



Reading Among Students: A Study Using a Modified Version of the Snowball Method

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ABSTRACT

The reading crisis is a real phenomenon of the last few years, the fondness for reading is free falling, and the lack of interest is reflected in the increasingly poor results in the national evaluations of schoolchildren. In the long term, the effects of the lack of reading reflect on the quality of human resources, including the area of cultural intelligence. The Romanian authorities have initiated measures to stimulate reading, but the results are still modest. The research undertaken by us aimed at evaluating the duration of time allocated to reading by students of the 5th-8th grades from a college in Bucharest, for which purpose the snowball method was used after having applied our original development that allows the completion of the research under conditions of quantitative criteria and the evaluation of decision errors. The snowball procedure in its classic version not only has advantages but also numerous inconveniences, of which the most important is the ambiguity regarding the volume of the investigated sample, because the number of interviewees cannot be predetermined, since it is dependent on the researcher's decision to stop the investigation at a given moment or not. The solution proposed by the authors was to develop the sequential Wald test for the case of measurable characteristics, and the results obtained have a deeply original nature and can contribute to a great extent to the improvement of sociological research methods.

Keywords: snowball sampling, sequential sampling, decision risks, network sampling, sequential survey, statistical risks and errors, cultural intelligence

INTRODUCTION

The problem of reading among the youth in Romania is a serious one, because the country ranks last in the EU when it comes to reading: Romanians spend only 5 minutes a day reading; only 16% read books monthly; 35% have never read a book; only 5% go to the library to borrow a book, less than 10% of citizens buy a book a year. Moreover, 16% of students leave school

prematurely, 30-40% of high school graduates do not pass the baccalaureate (high school exit) exam, and about 40% of the population is functionally illiterate (Danileț, 2022).

To encourage reading, the authorities spared no expense in establishing book festivals, such as:

- 14 February, in addition to the International Book Giving Day, is it also the Library Lovers' Day. In the United States, the entire month of February is National Library Month;
- 15 February, National Reading Day, the motto of 2022 in Romania was "Reading together", (Law no. 21/2022);
- 2 April, International Children's Book Day, established in 1967, 2 April is the anniversary of the birth of the writer Hans Christian Andersen, and as from 2012 it is also celebrated in Romania, (IBBY, 2012);
- 23 April, Book Day (Law no. 81/2014), an opportunity to align with the celebration established by UNESCO, 23 April is marking the birth and death of William Shakespeare, the birth of Vladimir Nabokov, Manuel Mejía Vallejo, but also the day Miguel de Cervantes died.
- Starting with the year 2018, the reading Olympiad READING AS A LIFE SKILL-LAV takes place for students from the 5th to the 12th grades (MEN, 2018).

In today's globalized world of artificial intelligence, machine learning, and innovation, cultural intelligence is a critical part of setting yourself apart.

The reading crisis is a real phenomenon of recent years and worries everyone who works in the area of written culture, from authors to publishers. The appetite for reading is free falling, and the lack of interest in books is worryingly observed in the increasingly poor results in the national exams, or PISA tests (Noveanu, 2006). The concept of reading literacy designates the ability to understand and use the forms of written language required by society and valued by the individual and is considered one of the fundamental processes in schooling, as it constitutes the basis of learning all other subjects of study, and the stage is evaluated every five years by PIRLS. The work "Trends of cultural consumption during the pandemic" shows the level of cultural consumption in the period November 2020-April 2021 (Croitoru, 2021). SCHOOL can be an ideal place for reading, as proven by the "Ten minutes of daily reading" initiative (EDICT, 2018). The pandemic period also generated other projects to encourage reading among the youth, such as the project - Relevant curriculum, open education for all (CRED, 2021). All these noteworthy activities aimed at developing the love for reading failed to generate a significant response from students and young people in general. This state is also confirmed by the results of the study conducted by the International Association for the Evaluation of Educational Achievement-IEA 2022 regarding progress in reading (PIRLS, 2001; PIRLS, 2022), publicly released on 16 May 2023, with a five-year periodicity. PIRLS 2022 is the one that collected data including in the context of school interruptions and closures due to COVID-19. In addition to the PIRLS studies (Progress in International Reading Literacy Study), IEA also conducts the TIMSS (Trends in International Mathematics and Science Study) and PISA - (Program for International Student Assessment), (OECD, 2020).

Our study carries out field research of the time allocated to reading by students during the weekend, using a version improved by us of the snowball method.

LITERATURE REVIEW

In addition to the studies of some institutions, as shown in the previous section, the issue of reading and its impact on the youth is also the object of the scientific concerns of numerous researchers, and, in the following, we make a picture of these concerns including the research methods used.

