addition, Bers (2020) states that powerful ideas are intellectual tools, that they arouse an emotional response and that children can connect powerful ideas with their interests and past experiences. Powerful ideas of computational thinking include Algorithms, modularity, control structures, representation, hardware and software, design process and debugging (Bers, 2018). The TechCheck-K instrument used in the current study was developed by considering 6 of Bers's (2018) 'developmentally appropriate seven powerful ideas of CT' (See Table 1).

Table 1. Powerful ideas are involved in computational thinking (Bers, 2018, p. 5)

Powerful idea	**Definition**
Algorithm	A series of ordered instructional steps are taken in a sequence in order to find a solution to a problem or achieve an end goal.
Modularity	The disintegration of tasks or procedures into simpler, manageable units so that they can be used to create a more complex process employing combination or re-use
Control Structures	The order (or sequence) in which instructions are followed or carried out within an algorithm or program is determined by control structures. For example, repeat functions, loops, conditionals, events, and nested structures, are all control structures.
Representation	Information is represented by programming languages utilizing the use of a symbol system. At the same time, data and values are stored and manipulated in computers in a variety of ways. This data is represented in various ways to make it available.
Hardware/Software	Hardware and software are needed for computing systems to operate. Instructions are provided to the hardware by the software. Tasks such as receiving, processing and sending information can be accomplished with the use of hardware and software together as a system.
Design process	This repetitive process includes several steps: ask, imagine, plan, create, test, improve, and share. The process is open-ended; that is, many possible solutions can be proposed for a problem.
Debugging	Fixing problems by conducting systematic analysis and evaluation, while troubleshooting strategies are being developed at the same time.

Research Questions

The research questions of the study are worded as follows:

1- Is TechCheck-K a valid and reliable measure of Turkish early childhood children's computational thinking skills?

2- What is the level of computational thinking skills (TechCheck-K scores) of children in early childhood in the case of Turkey?

3- Do the computational thinking skills of early childhood children differ between boys and girls in the case of Turkey?

4- In the case of Turkey, do the early childhood children's computational thinking skills vary significantly depending on their pre-school education status?

Methodology

The current study employed the survey method, one of the quantitative research methods. Survey studies are studies conducted on larger samples to determine the views of participants on a subject or their skills, interests, abilities, etc. (Büyüköztürk et al., 2017). In the first stage of the study, which consists of two stages, the TechCheck-K instrument was adapted into Turkish. The adaptation process of the TechCheck-K instrument included the following stages: (1) Obtaining permission from the authors to use the TechCheck-K measurement tool (2) translation of the instrument from the original language (English) to the target language (Turkish) by 1 researcher who is specialized in pre-school education and is doing a doctorate in science education, 1 professor and 1 assistant professor doctor from the field of science education, (3) back-translation of the instrument into the original language (English) by an English linguist, (4) reaching a consensus by the researchers on the back-translated instrument and (5) conducting a pilot study with the participation of 10 (6 girls, 4 boys) early childhood children in order to determine whether the visuals in the items in the TechCheck-K instrument whose Turkish language validity was established and the verbal instructions read by the researcher who carried out the application could be correctly understood by the children. The instrument translated into Turkish was administered to Turkish early childhood children and the validity and reliability studies of the instrument were carried out by calculating the item discrimination and item difficulty indices for the items in the instrument. In the second phase of the study, CT skill levels of early childhood children were determined with the TechCheck-K instrument, which was adapted to Turkish, and whether their CT skill levels varied significantly depending on the gender and preschool education status variables was examined.

Participants

The study group of the current research is comprised of 106 (57 girls, 49 boys) Turkish early childhood children. The mean age of the children in the study group is ($\bar{X}$=5.12, sd=0.33) with a minimum age of 5 (N=93) and a maximum age of 6 (N=13). Of the early childhood children in the study group, 53 had not received pre-school education before while 53 had previously received preschool education in any institution (kindergarten, nursery school, etc.). Consent forms were obtained from the parents of all the children participating in the study, stating that they allowed their children to participate in the study, and the children who volunteered to participate in the study were included in the applications.

