

# STATISTICAL GRAPHS COMPLEXITY AND READING LEVELS: A STUDY WITH PROSPECTIVE TEACHERS

Pedro ARTEAGA<sup>1</sup>, Carolina BATANERO<sup>2</sup>, Jorge MIGUEL CONTRERAS<sup>3</sup>  
y Gladys R. CALDAS<sup>4</sup>

## TITRE

Complexité des graphes statistiques et niveaux de lecture : une étude avec des enseignants

## ABSTRACT

Il s'agit d'une étude de la complexité des graphes statistiques et des niveaux de lecture de 207 enseignants en formation. Les graphes statistiques ont été classés en fonction de leur complexité et les enseignants ont été classés en fonction de leur niveau de lecture. Les résultats montrent que la complexité des graphes statistiques est liée au niveau de lecture des enseignants. Les graphes statistiques les plus complexes sont lus par les enseignants ayant le plus haut niveau de lecture. Les graphes statistiques les moins complexes sont lus par les enseignants ayant le plus bas niveau de lecture. Les résultats de cette étude ont des implications pour la formation des enseignants et pour la recherche sur la complexité des graphes statistiques.

**Keywords:** *statistical graphs, semiotic complexity, graph interpretation and comprehension.*

## RESUME

Da ce a ice, a ac e ce de 207 f e eig a c i e de g a h i e 'a i i e a e c e i e a de e c e g a h i e. Le g a h i e d i d a e a c i da j e a i i e, e e e i g a d c a e i a i e de d i b i c a e a e i e a d i f f e , e f c i de e c e i i i e. De i e e , e i e a i de c e g a h i e de a i c i a c a e e C c i (1989) a e i e a de e c e g a h i e e , e f i , a c c i d a i c i a a e i de e c h e c h e d a e j e e e a i e. Le i e a de c e i i i e d a e g a h i e d i a e f e e i g a e , e g a , a e h a d e a c h e e ; e f i , a c c i c e c e a e i e d a e j e a f e e e e a e i i d' e i g a , a c e e b e a c d' e e e a i e i c a a b e de i e e g a h i e d i a e - e a i e a " i e de i e e d e ". De i e a i e de c e i i i e g a h i e f a i ' i e a i d g a h i e , i e e g a h i e de i e a i i e e e c e d g a e e c e a g e i e de i e a i e a - d e d e e i e e e d e da e a c i de a i c i a . De i e a e de c e i i i e d a e g a h i e g a e e f a i ' a e i e d' e c c i a e i de e c h e . A c e d i f f e c e ' a a b e e e e a i a b e c a e .

**Mots-clés :** *graphiques statistiques, complexité, niveaux de lecture, enseignants.*

<sup>1</sup> Universidad de Granada, arteaga@ugr.es  
<sup>2</sup> Universidad de Granada, bataanero@ugr.es  
<sup>3</sup> Universidad de Granada, jcontreras@ugr.es  
<sup>4</sup> Universidad de Granada, gcaldas@ugr.es

## 1 Introduction

Graphical representation of data is a common feature in many educational contexts. The complexity of these graphs varies significantly, and this complexity can be a barrier to understanding for many students. This study aims to explore the relationship between the complexity of statistical graphs and the reading levels of students. The research is based on a sample of 100 students from a primary school in Beijing. The results show that there is a positive correlation between the complexity of the graphs and the reading levels of the students. This finding has important implications for the design of educational materials and the assessment of student learning.

The study was conducted in a primary school in Beijing. The participants were 100 students, aged between 6 and 12 years. The researchers used a variety of statistical graphs, including bar charts, line graphs, and pie charts. The complexity of these graphs was measured using a set of criteria that included the number of data points, the number of axes, and the use of labels and titles. The reading levels of the students were assessed using a standardized reading test. The results of the study are presented in the following sections.

The first section of the study focuses on the design of the statistical graphs. The researchers identified several key factors that influence the complexity of a graph, such as the number of data points, the number of axes, and the use of labels and titles. These factors were used to create a set of 100 graphs that varied in complexity. The second section of the study focuses on the assessment of the students' reading levels. The researchers used a standardized reading test to measure the students' reading skills. The results of this test were used to categorize the students into different reading levels.

The third section of the study focuses on the analysis of the data. The researchers used a series of statistical tests to examine the relationship between the complexity of the graphs and the reading levels of the students. The results of these tests show that there is a positive correlation between the two variables. This finding suggests that students with higher reading levels are better able to understand and interpret complex statistical graphs. The final section of the study discusses the implications of these findings for the design of educational materials and the assessment of student learning.

The study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study only focused on primary school students, so the results may not apply to other educational contexts. Finally, the study did not control for other factors that may influence the relationship between graph complexity and reading levels.

## 2 Background

### 2.1 Understanding statistical graphs

Statistical graphs are a common way of presenting data. They allow us to see patterns and trends in the data. However, understanding these graphs can be difficult, especially if you are not familiar with the symbols and labels used. This section will explore the different types of statistical graphs and how to interpret them. We will look at bar charts, line graphs, and pie charts. We will also discuss the importance of labels and titles in making a graph easy to understand.

(M... a e (K... d & Higgi..., 2003) g...  
c... ci f... ecific g... a h (Pe... ei a Me... d... a & Me..., 1990; Lee & Me... ei..., 2003;  
Ba... e, Bie... h... e & K... d..., 2004).

O... he a... h... a... a... ed diffe... e... ibe... e... e... i... g... a... h... eadi g... a... d... gge... ed ha... e...  
de... a... a... ha... e... diffic... i... i... e... e... i... g... a... i... ca... g... a... h... .F... h... i... a... i... ca... e... ea... ch...  
e... i... e... he... f... i... g... h... ee... e... e... e... defi... ed b... C... ci (1989) (ee... a... F... ie..., C... ci &  
B... igh..., 2001):

(a) *Reading the data.* Thi... i... he... fi... ee... e... a... ee..., he... e... he... de... f... c... e...  
e... ac... i... g... da... a... f... a... g... a... h... (i.e., ca... i... g... a... a... i... g... i... f... i... ai...). Thi... ee... de... c... i... be...  
he... ca... aci... fa... de... h... i... abe... ead... i... ea... he... li... ec... fa... ci... a... i... f... ai...  
he... g... a... h..., a... e... i... ee... i... ci... ee... i... f... h... i... ch... he... bi... a... e... i... igh...  
he... e... he... g... a... h... .A... ea... e... f... h... i... ee... i... he... de... h... i... abe... ead... he...  
g... a... h... i... e... i... g... ed... a... a... e..., b... i... abe... a... e... e... ffic... ee... i... .