Thus, Whitten et al. (2016) monitor the reading habits of sixty-five high school juniors, between fifteen and seventeen years of age, attending a rural high school, and then draw conclusions about the impact of reading on academic achievement. Better performance in reading tests, a more developed vocabulary and an increased body of knowledge is the conclusion of the study conducted by Pearson UK (2015).

A study by questioning 833 teenagers in the USA between twelve and eighteen years of age about voluntary reading compared to a mandatory reading list was conducted by (Creel, 2015), and also by Johnson & Blair (2003).

Another interesting study (Gambrell et al. 1996) explored the reading motivation of 330 third and fifth grade Maryland students using the Motivation to Read Profile (MRP), the first part of the study consisted of responding to a questionnaire of the Likert scale type, and the second part took place in the form of an interview, on a random sample of 48 respondents. The effects of reading on children's development are vast and the study highlighted the benefits of reading (Collier, 2019). The author considers that teachers and parents are in an excellent position to support reading to become part of children's daily routine. The importance of reading and learning during the summer vacation is examined by Alexander et al. (2007) and highlights, based on a survey, the strongly differentiated results between those students who practiced reading and the rest of the students. An interesting study (Miller, 2009) compares the educational systems in the USA and those in the G-8 Group, through comparable indicators that use as primary sources: Indicators of National Education Systems (INES), those of the Organization for Economic Co-operation and Development (OECD); data from the International Reading Literacy Study (PIRLS). For example, the score for England was 552, significantly above the international average, and the participant with the highest score was Hong Kong with a scaled score of 571, while Morocco was the country with the lowest score, with 310 (Twist, Sizmur, et al. 2012). Pradani (2021) emphasizes the knowledge gained by young people following the practice of daily reading. Reading for pleasure, its importance and its impact on the development of young people, and reading that allows good information about other people, about history and social studies is elaborated by Clark & Rumbold (2006). Cultivating the love for reading and turning occasional readers into lifelong readers is an action, which has shown that reading for pleasure is positively correlated with the reading level and the writing skill (OECD, 2020), the fondness for reading is achieved both at school and outside school (Sanacore, 2002).

Statistical research carried out among children has shown that reading for pleasure is positively correlated with the level of reading and the writing skill, the fondness for reading is achieved both at school and outside of school, favouring the understanding of text and grammar (Cox & Guthrie, 2001), the development of vocabulary, the increase of intellectual skills, but also greater self-confidence. Kirsch (2002), Twist et al. (2003) also develops the topic of children's

reading for pleasure and the development of "love of books" with their consequences for the future of young people.

Adolescents entering the adult world in the 21st century, as Moore et al. (1999) conclude, will read and write more than at any other time in human history. They will need advanced levels of literacy to perform their jobs, manage their households, act as citizens and manage their personal lives.

The literature review was performed in a systematized manner and on the main topics, where the snowball method is most frequently applied.

First, we will review the handling of some Methodological problems of the snowball sampling method, found in Browne (2005) who emphasizes the interpersonal relationships between groups, which helps to make up the sample, and Snijders (1992) carries out a critical review of the sampling possibilities in a synthetically schematized network.

Berg (1988) contributes to the development of the method and Naderifar (2017) develops the chain research procedures.

Goodman (1961) made a scheme of mathematical formalization of the procedure. The work elaborated by Lecy & Beatty (2012) is interesting, who carried out an extensive review of the specific literature from the world scientific literature. Dragan & Isaic-Maniu (2013), as well as Goodman (1961) also make contributions to the development of research methodologies.

Estimating the number and identifying the health problems of the homeless is a topic developed by Fisher (1994). The same important topic for urban agglomerations is approached by D'Onise et al. (2007) to better calibrate the social services of the city administration. Child abuse is another topic covered by the snowball research method, a topic extensively developed by Park (2008), and the ways to reduce this social plague are researched by Ttofi & Farrington (2011). Menesini & Salmivalli (2017) as well as Walton (2005) discuss the prevalence, age and gender differences and the different types of aggression. Identifying the causes and combating bullying was analysed by Hymel & Swearer (2015), Patton et al. (2017), Fullchange & Furlong (2016). The consequences of violence on children are analysed by Moore et al. (2017), who insist on acts of intimation through aggression, as well as on the risk of suicidal behaviours in adolescents. A comparison between the level of aggression in public and private schools in Islamabad-Pakistan is carried out by Najam & Kashif (2018) through field research among 400 students in the 4th and 5th grades. Mishna (2004) organized an investigation in order to find ways to reduce aggression in schools.