Research Instruments and Procedures

TechCheck-K

The TechCheck-K instrument was prepared by Relkin and Bers (2021) to determine the CT skills of early childhood children (5-6 years old) and includes questions directed to the six of the seven CT areas expressed as powerful ideas by Bers (2018) (Algorithms, Modularity, Representation, Debugging, Control Structures, Hardware/Software). Any question about Design Process, which is expressed as the seventh powerful idea by Bers (2018) was not included in the measurement tool as it is not suitable for the multiple-choice structure of TechCheck-K. Examples of questions for six CT powerful ideas in the TechCheck-K instrument are given in Appendix-1. TechCheck-K consists of 17 questions, the first 2 of which are practice questions prepared to familiarize children with the TechCheck-K format. The questions contain images to are suitable for illiterate children. In the instrument, there are 3 response options consisting of images for each question.

Data Collection Process

During the data collection phase of the study, the applications were carried out individually by the researchers and the data were collected from each child one by one. The study was carried out following the procedure given below;

1. Having color printing of the questions in the TechCheck-K instrument for each child (3-4 extra printouts for potential technical problems),
2. Obtaining parental consent forms from families so that children could be included in the application,
3. Asking the children if they wanted to participate in the TechCheck-K application and including those who wanted to participate in the application,
4. Meeting the children and making them ready for the application process by communicating with them,
5. Giving each child information on how to mark (circle, cross, draw on, etc.) the questions during the application,
6. Reading each question aloud to each child twice by the researcher and asking the children to guess if they did not answer the question,
7. During the application, giving each child approximately 1 minute for each question and recording the application time for each child during the application,
8. Thanking the children and completing the application.

Data Analysis

In the study, the first two of the 17 questions in the TechCheck-K instrument were not included in the scoring because they were practice questions. Analysis of the questions in the instrument was carried out on the scores obtained from 15 questions. Each correct answer was given 1 point and each wrong answer was given 0 points. The maximum score that children can get from the Turkish version of the TechCheck-K instrument is 15 and the minimum score is 0. In the data analysis phase, the correct and wrong answers given by each child to the questions were scored and tabulated. Each child's gender, pre-school education status and time to complete the TechCheck-K instrument are also included in the table.

Data Analysis related to the Adaptation of TechCheck-K

Within the context of validity and reliability studies of the TechCheck-K instrument, the mean item difficulty and mean item discrimination indices of the items in the instrument were calculated. The analysis of the items in the TechCheck-K instrument was carried out with the Microsoft Excel 2016 tabulation tool. The item difficulty index value in the study was calculated with the following formula;

$P = \frac{N_{\alpha}}{N}$ (Hasançebi et al., 2020). Where,

N_{α}: The number of respondents answering the item correctly

N: The number of the total respondents.

After calculating the item difficulty index of all the items, the mean item difficulty index of the instrument was calculated. The item difficulty index is the rate of correct answers in the group to which the items are administered and this index's having values converging to 0 indicates that the item is difficult while this index's having values converging to 1 indicates that the item is easy (Doğan Gül & Çokluk Bökeoğlu, 2018). Item difficulty is expected to be around .50 in a measurement tool (Büyüköztürk et al., 2017). The item difficulty index values in Table 2 were taken into consideration in the item evaluation based on the item difficulty index.

Table 2. Item difficulty index values are used in item evaluation (Hasançebi et al., 2020)

Item Difficulty Index	Item Evaluation
0.29 and lower	Difficult
0.30-0.49	Moderately Difficult
0.50-0.69	Easy
0.70-1	Very Easy

Item discrimination is generally calculated using three methods;

a) Correlation-based item analysis,
b) Item analysis based on the difference between the means of 27% lower and upper groups,

c) Item analysis is based on the simple linear regression technique (Büyüköztürk et al., 2017).