(b) *Reading between the data* i... a... i... e... edia... ee... e... c... ac... e... i... ed b... i... eg... a... i... g...,  
i... e... ei... g..., i... e... a... i... g... a... d... fi... di... g... ea... i... hi... i... he... da... h... i... ee... e... i... e... ha... he...  
de... eadi... g... he... g... a... h... ce... e... hi... he... a... e... i... e... da... a... i... he...  
g... a... h..., a... d... be... abe... a... e... ai... he... da... a...; fe... f... ai... e... a... d... f...  
fi... di... g... ea... i... hi... i... he... da... a... i... g... a... i... e... i... he... de... h... i...  
abe... de... ee... i... e... i... a... h... i... g... a...

(c) *Reading beyond the data* i... a... i... e... edia... ee... e... c... ac... e... i... ed b... i... eg... a... i... g..., i... fe... g...  
ed... i... g... f... he... da... a... i... g... a... h... e...  
e... i... e... a... ed... he... da... a... i... g... i... e... a... ca...  
a... d... i... abe... de... ee... i... e... h... c... i... e... e... ee...  
he... a... i... abe... ee... ee...

I... ee... ea... ch... ea... a... (A... ne...,  
2003; A... a... a..., 2007) ha... ca... i... fied he... de...  
i... he... f... i... g... ca... eg... i... e..., a... i... g... i... acc... he...  
he... i... f... ai... i... a... g... a... h... a... d... ea... e... hi... i... f... ai...  
he... de... c... ec... ead... he... g... a... h..., a... e... abe... i... e...  
ha... i..., ea... a... he... eadi... g... be... d... da... a...):

1. *Rational/literal level.* A... hi... ee... de... a... e... c... i... ca... eadi... g... f... he... i... f... ai... .  
The... c... ec... ead... he... g... a... h... a... da... e... he... ee... i... ed... a... he... eadi... g... be... d... he...  
da... a... ee..., b... a... e... abe... c... i... ci... e... he... i... f... ai... i... he... g... a... h... ide...  
a... e... a... i... ee... a... ai... .F... ea... e..., he... gi... e... a... ca... e... ha... h... a... e... ga... i... e...  
c... ea... i... be... ee... he... bi... h... a... ead... he... i... fe... e... ca... i... i... a... g... f... c... i... e... he... a...  
e... i... he... ea... ch... ea... e... i... ha... he... ee... i... a... ca... a... ea... i... hi... be... ee... b... h...

gge ha he e ce f e a fe  
 e ec a c i highe; a i he e e i a di e  
 be ee he e ce a d e e e

## 2.2 Graphs

O  
 c e e ed i e ice ch  
 eache i e he eache e e ica  
 e e e ai a ed chi d e he ch  
 e b . Re hica c e e c ec i e  
 eache (G

F e a ai , B  
 a d E i e (20 g . I  
 a he d cia  
 (2008) be ei  
 e a ai f a

a e f 218 Ba i a ec i a che gge ed ha fe f he  
 a edge a e f dai e . I B ge  
 i e i e i a h e e gi e each a e f 16 d  
 ca d a d e i ed he e a i e  
 i e ha i e e a  
 ga f he e e abe he  
 c e ge e

I c i e eache a  
 a B ge , a  
 he e e a d e h gh he c e e i e iga  
 Pfa ch (1999) (e e a ch e i , c e c da a, a a  
 e i ). O e e a ch i a ba e d i a he e ica fa e

## 2.3 Theoretical background

Diffe e a h ha e e ha i ed he e i ic a c i i i ed i he d c i a d  
 i e e ai f g a h (e.g., C e e a d, 1987; N , Ba e , H e , & Ke , 2007). Whe  
 e b i d a g a h, e e c d e he i f ai i g d i f f e e e e , ch a g e e ica  
 fig e , c i h e g a h. Whe a d i f f e e e e a d h e g a h, h i i f a i i  
 i a d e d e d i a c e f g a h i c a e c e i (C e e a Acc d i g  
 a h , a g a h i b e e f i f i i a d e d i g c a acc a e  
 efficie

Ba a e , A e a g a a d R i (2010) d e f i n e d a e e f e  
 g a h (d e c i b e d i d e a i i S e c i 4.1) i g e i d e a f  
 a h e a i c e d c a i (e e , f e a e , D i j e , G d i ,  
 G d i , & G a a d , 2012; G d i , B a a e , & F , 2007).

A i i a c c e d i a h e a i c e d c a i , e a i g i a e i i h e e i c  
 a a c h , a d i b a i c a c c e i e d f i a . F i , e a i g i d e f i n e d h g h h e  
*semiotic function*. Acc d i g H j e e (1943) a d E c (1976) a e i c f c i i a

*P. Arteaga et al.*

c e de ce be ee a a ecede (e e i , ig ifie) a d a c e e (c e , ig ified ea i g) e ab i hed b a bjec acc di g a e habi. F e a e, he e e he d edia ee ab i h a c e de ce be ee he e e i edia a d he a he a i ca c ce f edia (ea i g). M e e, acc di g F , G di , a d D A e (2007) a he diffe e e f bjec ha i e e e i a he a i ca acice : be , ced e , c ce , a g age, e ie a d a g e ca be ed a ei he e e i c e i a e i ic f ci . Acc di g he e a h , he e i ic f ci , a d he ce he ea i g, ca be e a i i i a , ia e ic (G di e a ., 2007). I age ee e i h Pei ce e i ic (1978 /1965), he - e i ic a ach a e ha b h he e e i (a ecede fa e i ic f ci ) a d c e (c e e fa e i ic f ci ) a be a e f a he a i ca bjec (f e a e, a defi i i , be , ced e, a g e , a i g i ce e e ).

Sec d, i he e i ca ach, ea i g ca be de di e f e. F hi e ecie he ea i g f he bjec i he e f acice i hich he bjec a a de e i i g e. Acc di g G di e a ., he e de a di g c e e each he, i ce a he a i ca acice i a he a i ca ha a e e a ed b ea f e i ic f ci .

I d e ea e e i- c ed jec de c i bed i he e e ci . T c ee he jec, he a he a i ca be (c a i g hee diffe e ai e f i g e a he a i ca acice . The f c i e ea ch i he a i ca g a h d ced b he eache a d he a he a i ca acice i ed b i di g a d eadi g he e g a h . Whe he eache d ced each g a h he had e f a e ie faci ( ch a decidi g he a i ca e f g a h fi g he ca e), he i i ci ed e c ce ( ch a a i ab e, a e, f e e c , a ge) a d e ie (e.g., e e dic a i ; i ai ) ha a i diffe e g a h . C e e he be a d c e i f e i ic f ci i i ci i b i di g each g a h a . We he e f e h d c ide he diffe e g a h a e i a e e e e ai f he da a di i b i b a diffe e c fig ai fi e e a ed a he a i ca bjec ha i e ac i h ha di i b i .