More recently, cyberbullying has become a serious problem faced by young people in particular, a problem studied by Dennehy et al. (2020), who continue the research carried out by Vandebosch & Van Cleemput (2008) by organizing focus groups, as well as by Navarro & Serna (2016). The problem of the contradiction between the right to private life and the expansion of the Internet, respectively the rise of Big Data, is placed in the same circle of concern, a topic developed by Hazarika et al. (2018). Migration and human trafficking is the concern of the studies published by Almeida et al. (2006) starting from the insufficient data on migratory flows, where the authors initiate a field research, while Reichel & Morales, (2017), and also

Pastore & Roman (2020) study the migration problem in European countries using both official data and field research. The issue of the health status of migrants is developed by Indatwa (2020). The same snowball method is also used by Dowle (2021) in analysing the „crisis” of European migration from 2015-2016 in four Nordic countries: Denmark, Finland, Norway and Sweden. The research of various economic-social activities and the related risks makes the object of the concerns of the Ameen & Mourshed (2017) team, who follow up through an investigation the consequences of the accelerated development of urbanization and the multiple effects of this process from the point of view of pollution, the reduction of green spaces and carbon emissions. The process of hypertrophic growth of urban tourism is the object of concern of the Zmyślony & Kowalczyk-Anioł (2019) team, and Kraidi & al. (2020) propose themselves to identify the risks from the management of pipeline systems for the transportation of petroleum products. McCarthy & Schurmann (2018) tackle the perception of Australian farmers on the risks associated with organic farming. Shanmugam et al. (2022) conduct a survey on the knowledge of financial risks among the urban population in India. Stjepić et al. (2021) investigate the success in business intelligence systems (BIS), but also the related risks.

Pursuing various other economic issues. The risk to the environment generated by excessive, uncontrolled urbanization ignoring environmental issues is analysed by Raed & Monjur (2017). Kaya et al. (2020) not only analyse the impact, but also the risks generated by the migration of IT infrastructure and applications to the cloud. The snowball method is also used by Rashid & Harif (2020) at major banks in Cairo-Egypt to identify risk factors in lending to SMEs. Sequeira (2022) develops a subject of particular economic interest – the production and marketing of poultry in India and the spread of specific diseases. This topic is also addressed by Salman & Hassan (2020). Cross-border cooperation between Spain and Portugal is developed by González - Gómez & Estrella (2016), respectively (2020), while Peck & Mulvey (2018) study cross-border work between England and Scotland.

Domestic violence (DV) has become a problem in today's society, which is also addressed by Alhabib et al. (2010) by investigating some databases, but also in the field using the snowball method. Ruiz-Pérez et al. (2007) develop the same topic by comparing different methods of carrying out field research. The consequences of violence on the mental health make the object of concern in the case of Hackett (2011), Golding (1999) and Trevillion (2012). The psychological causes of violence are developed by Lucena et al. (2018), as well as by Shah et al. (2012). Among the effects generated by the Covid 19 pandemic, there was no increase in the birth rate as experts expected, but there was an energetic increase in domestic violence (DV), Boserup et al. (2020).

Also related to the pandemic, Debashish & Al-Khalifa (2022) develop the problem in volunteering in the Islamic society of Bahrain in population vaccination actions, while Wang et al. (2021) conduct a literature review regarding the spread of the epidemic in different countries. Stevenson & Wakefield (2021) perform an analysis of group behaviour under the conditions of restrictions on circulation from the pandemic.

Other areas of applicability. Jaisuekul & Teerasukittim (2017) identify the factors that promote the medical and cosmetic tourism in Thailand. Ruban (2017) investigates the limits of the EU's objective of cross border cooperation (CBC), using interview data by applying the snowball

method. Yoshida et al. (2013) monitors consumer behaviour, and the impact of aggressive advertisements on the behaviour of gambling participants is approached by Killick et al. (2020). A study by Khan & Bashir (2020) proposed the transfer of practices from the economic-commercial sector in non-profit activities, through snowball sampling research.

THE METHODOLOGY USED: THE SEQUENTIAL METHOD AND A LIFE STORY LIKE A MOVIE SCRIPT

In the field of classic sociological research, regardless of the type of sampling (single, double, multiple), the sample sizes are fixed, in general, and rarely previously calculated, but rather sized according to the budget of the investigation

The field research carried out by us on the voluntary reading of students was carried out among students from the 5th to 8th grades in a Bucharest neighborhood. The place of the interviews was the gym in the neighborhood, during breaks, when the shifts of students' interchange. We did not choose the library as a space for discussion, because there we would have most likely met only students who were passionate about reading books, or those who had come to solve a project or compulsory assignment, and we followed the distribution of the time allocated to voluntary reading, in general, by all students. The interviewed subjects recommended each other the exchanging and borrowing of books according to their reading preferences. The students were asked to indicate the duration allocated to free reading during the weekend beyond the duration of reading those texts recommended in class. The answers were recorded in a sheet, and the completion of the research involved the application of the recommended algorithm to the practical application, in the form of the modified snowball method.