In the current study, the correlation-based item analysis technique was used to calculate the item discrimination index value of the measurement tool. Correlation-based item analysis is based on the calculation of the correlation coefficient between the score series of each item in the measurement tool and the score series of the scale (Tezbaşaran, 2008). In the current study, after the item discrimination index was calculated for each item, the mean item discrimination index for the instrument was calculated. The item discrimination level reveals to what extent the questions in the measurement tool distinguish the individuals who know and do not know about the measured feature (Saraç, 2018). In the item evaluation based on the item discrimination index, the item discrimination index values in Table 3 were taken into consideration.

Table 3. Item discrimination index values are used in item evaluation (Büyüköztürk et al., 2017)

Item Discrimination Index	Item Evaluation
0.40 and larger	The item is very good
0.30-0.39	The item can be kept on the scale without making any change to it. However, small improvements can be made. A good item.
0.20-0.29	The item is recommended to be improved by making changes to it.
0.19 and lower	The item should be removed from the scale or it should be completely revised.

Data Analysis related to CT Skill Levels

In the current study, in order to determine the CT skill levels of the early childhood children, scores were calculated on basis of the correct and wrong answers given by each child to the items in the TechCheck-K instrument. On the basis of the calculated scores, the mean score values and standard deviation values of the children's CT skill levels were calculated with the Microsoft Excel 2016 program. In order to determine whether the CT skill levels of the children vary significantly depending on the variables of gender and pre-school education status, the independent samples-test was performed and the SPSS 21 program was used for this analysis.

Results

The findings obtained as a result of the analysis of the data collected in the current study are presented in the order specified by the research questions.

Is TechCheck-K a Valid and Reliable Measure of Turkish Early Childhood Children's Computational Thinking Skills?

In the validity and reliability studies carried out for the TechCheck-K instrument, the item difficulty index and item discrimination index values for 15 items in the instrument were calculated. As a result of the analysis performed, the mean item difficulty index of the TechCheck-K instrument was found to be 0.49. In the literature, items with item difficulty index values between 0.39 and 0.49 are considered moderately difficult. It was concluded that the items in the TechCheck-K instrument are moderately difficult. In this connection, it can be said that the instrument includes items with the desired item difficulty in a good measurement tool.

As a result of the item discrimination index calculations for the items in the measurement tool, the mean item discrimination index of the TechCheck-K instrument was found to be 0.32. In the literature, items with values between 0.30 and 0.39 are considered to have good item discrimination indexes. Accordingly, it was concluded that the item discrimination of the items in the TechCheck-K instrument was at a good level. When the results of the study were examined, it was determined that the TechCheck-K instrument, which was adapted to Turkish, had the validity and reliability features required for the evaluation of the CT skills of Turkish early childhood children. Thus, the Turkish version of TechCheck-K was introduced to the literature.

What is the Level of Computational Thinking Skills (TechCheck-K scores) of Children in Early Childhood in the Case of Turkey?

The early childhood children participating in the current study completed the TechCheck-K application with an average of ($\bar{X}$=7.24) minutes. The minimum score obtained by the early childhood children from the TechCheck-K instrument, which was adapted into Turkish, is 1 and the maximum score is 12 out of a total of 15 points. It was concluded that the mean CT skill level of Turkish early childhood children, which was aimed to be measured with the TechCheck-K instrument, is ($\bar{X}$=7.42, sd=2.28). Considering that the maximum score that can be obtained from TechCheck-K is 15 points, it can be said that the CT skill levels of the children are approximately moderate.

Do the Computational Thinking Skills of Early Childhood Children Differ Between Boys and Girls in the Case of Turkey?

The results of the group statistical values obtained from the analysis of the CT skills of Turkish early childhood children according to gender are given in Table 4.

Table 4. Independent samples-t-test analysis for gender

	Gender	N	Mean	Std. Deviation	t	df	p
TechCheck-K scores	Male	49	7.41	2.24	0.029	104	.977
	Female	57	7.42	2.34			

As can be seen in Table 4, the CT skills of the early childhood children do not vary significantly depending on gender t(104)=.029, p>.05 and the mean score is taken from the TechCheck-K instrument adapted to Turkish is ($\bar{X}$=7.42) for the girls and ($\bar{X}$=7.41) for the boys.

In the case of Turkey, do the Early Childhood Children's Computational Thinking Skills Vary Significantly Depending on Their Pre-School Education Status?