U i g he ab e idea , i Ba a e , A eaga & R i (2010) e defi ed a e e f e i ic c e i i a i ca g a h , i de ide a i dica f g a h i ca c e e ce. We a be ed ha , a h gh ab hi d f he a i ca i ha e ea ch d ced a g a h i h high e i ic c e i , e hi d f he e e ab e ge a c c i i e a i he e ea ch e i . A c jec e a ha he ecie eache g a h eadi g c e e ce a a d ha hei eadi g e e (i C ci , 1989 a d A a a , 2007 ca e g i ai ) a e a ed hei c e e ce i b i di g he g a h ( ea ed b hei g a h e i ic c e i ).

The ai f hi e ea ch a e e hi c jec e a a i g he e e a a i a i f he a i ca ac i i ed b Ba a e , A eaga a d R i (2010) i a bigge a e f 207 ecie eache . Be e fi de c i be he jec, da a a di c i gi e a i ca ; ec d e ca i f he g a h d ced acc di g hei e i ic c e i ; e he a a e he ecie eache eadi g f he g a h d ced a d ca ified he acc di g he C ci (1989) e e ; e he c b h ca ifica i f g a h d hei i b e a cia i a d d he e ai hi be ee g a h c e i e e a d c c i eached. Fi a e e e a di c i f e a d e i i ca i f eache ed ca i .

### 3 Method

A total of 207 participants (104 females and 103 males) were recruited from a university in the United States. The participants were divided into two groups: a high reading level group (35-40) and a low reading level group (15-20). Each participant completed a reading test to determine their reading level. The high reading level group was defined as those who scored 35 or higher on the reading test, and the low reading level group was defined as those who scored 20 or lower. The participants were then assigned to one of the two groups based on their reading level. The high reading level group was used as the control group, and the low reading level group was used as the experimental group.

#### 3.1 Tasks given to participants

The data were collected from the participants using a computer program. The program presented the participants with a series of statistical graphs and asked them to identify the data presented in each graph. The graphs were designed to be challenging for the low reading level group and easy for the high reading level group. The graphs included bar graphs, line graphs, and pie charts. The participants were given 10 minutes to complete each graph. The data were then collected and analyzed.

1. *Introducing the graphs and carrying out the experiment.* We gave each participant a set of instructions and a list of 10 statistical graphs. The participants were asked to identify the data presented in each graph. The graphs were designed to be challenging for the low reading level group and easy for the high reading level group. The graphs included bar graphs, line graphs, and pie charts. The participants were given 10 minutes to complete each graph. The data were then collected and analyzed.
2. *Collecting data.* Each participant completed a reading test to determine their reading level. The high reading level group was defined as those who scored 35 or higher on the reading test, and the low reading level group was defined as those who scored 20 or lower. The participants were then assigned to one of the two groups based on their reading level. The high reading level group was used as the control group, and the low reading level group was used as the experimental group. Each participant completed a series of 10 statistical graphs. The graphs were designed to be challenging for the low reading level group and easy for the high reading level group. The graphs included bar graphs, line graphs, and pie charts. The participants were given 10 minutes to complete each graph. The data were then collected and analyzed.



each graph... a graph... the average... (A... ). A... he g... ). A... i... a... e... e... he a... i... a... ed he... ge... ac... c... i...

A... a... ab... he... e... i... e... e... a... e... fa... ica... a... fe... e... ed... i... e... ea... ch... di... ec... ed... e... a... ae... e... e... e... ce... i... f... a... d... e... . We... ha... e... ed... ea... ed... a... i... e... ea... ch... i... h... ec... ie... ea... che... ;... f... ea... e... ,... i... Ba... ae... ,... G... di... a... d... R... a... (2004)... e... de... ce... ibe... a... ce... fi... ci... i... babi... i... h... ea... che... ;... a... a... f... he... i... ci... ,... he... ea... che... a... e... gi... e... a... ie... i... h... ic... h... e... e... ce... f... e... ffi... i... g... a... ci... 40... i... e... h... d... be... c... a... ed... de... ce... de... h... ic... h... f... he... e... e... ce... i... a... d... . O... he... a... h... e... e... e... ce... f... diffe... e... gh... a... gi... g... f... 5... e... e... (e.g.,... Che... ff... ,... 2009)... 150... (e.g.,... G... ee... ,... 1983). I... i... e... f... he... e... diffe... e... ce... i... e... gh... e... ,... e... c... ce... i... g... e... e... e... ce... i... f... a... d... e... c... i... cide... ha... he... e... i... a... g... d... e... ce... i... f... he... e... ec... ed... be... f... head... i... he... e... e... ce... a... da... e... ce... i... f... he... i... de... e... de... ce... f... ia... a... d... he... e... gh... f... . I... e... ea... ch... ed... f... c... he... ea... che... e... ce... i... f... a... d... e... (a... h... gh... he... e... ie... e... a... e... e... a... e... hi... i... )... b... i... he... ea... che... ga... h... ic... a... c... ee... ce... bi... da... di... e... ga... h... a... a... a... f... he... i... ai... ica... a... a... e... . A... he... diffe... e... ce... i... ha... i... e... ea... ch... de... ai... g... i... h... e... e... ce... i... f... a... d... e... i... i... he... e... ea... che... h... a... a... e... he... da... a... d... ced... i... he... e... e... i... e... ;... hi... e... i... hi... a... e... he... a... a... i... ca... i... ed... b... he... a... i... ci... a... he... e... e... .

## 4 Results and discussions

O... ce... he... ec... ie... ea... che... i... e... e... ec... ec... ed... ,... e... ef... ed... a... ai... ai... e... a... a... i... f... he... e... e... . A... h... gh... a... a... i... ci... a... a... c... ed... he... a... ai... ic... (i... ia... h... e... ee... ed... i... Tabe... 2)... i... hi... a... e... e... c... ce... ae... i... he... a... a... i... ga... h... d... ced... a... a... a... f... he... i... a... a... e... a... di... he... c... c... i... he... bai... ed... di... ec... he... e... ga... h... .

F... a... a... f... 207... a... i... ci... a... i... he... d... 181... (87.4%... f... a... i... ci... a... ),... 146... (70.5%... 128... (61.8%... )... d... ced... e... ga... h... a... a... e... he... be... f... head... ,... be... f... e... gh... f... he... ge... ,... ee... if... he... i... ci... gi... e... b... he... ec... e... did... e... i... ci... he... c... c... a... ga... h... . The... e... high... e... ce... age... gge... ha... he... ec... ie... ea... che... fe... he... eed... fb... i... di... g... a... h... ea... ch... ,... h... gh... a... a... e... ai... ce... (Wi... d... &... Pfa... ch... ,... 1999)... ei... f... ai... ha... a... a... ai... ab... ei... he... a... da... a... ;... f... e... a... e... ,... fi... di... g... he... de... . The... e... ee... ce... age... a... h... he... ea... ie... diffic... f... he... a... i... ab... e... be... a... a... ed... ,... a... he... be... f... head... a... e... fa... ia... he... ec... ie... ea... che... ha... he... be... f... he... e... gh... f... he... ge... .