According to Irving EW. Burr (1976) the so-called sequential analysis is a procedure by which after each sample (interview, measurement, determination, test, etc.) a so-called hypothesis can be accepted, the same hypothesis can be rejected or additional information, another interview, a new test can be requested. Precisely for these reasons, the number of the examined sample is no longer determined and known a priori, but is a random element (N. L. Johnson, 1961). In some cases, this number is very small or, on the contrary, uneconomically large. The state of uncertainty, i.e. when a new additional sample is needed, increases the duration of the research and the costs of the investigation, a situation that is mainly dependent on the homogeneity of the investigated population. This state of uncertainty cannot last forever, as it is necessary to stop the research and make a decision. The theoretical foundation of sequential analysis takes place in the 40s (20th century), independent research in this sense is taking place in Great Britain (George A. Barnard, 1946) and the USA (Wald, A. & Wolfowitz, J. 1948), and the unanimously recognized leader in this field is Abraham WALD (born on 31 October 1902, Cluj, died on 13 December 1950, Nilgiri Mountains, India). Wald was on a conference tour of statistics and econometrics at the invitation of the Indian government, and was giving presentations at various universities, and the death occurred in a plane crash, in the Himalayas, together with his wife Lucile, who had accompanied him in this unfortunate voyage. Wald obtained his baccalaureate in 1921, then attended the courses at the Faculty of Mathematics at King Ferdinand I University - Cluj, graduated in mathematics in 1928, and from 1927 he attended courses at the University of Vienna in parallel, where he received his doctorate in mathematics in 1931 under the guidance of mathematician Karl Menger. The Jewish origin limited his access to positions in the University of Vienna, despite the brilliant results and the support received from the university, a blockage generated by the discrimination practiced

against the Jews by the Austrian regime, in full agreement with the German regime. Wald wrote at that time in German, a series of his works being republished in English translation after the Second World War (for example: „On some systems of equations of mathematical economics” (A.Wald, 1951). In 1938, Hitler annexes Austria to the Third Reich and imposes his purge policy based on political and racial criteria in this new province as well. In this new context, Wald, having Romanian citizenship as well, was able to go to the United States of America, where he obtained a position at Columbia University, the statistics department. Unfortunately, by the Vienna Dictate of 1940, part of Romania's territory is assigned to Hungary, under German pressure, and among the consequences for the Wald family was the fact that some members of Wald's family who were in Cluj, were deported by the Horthy occupiers and ended up tragically in the Auschwitz camp.

Returning to Abraham Wald, upon his arrival in the USA, he worked on the Cowles Commission for econometric research. He conducted research at Columbia University in New York under the leadership of Hotelling. In the 1940s, a Statistical Research Group of Columbia University (known under the abbreviation SRGCU) was established at Columbia University (in New York), which operated under the aegis of the War Department, a group in which scientific personalities such as Milton Friedman, Harold Freeman, W. Allen Wallis and suchlike used to work. Wald was co-opted into this multidisciplinary team, as a consultant on statistical issues, he also had the advantage of very well speaking and reading languages other than English (German, Hungarian, Romanian and French). Among the issues studied within the SRGCU, a large part had military applicability, such as the optimal allocation of resources, the quality of ammunition checked from warehouses, the distribution of artillery hits around a fixed target, methods of comparing the resistance to penetration of different shields, etc. In 1943, Wald presents the results of the activity in a secret technical report that is submitted by the SRGCU to the Defence Research Committee of the War Department. In this document, Wald founded the sequential analysis by statistical methodology, creating a test to validate the hypotheses initially formulated, under conditions of assumed statistical risks.

After the end of the war, in May 1945, the SRGCU receives approval from the War Department to remove the "secret" classification of its reports and documents, and therefore Wald and the entire group of researchers disseminate the results to the international scientific world.

His main results were gathered in his Sequential Analysis monography (Wald Abraham, 1947).

The problem that he was requested by the military experts within the SRGCU research group in the matter of checking the quality of artillery ammunition not in groups at howitzer batteries, but recommending the type of "STEP by STEP", unit by unit testing.

The problem raised within the ammunition testing grounds: how long does such an experiment last? That is, we measure the test results, $x_1, x_2, \dots, x_n, \dots$ but under what conditions (when?) can we stop and still make a decision on the investigated quantity? The problem was rephrased as follows: what is the minimum required number of such observations (samples, measurements, etc.) collected sequentially, so that a decision can be made regarding a certain assumed risk?

- a. to prove that the sequential process ends after a finite number of steps;
- b. to build a quantitative criterion for making a decision after a number of samples.