The results of the group statistical values obtained by examining the CT skills of the Turkish early childhood children according to their pre-school education status are given in Table 5.

Table 5. Independent samples-test analysis for pre-school education status

	Pre-school education status	N	Mean	Std. Deviation	t	df	p
TechCheck-K scores	Educated	53	7.74	1.98	1.46	104	0.148
	Uneducated	53	7.09	2.52			

When Table 5 is examined, it is seen that the CT skills of the early childhood children do not vary significantly depending on their previous pre-school education status $t(104)=1.46$, $p>.05$ and the mean score obtained from the TechCheck-K instrument adapted to Turkish is ($\bar{X}=7.74$) for the children who have received pre-school education and is ($\bar{X}= 7.09$) for the children who have not received pre-school education.

Discussion & Conclusion

As a result of the analysis carried out for the TechCheck-K instrument, which was adapted to Turkish in order to determine the CT skills of Turkish early childhood children, it was concluded that the instrument is valid and reliable; thus, it can be used to measure CT skills. Since there is no measurement tool developed to measure CT skills in Turkey or adapted to Turkish for Turkish early childhood children and the studies on this field are limited, it can be argued that this instrument is an important contribution to the literature in terms of measuring Turkish early childhood children's CT skills. The mean CT skills score of the early childhood children participating in the current study was found to be as ($\bar{X}=7.42$). In the study carried out by Relkin and Bers (2021), it was aimed to measure the CT skills of early childhood children with the original version of TechCheck-K, and it was concluded that the TechCheck-K mean score of the children participating in the study is ($\bar{X}=8.38$, sd=2.41). The mean CT level scores obtained from the TechCheck-K instrument by the Turkish early childhood children are lower than the ones obtained in the study by Relkin and Bers (2021). This might be since countries such as the USA and the United Kingdom have updated their curricula to include CT from early childhood onwards and have made CT a priority in their learning environments (Bers, 2018; US Department of Education, 2010), that there are no such practices and that children do not encounter activities for CT skills in institutions providing early childhood education in Turkey. This shows the necessity of carrying out activities focused on CT skills with early childhood children.

In the study, it was concluded that the CT skills of early childhood children did not vary significantly depending on gender. Similarly, in the studies conducted by Relkin and Bers (2021) and Relkin, de Ruiter and Bers (2020), the CT skills of early childhood children in the United States were compared according to the gender variable and no statistically significant difference was found between the two groups. In this connection, it can be said that the variable of gender is not an influential factor in the CT skill levels of early childhood children.

It was also found that the CT skills of the Turkish early childhood children did not vary significantly depending on whether they're having taken preschool education or not, but the mean score of the children who had received preschool education ($\overline{X}$=7.74) was found to be slightly higher than the mean score of the children who had not received pre-school education ($\overline{X}$=7.09). This indicates that the school environment is partially influential on CT skills. Considering this situation, it can be said that early childhood children should be directed more towards pre-school education.

Recommendations

In light of the findings of the current study, the following suggestions can be made;

- By using the TechCheck-K instrument, which was adapted into Turkish by the researchers, studies can be carried out on larger samples to determine the CT skills of early childhood children.
- The data collection process can be further enriched by using TechCheck-K in tandem with qualitative data collection tools such as observation, interview or project-based assessments.
- The preschool education program can be revised by adding objectives, specifications, content and practices to improve CT skills.

- Children's CT skills can be compared according to their previous use of technologies such as computers and iPads and their parents' education levels.

Acknowledgments or Notes

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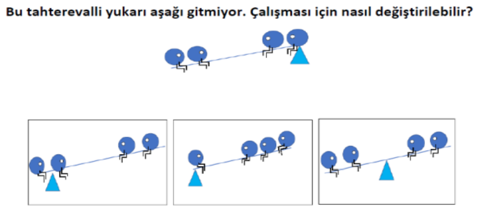
Appendix 1. Sample TechCheck-K Items

Question Example	**Computational Thinking Domain**
	Hardware/Software

	Debugging
	Modularity
	Algorithms
	Representation
	Control Structures