### 4.1 Level of semiotic complexity in the graphs produced

The... ga... h... d... ced... b... he... ec... ie... ea... che... ee... fi... ca... i... fied... acc... di... g... hei... e... i... ic... c... ei... a... defi... ed... b... Ba... ae... ,... A... e... ga... ,... a... d... R... i... (2010)... (ee... ea... e... i... Fig... e... 1). I... hi... ca... i... f... i... ca... i... ,... he... high... e... i... ic... c... ei... ee... f... he... ga... h... ,... he... e... c... e... ae... he... a... he... a... i... ca... b... jec... i... i... ci... a... d... he... high... e... i... he... be... fi... ee... ea... ie... .



P. Arteaga et al.

- ce e i ed i i c ci . Be , e b ief de c i b e each f h e e e e .
- L1. Representing only individual results.* E e if ec i e eache e e gi e a c e e da a e ( i h 35-40 a e f each f h e a i a b e ), a f e f h e e e a b e d c e a e e e a i f h e h e da a e . I ead, h e d c e a g a h h e e h e e e e e d e i a e d da a e ; a h e i da a , i h c i d e i g h e i c a a e e . I h e e a e h i F i g e 1 , h e ec i e eache e e e e d h e b e f h e a d a i i h i i d i d a e e i e i g a i e c h a . A h g h h e a i c i a c e c d a h i g a h f h i i a e d da a , a d e d i a e a i g , h e d i d e h e a i c a a i a b e N b e f h e a d h e d i i b i f h e b e f h e a d h e d c i g h e g a h .
  - L2. Representing all the individual values for one or several variables, without forming the distribution.* S e a i c i a d i d f h e f e e c d i b i f h e a i a b e , h e h e e e g i e h e da a e . T h e d i d g h e i i a a e i e i h e h e e a i h e i a e d e e c e . I ead, h e e e e e d h e a e ( a e ) b a i e d b e a c h d e i h e c a i h e d e h e da a e e c e c e d . C e e e h e e i h e c e d h e f e e c f h e d i f f e e a e e i c i e d h e i d e a f d i b i . T h e d e f d a a i h e X - a i a a i f f i c i a , i c e i i d i c a e d h e a b i a d e i h i c h h e d e e e c a e d i h e c a . I h e e a e h i F i g e 1 , h e a i c i a b i a i e g a h f h e g e i h e i a e d e e c e ; h e a i c i a i h i e e b i h i a e i c a b a g a h . N i c e h a h e e g a h d e e i a i e h e a e a g e f h e d i b i , a d h e i i d i f f i c i a i e h e d i b i c e e , a h g h h e g a h h h e da a a i a b i .
  - L3. Producing separate graphs for each distribution.* W h e c a i g a a i f d i b i , e a i c i a d c e d a d i f f e e g a h f e a c h f h e a i a b e . C e e e , h e e ec i e eache e e a b e g f h e da a e h e a i c a a i a b e b e f h e a d i e a c h e e e c e ( e e b e f e g h f h e g e ) a d e e a b e d c e i d i b i ; h e e f e h e e d h e i d e a f f e e c a d d i b i . T h e d e i h e X - a i i h e e g a h ( e e e a e i F i g e 1 ) i h e a a d e i h e e a i e . T e a c h e e f i g g a h i h i e e d c e d a e a e g a h f e a c h a i a b e b e c a e d ; f e h e e d d i f f e c a e i b h g a h a d e e d i f f e e g a h f b h d i b i , a d h e e f e h e c a i a e a f h e .
  - L4. Producing a joint graph for both distributions.* T h i e e c e d h e a i c i a h f e d h e d i b i f h e a i a b e b e c a e d a d e e e e d h e i a j i g a h , h i c h f a c i a e d h e c a i . T h e e g a h e e h e c e , i c e h e g a h d c e h a d e e c a c c a e a d e f g a h e e e b h d i b i . I h e e a e i F i g e 1 h e a i c i a e d c b i e d i e g a h i h a c c a e c a e h e d i b i f h e b e f h e a d i h e e a a d i a e d e e c e .

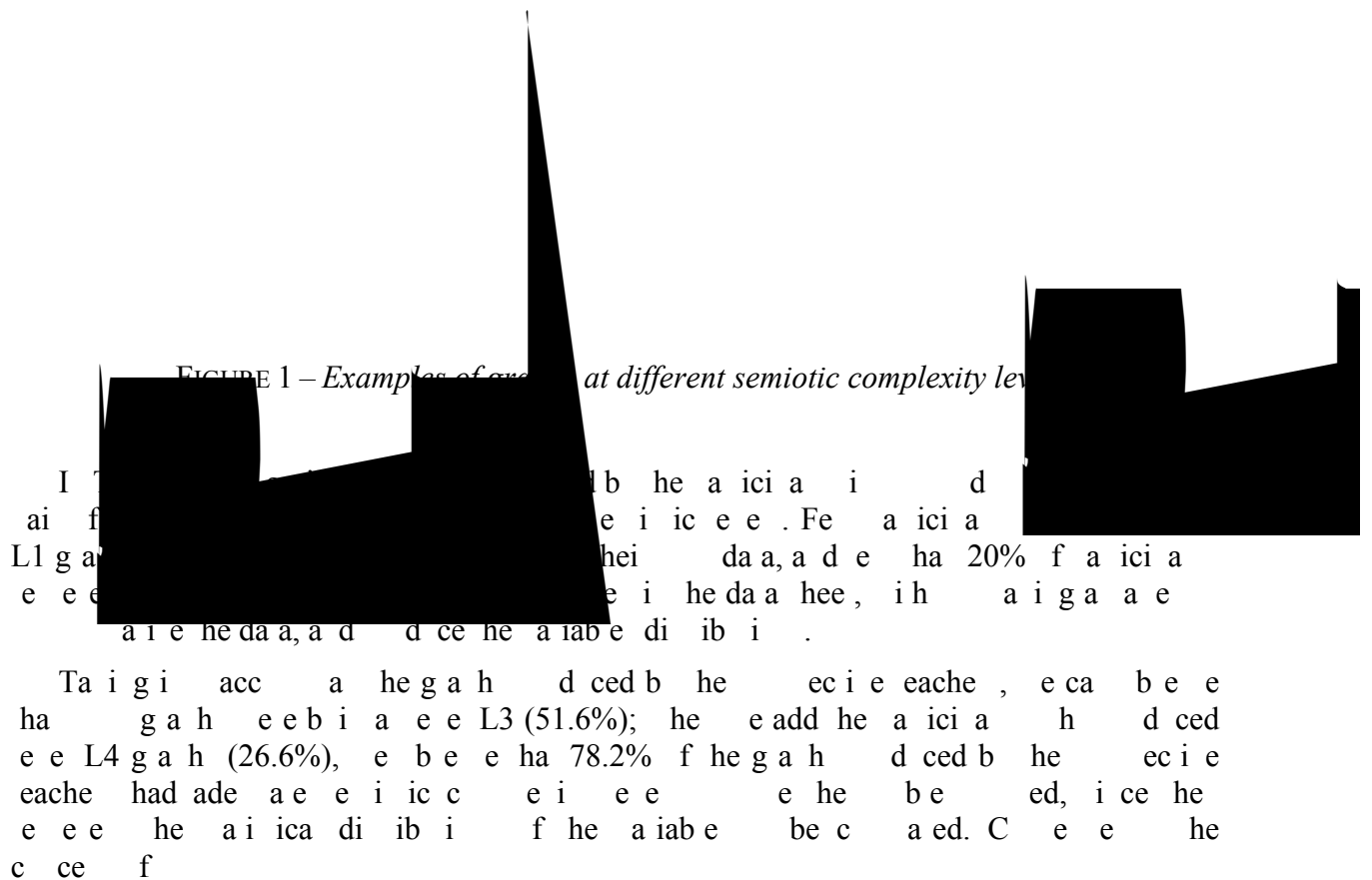
*Statistical graphs complexity and reading levels*