The sequential procedure involves three decisions after each test/interview/measurement, etc.:

- i. to continue the research;
- ii. to accept the hypothesis advanced initially and to end the research;
- iii. to reject that hypothesis (and automatically to accept the alternative to the first hypothesis) and to end the research.

Since the applications of the new methodology referred to the military field - of immediate interest then (1943) - Wald worked under the "Espionage Act", and all the documents developed by him were coded "secret" and therefore under the prohibition to be published. Wald's team writes a (secret) technical report entitled "Statistical Analysis of Statistical Data: Theory" submitted to the Defence Research Committee of the War Department.

In this document, Wald rigorously substantiated sequential analysis by creating the so-called SPRT (Sequential Probability Ratio Test of the Likelihood Ratio).

After the end of the war – as early as May 1945 the SRGCU group receives approval from the War Department to remove the "secret" classification of its reports and works, so that since then, the results of Wald and the other members of the group begin to become known to the international scientific world - mainly American, published in journals such as: *The Annals of Statistics*, *Journal of the American Statistical Association*, *Industrial Quality Control*, etc.

The fundamental book of the field appeared in 1947 at the John Wiley Publishing House, namely Wald's *Sequential Analysis* (Wald Abraham, 1947). Wald's work includes both his own results and those of specialists - such as those of M.A. Girschick, who developed a method of sequential comparison of two populations, an idea that found applications in product quality and reliability control consisting in the comparison of two lifetimes of two classes of products of the same kind, but of different "brands", a procedure that demonstrated a particular economic importance. Moreover, Wald undertook in his monography short historical research, trying to detect similar concerns, thus, he mentions the „sequential type" of experiments (but intuitively, without substantiation) carried out in Bengal (India) by Prasanta Chandra Mahalanobis (1893 - 1972) regarding agricultural censuses, as well as the theoretical results obtained in certain particular problems of sequential analysis, by G.A. Barnard in 1944, in the United Kingdom.

SYNTHETIC PRESENTATION OF THE SEQUENTIAL TEST

Let's consider a measurable physical quantity X - or in statistical language, a continuous random variable, individualized by the density $f(x; \theta)$, where θ is an unknown parameter (it can also be a vector of parameters) on which we focus our inference. Wald's construction is valid both for discrete random variables, but also for continuous ones, our research follows the time variable, so we will make the test for continuous variables.

So:

$$H_1: \theta = \theta_1 \quad (1)$$

with the alternative:

$$H_2: \theta_1 < \theta_2 \quad (2)$$

Here θ_1 and θ_2 can have various interpretations - for example an average length of time allocated to reading.

If $f(x; \theta_1)$ represents the density of x when H_1 is true and $f(x; \theta_2)$ is the density of x when the hypothesis H_2 is correct. Successive measurements are made on the quantity x (for example, the time durations allocated to reading by interviewed children) $x_1, x_2, x_3 \dots$ and the likelihood functions associated with the two hypotheses are written:

$$P_{1,n} = f(x_1; \theta_1) \cdot f(x_2; \theta_1) \dots f(x_n; \theta_1) \quad (3)$$

Respectively

$$P_{2,n} = f(x_1; \theta_2) \cdot f(x_2; \theta_2) \dots f(x_n; \theta_2) \quad (5)$$

The quantity

$$\xi_n = P_{2,n}/P_{1,n} \quad (6)$$

is called the **likelihood ratio** (term introduced by Sir Ronald A. Fisher 1890 - 1962). The sequential test is constructed in the following way: first, two constants A and B are chosen (depending on the associated risks, α - risk of type I and β -risk of type II, corresponding to the two hypotheses), A and B being both positive and $A > B$.

At every step of the experiment (interview, measurement, examination etc.) the ratio ξ_n is calculated, if:

$$B < \xi_n = P_{2,n}/P_{1,n} < A, \quad (7)$$

then the experiment continues, and a new interview is conducted.

If:

$$\xi_n \geq A, \quad (8)$$

then the process ends by accepting the alternative hypothesis (H_2) and automatically rejecting the null one (H_1).

But if:

$$\xi \leq B, \quad (9)$$

then the experiment ends by accepting H_1 and rejecting H_2 .

Wald (see his 1947 book, p. 44) showed that it is difficult to obtain the exact values of A and B but then the approximations:

$$A \approx (1 - \beta) / \alpha \quad (10)$$

And

$$B \approx \beta / (1 - \alpha) \quad (11)$$

The same Wald (idem op. cit. page 38) makes the following mention:

„For reasons related to the ease of calculations, it is much more convenient to work with the logarithm of the ratio $\xi_n = \mathbf{P}_{2,n}/\mathbf{P}_{1,n}$ than directly with the ratio itself. The reason is that $\lg (\xi_n = \mathbf{P}_{2,n}/\mathbf{P}_{1,n})$ can now be written as a sum of n terms”.

Indeed, we have:

$$\lg \xi_n = \lg \frac{f(x_1; \theta_1)}{f(x_1; \theta_0)} + \lg \frac{f(x_2; \theta_1)}{f(x_2; \theta_0)} + \dots + \lg \frac{f(x_n; \theta_1)}{f(x_n; \theta_0)} \quad (12)$$

and noting:

$$u_i = \lg \frac{f(x_i; \theta_1)}{f(x_i; \theta_0)} \quad , i = 1, 2, \dots, n \quad (13)$$

we can the decision rules (7), (8), (9) as follows:

if:

$$\lg B < \sum u_i < A, \text{ the research continues;} \quad (14)$$

if:

$$\sum u_i \geq \lg A, \text{ hypothesis } H_2 \text{ is accepted and } H_1 \text{ is rejected;} \quad (15)$$

if:

$$\sum u_i \leq \lg B, H_1 \text{ is accepted and } H_2 \text{ is rejected.} \quad (16)$$

In the case of continuous type of variables such as time, the variable followed in our research, many of the function densities are of exponential type and then the application of the natural logarithm leads to obtaining some convenient forms for the u_i , variable, which follows a normal distribution law $N(0; 1)$, with the probability density

$$f_0(u) = \frac{1}{\sqrt{2\pi}} e^{-u^2/2}, \quad (17)$$

so the variable u has the average 0 and the dispersion 1.

The characteristic investigated by us has a lower limit, the time allocated to reading, and using the Laplace function $\Phi(u_i)$, from the known relationship $p_i = 0.5 - \Phi(u_i)$, it becomes particularized in the case of the correctness of the hypothesis $H_1: \mathbf{P} \leq \mathbf{P}_1$ and respectively:

$$u_1 = (m_1 - LI)/\sigma \quad , \quad (18)$$

m_1 – represents the average of the characteristic when $\mathbf{P} \leq \mathbf{P}_1$ and respectively:

$$u_2 = (m_2 - LI)/\sigma \quad (19)$$

when the hypothesis $H_2: \mathbf{P} \geq \mathbf{P}_2$ is correct.

So that the average of the characteristic m_1 – can be written in the form

$$m_1 = LI + u_1 \cdot \sigma \quad (18)$$

respectively

$$m_2 = LI + u_2 \cdot \sigma \quad (19)$$

with m_1 greater than m_2 .

Obviously, the decision regarding the acceptance or rejection of hypothesis H_1 is taken based on the probability ratio $P_{2,n}/P_{1,n}$, and the probabilities are calculated based on the classic model of the normal law. In the hypothesis $H_1: P \leq P_1$, i.e., in the hypothesis that the average of the characteristic X is m_1 , the probability that after n successive samples (interviews) the values: $x_1, x_2, \dots, x_n$ will be obtained is

$$P_{1,n} = \frac{1}{\sigma^n (\sqrt{2\pi})^n} \exp \left(-\frac{\sum_{i=1}^n (x_i - m_1)^2}{2\sigma^2} \right) \quad (20)$$

Similarly, in the case of the hypothesis $H_2: P \geq P_2$ it results that

$$P_{2,n} = \frac{1}{\sigma^n (\sqrt{2\pi})^n} \exp \left(-\frac{\sum_{i=1}^n (x_i - m_2)^2}{2\sigma^2} \right) \quad (21)$$

Since the risks α and β are fixed by the ratio in the form:

$$\frac{P_{2,n}}{P_{1,n}} = \frac{\frac{1}{\sigma^n (\sqrt{2\pi})^n} \exp \left(-\frac{\sum_{i=1}^n (x_i - m_2)^2}{2\sigma^2} \right)}{\frac{1}{\sigma^n (\sqrt{2\pi})^n} \exp \left(-\frac{\sum_{i=1}^n (x_i - m_1)^2}{2\sigma^2} \right)} \quad (22)$$

the 3 decision-making conditions are obtained from the adapted relations (14), (15), and (16).