TABLE 3 Frequency (percentage) of participants producing graphs in each semiotic level and pair of variables

	N. f head	N. f	L ge	A a iab e c bi ed
L1. Re e e i g i di id a da a	6 (3.3)	6 (4.1)	3 (2.3)	15 (3.3)
L2. Re e e i g he da a i	40 (22.1)	23 (15.3)	21 (16.4)	84 (18.4)
L3. P d ci g e a a e g a h f each di ib i	91 (50.3)	77 (52.3)	67 (52.3)	235(51.6)
L4. P d ci g a j i b h di ib i	44 (24.3)	37 (28.9)	37 (28.9)	121(26.6)
N be f a i c i a g a h			128	455(100.0)

With the aim of checking the hypothesis that if the frequency of the variables analyzed (number of heads, number of variables, number of degrees of freedom) in the graph is related to the level of the Chi-square test, we calculated a Chi-square test with 3 degrees of freedom, which resulted in a non-significant result ( $p = 0.7339$ ). Consequently, the frequency of the variables analyzed does not depend on the variable analyzed, that is, the frequency of the variables analyzed is not related to the level of the Chi-square test.

## 4.2 Part 2: The interpretation of graphs

In the field of statistics, Cicciardi and Bighi (2001) argued that the interpretation of graphs is not a technical process, but an activity in which a wide range of knowledge, experiences and feelings are mobilized (Meyers & Aiken, 2004, p. 8).

Based on the study by Cicciardi and Bighi (2001), we had read a study by Cicciardi and Bighi (2001) that argued that the interpretation of graphs is not a technical process, but an activity in which a wide range of knowledge, experiences and feelings are mobilized (Meyers & Aiken, 2004, p. 8).

*R0. Not reading the graph or incorrect reading:* Some participants had not read the graph; in addition, some participants had read the graph incorrectly. For example, some participants had read the graph as if it were a bar chart. Based on the study by Cicciardi and Bighi (2001), we had read a study by Cicciardi and Bighi (2001) that argued that the interpretation of graphs is not a technical process, but an activity in which a wide range of knowledge, experiences and feelings are mobilized (Meyers & Aiken, 2004, p. 8).

*Statistical graphs complexity and reading*

he e e f fi di g he i f ai e i ed. O he c  
 he f i ge a e; a h gh he ea i b h di ib  
 g a h d ced b ER) e e c e 10, he e c i e  
 c e e e . C e e e he d e each C ci (1989) *reading between the data* e e  
 (e ac i g e d i he da a) M e e , ER i c e c i he idea f e e e  
 he a da d de ia i , h gh hi i a e f he ea e f ce e.

*"In analyzing the "number of heads" I noticed that the range of the simulated  
 suggest the uniformity of the mean in the real sequence. Moreover b  
 deviations suggest a high representativeness, since both means are close to z*

R1. *Reading the data:* S e a i c i a a d e a c e c i e a e a d i g f g a h a b e  
 a d c a e , b he e e a b e e a d i a e d i f a i i h a i g a g b a  
 i e e a i f h e g a h b e i g a b e i a i e a i e , c h a e a e f c e e  
 e a d . F e a e , h e c a e d i a e d a e f h e a i a b e , i d e d h e  
 f e e c f a g i e a e a d e a g e e a c e a b h e h a e f h e g a h i h  
 c i d e a i f e d e c i e a i a b i i i h e d a a . I h e f i g e a e , i h i c h  
 M L A c e c b i a e i i c c e i L 3 i e c h a , h i c h a a e c e e  
 i e e a i , h i a i c i a a d e a i e a e a d i g f h e f e e c i e a c i a e d e a c h  
 b e f h e a d .

*"The (simulated) graph helps us to see the percentage of students who obtain x heads.  
 These percentages are as follows: 45% students obtain 10 heads, 21.21% obtain 12  
 heads, 15.15% 11 heads, 9.09% 9 heads, and 3.03% 7 heads "* (MLA).

R2. *Reading between the data:* I h i e e , h e a i c i a h e d a d e a e g b a  
 e a d i g f h e g a h ; h e a d e c a i f d e a i h i b e e e d i f f e d a a  
 b e i h i h e g a h . P e c i e e a c h e a h i e e e i h e c a e d a e a g e ( e a ,  
 e d i a d e ) a e i b h d i i b i ( i h c i d e a i f a i a i i h e d a a )  
 e e c a e d e a d ( i h c a i g a e a g e ) . T h i i e a h i g h e e e f  
 d i f f i c i l e , h a e a d i g i a e d f e e c i e . I h e f i g e a e , A G , i e e e a i e  
 g a h ; d e i e h e i e c i e a g a g e , h e c e c e c e i e h e g a h d e c ( i e i e  
 g a h , h e h e g a h i c e a e , h e f e e c a i c e a e ) h e d e  
 d i i b i :

*"In the line graph you can see the differences between  
 sequences: when the line rises, the frequency increases, the  
 corresponds to the variable value whit the highest frequency*

R3. *Reading beyond the data:* T h i e e i e a i g i f e e c e a d d a i g  
 c c i f h e g a h . P e c i e e a c h e a h i e e e f e d e c e e  
 e a d i g f h e g a h h a h e c a i f i e h e a b e e e , a h e e e a b e a a e  
 b h h e e a d a d c e e i h e d i i b i a d c c d e a b h e d i i b i  
 d i f f e e c e , h e e a i g b h e a e , h i c h e e i d e i f i e d f h e i e a d i g f  
 a i c a g a h . I h e f i g e a e R C e a c e d i f a i a b h e d e a d  
 a g e f h e b e f i b h e e c e f h e g a h h e b i . E e i f h e a g a g e



*Statistical graphs complexity and reading levels*

In order to determine the effect of the complexity of the graphs on the reading levels of the students, we conducted an experiment. The results are presented in Figure 2. The data show that the reading levels of the students are significantly affected by the complexity of the graphs. The results are presented in Table 1.