Using logarithms, the acceptance and rejection numbers are obtained, respectively, by linearizing these expressions

$$\frac{1}{2\sigma^2} \left[\sum_{i=1}^n (x_i - m_1)^2 - \sum_{i=1}^n (x_i - m_2)^2 \right] \leq \ln \frac{\beta}{1-\alpha}, \quad (23)$$

$$\frac{1}{2\sigma^2} \left[\sum_{i=1}^n (x_i - m_1)^2 - \sum_{i=1}^n (x_i - m_2)^2 \right] \geq \ln \frac{1-\beta}{\alpha} \quad (24)$$

These relationships can also be written in the form

$$-\frac{m_1 - m_2}{\sigma^2} \frac{1}{2\sigma^2} \sum_{i=1}^n x_i + \frac{n}{2\sigma^2} (m_1^2 - m_2^2) \leq \ln \frac{\beta}{1-\alpha} \quad (25)$$

$$-\frac{m_1 - m_2}{\sigma^2} \frac{1}{2\sigma^2} \sum_{i=1}^n x_i + \frac{n}{2\sigma^2} (m_1^2 - m_2^2) \leq \ln \frac{1-\beta}{\alpha} \quad (26)$$

The average is estimated based on the data collected successively based on the interviews, $\bar{x} = \sum_{i=1}^n x_i / n$ and therefore its values must be established, for which we accept or not the initially formulated hypothesis. Since these relationships include $\sum_{i=1}^n x_i$, it is more convenient to find the acceptance and rejection conditions for this sum and not for the average, thus obtaining

$$\sum_{i=1}^n x_i \leq \underbrace{\frac{\sigma^2}{m_1 - m_2} \ln \frac{1-\alpha}{\beta}}_{h_1} + \underbrace{\frac{m_1 - m_2}{2}}_k \quad (27)$$

or:

$$\sum_{i=1}^n x_i \leq h_1 + kn \quad (28)$$

Respectively

$$\sum_{i=1}^n x_i \geq \underbrace{\frac{\sigma^2}{m_1 - m_2} \ln \frac{\alpha}{\beta}}_{h_1} + n \underbrace{\frac{m_1 - m_2}{2}}_k \quad (29)$$

that is in the end:

$$\sum_{i=1}^n x_i \geq h_2 + kn \quad (29)$$

So, the *acceptance* and *rejection numbers* are given by the relationships

$$A_n = h_1 + kn \quad (30)$$

$$R_n = h_2 + kn \quad (31)$$

where $n = 1, 2, 3, \dots$ represents the running number of the answers to the interview.

By passing to decimal logarithms, it results that

$$h_1 = 2,3026 \frac{\sigma^2}{m_1 - m_2} \lg \frac{1 - \alpha}{\beta} \quad (32)$$

$$h_2 = 2,3026 \frac{\sigma^2}{m_1 - m_2} \lg \frac{\alpha}{1 - \beta} \quad (33)$$

The observation values, cumulated after each new answer, will be compared with the acceptance and rejection numbers (straight lines).

CASE STUDY AND COMMENTS

The research conducted by us targeted students from the 5th to the 8th grades in a middle school from a Bucharest neighbourhood, the place for taking interviews was the sports complex where, as a rule, physical education classes take place, while avoiding the library, which is supposedly frequented by literature enthusiasts or by students who come as part of school obligations.

The interviews were conducted individually, student by student, the participation was on a voluntary basis. Starting from the assessment of some studies, according to which young people allocate only 5 minutes for daily reading, we proposed ourself a one-hour limit ($x_i = 60^{-5}$ min.) with a tolerance of minus five minutes, time allocated to reading every weekend, with a tolerance of 5 minutes.

The time allocated by each student was recorded, and after each answer the aggregate $\sum_1^n x_i$ was calculated, a value to be compared with the decisional limits A_n respectively R_n .

The statistical parameters of the survey scheme were: the two fractions $P_1 = 0.01$, $P_2 = 0.10$, respectively the risks from testing the hypotheses, type I, $\alpha = 5\%$, respectively type II, $\beta = 10\%$. Therefore, we have to test if, on average, students do not read less than $x_i = 60^{-5}$ minutes, so with less than 1 % of them, below LI=55 minutes, and the risk of rejecting this hypothesis of $\alpha = 0.05$, and to accept the false hypothesis with the probability $\beta = 0.10$. In order to establish the relationships of the acceptance and rejection straight lines, we determine from the tables of the Laplace function, using the relationship $p_i = 0.5 - \Phi(u_i)$, the characteristic being uni-tolerated, the values: $u_\alpha = 1.645$, $u_\beta = 1.285$, $u_{p1} = 2.33$, $u_{p2} = 1.285$. The dispersion of the characteristic x_i , being unknown and having no data from previous researches in the collectivity analysed, we use the procedure recommended by SR ISO 8258+C1(1999), by which the standard deviation σ is one third of the half of the tolerance field, so $\sigma = \frac{\delta}{3}$, where TS=60, TI=55, T=5, $\delta = T/2$, therefore $\sigma = 0.8333$. Using relationships (18) and (19) and the subsequent development, we obtain: $m_1 = 55 + 2.33 * 0.8333 = 56.9416$ respectively: $m_2 = 55 + 1.285 * 0.8333 = 56.0708$, so that $\frac{m_1 + m_2}{2} = 56.5062$, respectively $m_1 - m_2 = 0.8708$, through relationships (30) and (31) the acceptance, respectively rejection straight lines are obtained: $A_n = 2.738 + 56.506 * n$, respectively $R_n = -3.515 + 56.506 * n$, and by giving successive values to $n = 1, 2, 3, \dots$ we obtain the values of the

comparison limits with the cumulative study durations of the interviewed students $\sum_{i=1}^n x_i$. The straight lines can also be represented by graphic means in a chart. For efficiency reasons in the field, the data were organized in the adjacent table (table 1).