Consequently, the results of the experiment show that the reading levels of the students are significantly affected by the complexity of the graphs. The results are presented in Table 1. The data show that the reading levels of the students are significantly affected by the complexity of the graphs. The results are presented in Table 1.

The Chi-square test results show that the reading levels of the students are significantly affected by the complexity of the graphs. The results are presented in Table 1. The data show that the reading levels of the students are significantly affected by the complexity of the graphs. The results are presented in Table 1.

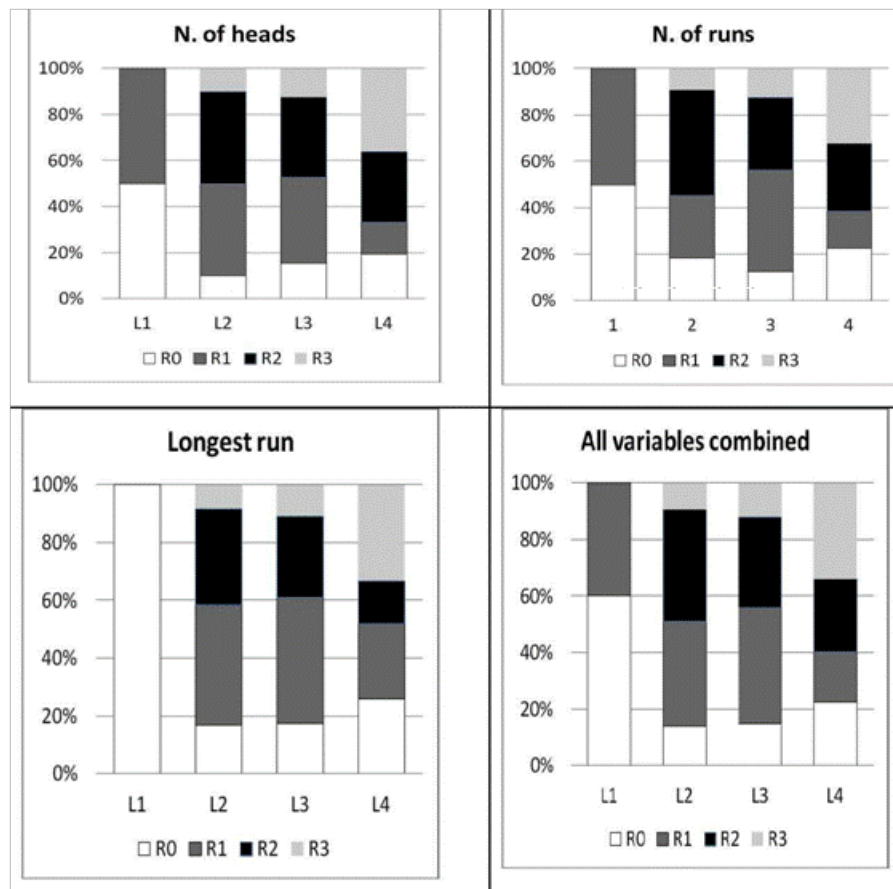


FIGURE 2 – Reading levels by semiotic complexity in the graphs

#### 4.4 Graph production and conclusions reached about the research ques

In the ject ed he a ici a h d h; he e each a c c i ega di g he c ecie i i ecie eache i he d ee abe ge a ef i ga if a i fe e ce ce (R a , 200 hei a i ca a a e he be ed i he The e ecie eache c c ded ha he g h a e age be f head , hi e a he a e i hei e ce i f he a e age be f a d f he a e age e gh f he ge a ea e. I he a e a he e ce i f a iabi i i a he a iabe a i ge ea . A e a ef ac eec c i ab he be f head i gi e be (C ided i ia e e f he he a iabe ):

*“As regards of heads, the in the classroom were very close to what happen in re not complete in the real and simulate sequences are very close; t and me however the standard deviations suggest that the spr and then we failed in perceiving the variability of*

This de i abe ead he g a h a A a a (2007) h he ica e e; i ce, i addi a i g a eadi g f he da a a be d he da a e e i C ci (1989) ca ifica i , he ca ded ce a e a a i f he a a e diffe e ce i he g a h .

O he a ici a eached a a ia c c i , bei g abe a e he a f i i i e a ed ei he he ce a e de c he ead i he a iabe a a ed. I he f i ge a e, TG a ge ab he c ec e fi i i i e ai he a e age be f head , b d ea i e ha hei i i ab he a i a i i :

*“Observing the table, I think that my friends have good intuition; since the most frequent values for the number of heads in the simulated sequence coincide with those in the real sequence; 10 and 11 are the most frequent values in both cases. The means are close to 10 in both sequences; therefore the intuitions are good” (TG).*

The e ai i g de ei he ee abe c c de eached a i c ec c c i . Pa f he c d c ec he e f hei a i ca a a e he de i i i ; ha i , he did ee he i ca i f he e ided b he a i ca a a i he i f he be ed (a e i g he de i i i ). A e a e i gi e be :

*“When I compare the data, I realize that many students coincided in their results. In spite of this, I still think there is mere chance; since in the simulated sequences we invented the results” (EL).*

I Fig e 3 e ca if he a ici a acc di g he c c i eached i he jec a d acc di g he he he d ced a g a h (Fig e 3a) a d acc di g he g a h e i ic ee c ei (Fig e 3b i h e h d ced a g a h). A he diffe e

Statistical graphs complexity and reading levels

a i a b e a e i e d i Fig e 3 b a i a g b a h e i f h e e f f e c f g a h d c i a d g a h c e i e e h e a i f h e c c i .

O a f e a i c i a i h e d e a c h e d h e h h e i c a e e i e a d i g h e g a h , a h e g h e c e c c c i a b h e g ' i i i . T h e e e c i e e a c h e e a i e d h a h e g h a d c e c i i i a b h e a e a g e b e f h e a d b i i i a b h e e a d . S e e g a a c e c c c i ; f e a e , h e a e d h e i i i e e g d b e c a e h e a e a g e f h e b e f h e a d h a d i a a e i h e i a e d a d e a e e c e .

T h e a j i e f e d a a h e a i c a c a i f h e a i a b e b g a i c e c c c i g c c i a b h e i i i i h e c a ( e . g . h e c e c c a e d a e a g e b d i d d e d h a e e h e i c a i i e a i h e d e i i i ) . I f e i e e h e e e a c c d i g h e A a a ( 2 0 0 7 ) e e , e c c d e h a h e a j i f e c i e e a c h e e a d h e d i b i d a a a a i a / i e a e e , i h b e i g a b e e a d h e e f h e i a a i e a a c i c a a h h e i c a e e .

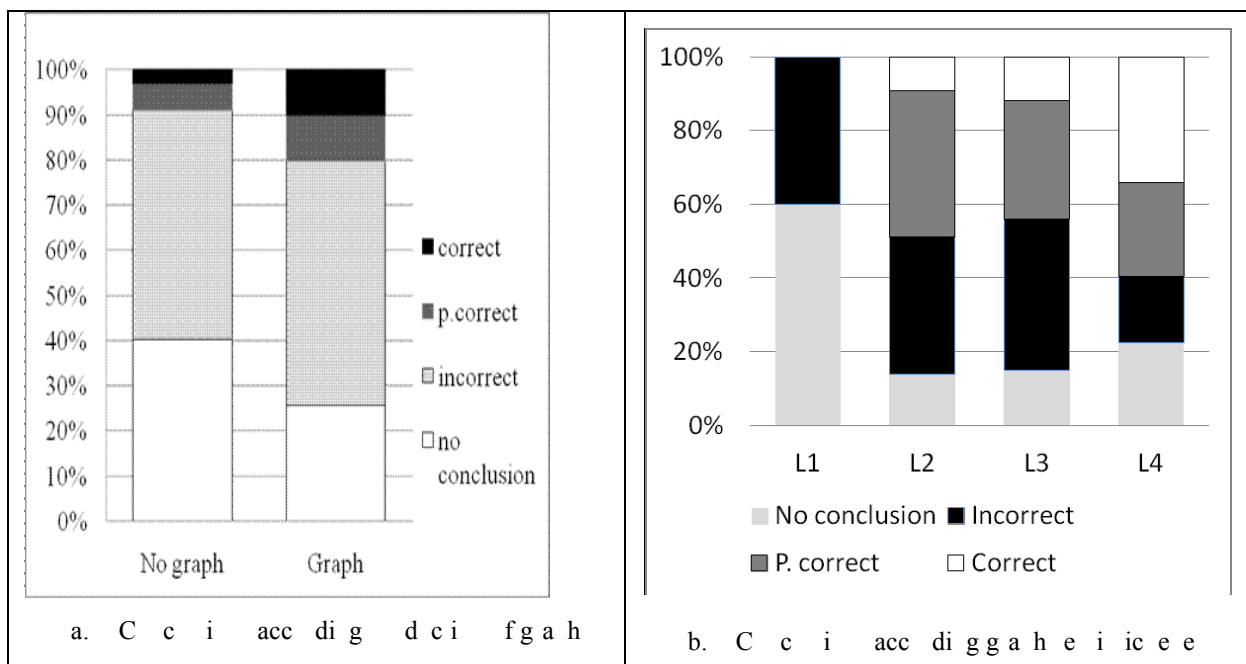


FIGURE 3 Conclusion according to (a) production of graph; (b) graph semiotic level

W h e c a i g h e e a b h e c c i b a i e d i a i c i a d c i g g a h d c i g g a h ( F i g e 3 . a ) e e e h a 3 % f h e e c i e e a c h e b i d i g g a h g a c e e c c i a d 6 % a a c e c c c i . T h e e e c e a g e i c e a e d 9 . 2 % a d 9 . 4 % i h e e a c h e h a d c e d g a h a a f h e i a a e . T h e C h i - a e e d h e a c i a i b e e e g a h d c i a d c e c e f c c i a a i c a i g i f i c a ( C h i = 1 8 , 7 2 , d f = 3 ; = 0 . 0 0 7 ) , h a e c a a c c e h a b i d i g a g a h h e e d h e e a c h e i h e i c c i .

I F i g e 3 b e e e h a h e e c e a g e f c e c c c i i c e a e d 3 4 % i e a c h e d c i g e e L 4 g a h , b e c a e , e h a d , a h a e e h e e a c h e e a d h e g a h a a h i g h e e a d i g e e a d ; h e h e h a d , i L 4 g a h h e e c e i f b h



aga et al.

e de cie a d ead i ea ie . i a highe a  
 e e L2 g a h (39.5%), beca e a h i ibe, b  
 he ece i f e de cie . b h a ia i  
 a d e de c i hi e e a ai ic he he  
 i hei c c i .

The Chi- a e e chec i de e de ce f e f c c i a d he e i ic  
 c e i e e f a he g a h c bi ed a ai ca ig ifica (Chi=40,45; df.= 9;  
 = 0,0000) a d he ef e e ca acce ha he e a iab e a e e a ed a d ha c e e  
 c c i i ea ie ih e e L4 g a h .

I ge e a (Fig e 2), a ici a i e e ed c ec a ia c ec he g a h  
 a ea a he ba ic e e i C ci (1989) ca ifica i ; a f he eached he eadi g  
 i e edia e e e (eadi g be ee he da a), i cea ig hi be ih he g a h  
 c e i . H e e , a i a a f a ici a i he g a h e e 3 a d 4, e e he  
 he eached he eadi g be ee he da a e e , c d achie e a c e e c c i  
 he e ea ch be (Fig e 3).

## 5 Implications for teacher education

I a , e ea ch gge ha b idi a di e eig g a h a e e  
 aci i ie a d c fi a f he diffic ie de cibe b Li a d She (1991) (04)  
 i de a d b B a d E ie (2005); E i (2007); E i e , B cia  
 (2008) i ecie eache . We ag e ih he ea i he ee a ce  
 ecie e eache e e f c e ce i b h di g a di e eig  
 he ca a e a e e e de .

Ma a ici a d i ci g g a h  
 ge a c c i achi g f  
 h d, c e e  
 ai ca g a h .  
 each  
 i e g a h a d g hich ge  
 f ce i i effect e.

P e e a ed e a be a d c e e a  
 de i a d a d He (2011) de ig c  
 de c a a g age a a e e  
 c i de ca a e e i e (i hi e ea e c  
 chec ig he i i a d e a d a a ic  
 he eache i i i ). Thi de c i i ead e  
 i if he i ai (i he e a e, he e gh  
 a d he e i babi i f head a d ai i he c i

Ne , he ec d e f he de ig ce i g  
 h he e i a a he a ca de i cha a e  
 e ibe i he i ia be . The eache a a ed he e i ( ha  
 c ce i he had a d e ) a d he ig h he e ai ca e ( he  
 c a ed he e ai f di ib i : he be f head , be f a d e gh f he  
 ge i b h e e ce a d f he h e ca ). C e e a ici a i

levels

a e b i a d ed ih diffe e ai ica de (each de ch d ced  
a ic a g a h , abe ai ica a ie c a e he e ai f di

The hid a d fi a e c i fi e e i g he a he a ica e  
e e ai , i ch a a ha he d ce e a e he  
A h gh he aj i f a i c i a i e ea ch c ec c eed  
de i g c ce, fe f he e e ca ab a a e he ai ica e he g a  
e e ab ha he i i i f he c a d e e e i e. Tha i, fe f  
he c d de a d ha he ai ica i dica ed ab he i i i he g  
a d he ef e, he e ec i e eache ed c e e he a a f he de i g  
ce .