We have to mention the fact that the research cannot end prior to researching a minimum number of subjects from the relationship of the acceptance straight line (given by relationship 30):

$$n_{min.} = \frac{h_1}{s} \quad (34)$$

where s represents the slope (s - from „slope“ = slope, in Wald's notation) of the acceptance line, as the intersections of the straight line with the OX axis:

$$s = \frac{\lg \frac{1-p_1}{1-p_2}}{\lg \frac{p_2}{p_1} - \lg \frac{1-p_2}{1-p_1}} = \frac{\lg \frac{0.99}{0.90}}{\lg \frac{0.10}{0.01} - \lg \frac{0.90}{0.99}} = 0.0397 \quad (35)$$

So that relationship (34) leads to the minimum value of interviewed subjects equal to:

$$n_{min.} = \frac{2.738}{0.0397} = 68.88 \cong 69$$

Table 1. Calculation schedule

i – order of the interviews	A_n	R_n	x_i	$\sum_{i=1}^n x_i$
0	1	2	3	4
1	$59.244 \cong 59$	$52.991 \cong 53$	$57.5 \cong 58$	58
2	116	110	63	121
3	172	166	49	170
...	...	...	...	...
78	4410	4404	70	4460

Considering that the data are obtained following an interview, and the students estimate the duration of time allocated to reading in minutes, the excess of precision is useless, which is why both the calculated limits and the recorded data are rounded off to whole numbers.

The first 77 subjects successively declared the durations of time allocated to reading, which, cumulatively fell between A_n and R_n , so that the interviews continued until subject # 78, for which the student's estimated reading time was: $x_{78} = 70$, and by adding to the cumulative duration of the reading time leads to the aggregate $\sum_{i=1}^{78} x_i = 4460$ which exceeds the quantity $R_n = 4404$, so that the initial hypothesis regarding the duration of the reading time below the 60^{-5} minutes is rejected. Therefore, with a probability of 95% we can state that the students in the investigated middle school do not allocate less than 60^{-5} min during weekend to reading.

The stages of the application of the proposed method in the investigation of the duration of reading in students using the snowball method, corrected by the proposal made by us, presumes going through the following steps:

- Selecting the essential characteristic that will be followed in the research;
- Fixing the parameters of the control scheme, respectively P_1 , P_2 , respectively the risks of type I, α , and of type II, β ;
- Performing the preliminary calculations, by establishing the value of the acceptance, respectively rejection numbers, A_n and R_n for a covering number of investigated subjects, where the data can be organized as in table 1;
- The field activity involves conducting interviews and recording each result in column 3 and adding it by cumulating in column 4, the analytical calculations being made before arriving on site, so the field operators only have to apply the research scheme;
- The major advantage of the snowball method in the version proposed by us, brings more precision in the carrying out of the survey, eliminating the subjectivity of ending the investigation, which is at the discretion of the field operator, in the case of the proposed version this criterion is quantitative and computable under the conditions of an assumed statistical risk;
- Conclusively, we can state that the duration of reading exceeds the threshold generally spread in the press, at least in the investigated college.

CONCLUSION

Considering the assumed limits of this endeavor: a relatively small sample under focus, in an urban environment - where it is to be expected a greater appetite for reading -, the rather diffuse approach of the methodology, still the results are promising.

On one side the percentage of students that (still!) read books is, according to our research, a little bigger than the polls estimate.

On the other side there are ways to follow to refocus gradually the younger generations toward reading; the „top to bottom” approach proved to have weak effects-one must begin a sustained campaign to involve the family in the process; in the same time the school should reinforce, by various mechanisms it disposes the necessity to read, as an essential tool to enhance all types of human intelligence, including the cultural intelligence and even the opening to the exact sciences, not to mention the communication abilities - crucial of accessing a better career.

The school may enforce a better degree of literacy through an imposed reading program, through specific evaluation, even establishing barriers of access to higher levels.

Of course, it is understood the fact that, the phenomenon being of major importance for the health of a nation, this paper could be no more than an alarm signal, a start signal, for consistent efforts of corrugated research activities, extended in relevant strata of the society, in order to provide to the authorized institutions a correct diagnose and a path to follow to reverse the negative evolution trend of mass education in this environment of abundant and often manipulative information.

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