Da a (1997) gge ha i c e c ce 2 ( he  
a he ai de i g c i i he ea ie de  
H e e a e e a de i g a di  
a he ef e f  
e i he ec i e  
ai ic a e a c ce  
ed ca i

C e e , ec i e eache eed e ai i g i g ih ai ica jec ,  
i ce i g ih jec i da ec e ded i he eachi g f ai ic f i a  
ch e e (NCTM, 2000; MEC, 2006).

**Acknowledgment.** P jec EDU2013-41141-P (Mi i e i de Ec a  
C e i i idad) a dg FQM126 (J a de A da c a).

## Références

- [1] A a a, K. (2007), I e i g a i g a e ach f de i e ai f g a  
*International Electronic Journal of Statistics Education*, 1(1), 1-10. O i e: .iej
- [2] A a a, K., & S e he , M. (2008), e ea ai ica i e  
A J a e e e ec i e, *Mathematics Education Research Journal*, 20(1), 3-22.
- [3] A e Ba a e , e i g a h  
c ai ica M. P a , T.  
R e h e f he E ea  
S d ca i . U f R e . P a d:  
ER e7/CERME7. df
- [4] Ba e dag g i eachi g  
a d ea i g each,
- [5] Ba e , A., Bie h e , e a ab b  
? I G. B i & *International Association  
for Statistical Education Development in Statistics  
Education* ( . 163-173). A c a d: IASE.  
O i e: . a a c a d.ac. / ia e/ b i c a i /.
- [6] Ba a e , C., G di , J. D. & R a, R. (2004), T ai i g eache each b a b i i .  
*Journal of Statistics Education*, 12(1). O i e: . a a . g/ b i c a i /j e/ 12 1.

P. Arteaga et al.

- [7] Ba a e , C., A eaga, P., & R i , B. (2010), S a i c a g a h d c e d b e c i e e a c h e i c a i g d i b i . I V D a d - G e i e , S. S -L a e g e , & F. A a e (Ed.), *Proceedings of the Sixth Congress of the European Society for Research in Mathematics Education*. L : E M E .  
O i e : . i . f / e d i i / e d i i - e e c e / c e e 6 / .
- [8] B , A., & E i e , M. C. (2005), R e a i c a , e c a a g f i c a e a i c a : e d i c e d i a e a a f e e (N e i e , c a e a d a i c a g a a : a d i h e c i e e a c h e ) , *Formación del Profesorado e Investigación en Educación Matemática*, VII, 57-85.
- [9] B , A., & E i e , M. C. (2005), R e a i c a d e a a i f h i g a i e a c h e a i c a g a h i c . *Journal of Research in Science and Technology*, 1(1), 1-10.
- [10] B g e , T. (2009), *Teacher Education in Africa: A Philosophical Perspective*. (Ed.), *Proceedings of the 10th International Conference on Teacher Education in Africa*. T , S h A f r i c a : I e a i a A d i e : . a a c a d . a c . / i a e / b i c a .
- [11] C h a , B., G i a d , J. C., & H e , M. (2008), *Statistics in School Mathematics- Challenges for Teaching and Teacher Education. A Joint ICMI/IASE Study* ( . 85-95-83). N e Y : S i g e .
- [12] C h e f f , E. (2009), *Subjective probabilities derived from the perceived randomness of sequences of outcomes*. Ph.D. O a a : S i F a e U i e i .
- [13] C e e a d , W. S. (1987), R e e a c h i a i c a g a h i c . *Journal of the American Statistical Association*, 82(398), 419-423.
- [14] C c i , F. R. (1989), *Developing graph comprehension*. R e , VA: N.C.T.M.
- [15] D a a , B. (1997), L e e j e d e a d i a i e b a b i i [ T h e b e i g f d e i g i b a b i i ] . I M. H e ( C d.), *Enseigner les probabilités au lycée* ( . 57-59). R e i : C i i I e - I R E M .
- [16] D i j e , P. G d i , J. D., F , V. & T c h e , L. (2013), O e e i d e , e e . A e f e c i e a a i f d e e a i g i h c e a g e b a f i e a a d - e i c e e c i e , *Educational Studies in Mathematics*, 82, 23-49. DOI: 10.1007/ 10649-012-9416-8.
- [17] E c , U. (1979), *Tratado de semiótica general* (G e a e i i c ) . B a c e a : L e .
- [18] E i e , C. (2007), C c c i a a i e d e g f i c e a d i c e a f a c i d e f e e . *Investigación en Educación Matemática*, 11, 99-119.
- [19] E i e , C., B , A., & P a e c i a , I. (2008), S a i c a g a h i h e a i i g f e a c h e . I C. B a a e , G. B i , C. R e a d i g & A. R a (2008), *Proceedings of the Joint ICMI /IASE Study Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education*. M e e , M i c : I C M I & I A S E . C D R O M .
- [20] F , V., G d i , J. D., & G a a d , J. (2012), T h e e e g e c e f b j e c f a h e a i c a a c i c e , *Educational Studies in Mathematics*. I e e , DOI: 10.1007/ 10649-012-9411-0.



Mitsaga et al.

- [35] Mitsaga, M., & ... (2015). The influence of media on mathematics education. *Journal of Mathematics Education*, 48(1), 1-10.
- [36] ... (2010). *Principles and standards for mathematical practice*. Washington, DC: National Academies Press.
- [37] N ... R., Ba ... (2007). *Si ... g g a h a ... ace ... edge. Ed ...*
- [38] Pe ei a-Me ... f ba g a h: S e ... e Third International Conference ... g St ... ica I i e. O i e: ... a.a ...
- [39] R ... a, A ... e: O e a i c i a ... ie, *Statist ...* O i e: h ... c. / e l ...
- [40] Tiefe b c, B. (2007). *of categorical data*. U ...
- [41] Wa ..., J. M. (2006). *La e ce E ba A ...*
- [42] Wid, C., & Pfa ... g i e i i c a e i i . *International Statistic ...*
- [43] W ..., Y. (2004, J ...), de a di g f a i i c a g a h . Pa e e e e d a *10th International Congress on Mathematics Education*. C e h a g e , D e a ...