

## Issues and challenges of statistical literacy in higher education

Peter Kovacs<sup>1</sup>

<sup>1</sup> Department of Statistics and Demography, Faculty of Economics and Business Administration, University of Szeged, Szeged, HUNGARY  
e-mail: kovacs.peter@eco.u-szeged.hu

### Abstracts

Statistical literacy is very important to describe and understand phenomena in real life. The relevance of statistical literacy is indicated by several definitions and researches which are well established in the statistical literature. A very important question is: what could universities do for statistical literacy? In 2012, the International Statistical Literacy Project set up special workgroups to examine statistical literacy in special target groups. One of them is higher education and research institutes. In fact, this target group comprises two subgroups: the first group consists of students and the other group consists of teachers and researchers.

In the presentation, I review the issues of teaching statistics, the expected outcome concerning society without the required outcomes of the training programs, the expected level of statistical literacy of the non-statistician staff. I examine the expected entrance elements of the students (IT knowledge, mathematical knowledge, statistical knowledge, etc.), the kind of skills and knowledge which have added values to the efficiency of increasing statistical literacy concerning researchers and teachers. These include knowing the students' knowledgebase, special features of Y-Z generation, pedagogic and teaching methods, skills and ability of the teachers, information about the trends of teaching methods and researches, as well as the attitude and the knowledgebase of the teacher. Finally, I suggest activities by which the universities could improve statistical literacy.

Keywords: education, literacy, teaching methods

### 1. Introduction

To understand the happenings of today and our environment, we need a certain extent of statistical literacy, which can include knowledge of basic statistical key figures, understanding concepts describing society (e.g. inflation, unemployment, GDP, etc.), basic information about research methods (from the viewpoint of both use and interpretation), basic information about visualization (about both visualization and interpretation) and the knowledge about data sources and the ability to evaluate the used data sources. However, the required level of these aspects is not consistent in the different studies. According to Gal (2002), statistical literacy is portrayed as the ability to interpret, critically evaluate, and communicate about statistical information and messages. It is argued that statistically literate behavior is predicated on the joint activation of five interrelated knowledge bases (literacy, statistical, mathematical, context, and critical), together with a cluster of supporting dispositions and enabling beliefs. Garfield and Ben-Zvi (2007) claim that statistical literacy involves understanding and using the basic language and tools of statistics: knowing what basic statistical terms mean, understanding the use of simple statistical symbols, and recognizing and being able to interpret different representations of data. Garfield and Ben-Zvi differentiate the concepts of statistical reasoning and statistical thinking from statistical literacy, which forms the basis of the formers.

Statistical reasoning is the way people reason with statistical ideas and make sense of statistical information. Statistical thinking involves a higher order of thinking than statistical reasoning. Statistical literacy, reasoning and thinking are unique areas but

there is some overlap and a type of hierarchy.

Watson and Callingham (2003) also maintain that statistical literacy is a complex hierarchical phenomenon. In one of his studies, he differentiated six levels of statistical literacy: Idiosyncratic, Informal, Inconsistent, Consistent non-critical, Critical, and Critical mathematical.

In my opinion, statistical literacy should be addressed based on the combination of Watson, Callingham, Gal, Garfield and Ben-Zvi's approach. It means that the expected statistical literacy can be understood as several successive levels:

- The 1<sup>st</sup> level refers to the level of general statistical literacy, i.e. the literacy expected from common people, combined with elementary statistical language. This level means that we can read statistics.
- The 2<sup>nd</sup> level is signifies the level of the users of statistics, characterized by a competent attitude.
- The 3<sup>rd</sup> level is the expert professional level.

Since many people links the development of a proper level of statistical literacy to the outcome of education, the question arises about what education, specifically higher education can do to improve statistical literacy. The importance of this question is also indicated by the fact that in 2012 the International Statistical Literacy Project set up special workgroups to examine the statistical literacy in special target groups. One of them was higher education and research institutes.

In case we search the expression of "statistical literacy", Google shows 36 000 results, and Google Scholar finds 2 990 results. Furthermore, if we search the "statistical literacy" and "higher education" expressions, Google finds 9 120, and Google Scholar finds 514 results. Therefore we can find several documents on Internet in this topic.

When we talk about what higher education can do to improve statistical literacy, we mostly think of the improvement of literacy of students in higher education. In addition to this, we actually must consider the improvement of the statistical literacy of teachers and researchers in higher education, and the role of higher education as an external multiplier (similarly to the 3<sup>rd</sup> mission of universities), when it acts in favor of the improvement of external actors' literacy (secondary-school students, population, decision-makers, etc.).

In the followings, I review the problems and challenges emerging in the improvement of the statistical literacy of the three groups (students, non-statistician teachers/researchers, and external actors), then I formulate proposals by which universities can increase the statistical literacy of each group.

## 2. Students

If we intend to improve students' statistical literacy, we must go over several questions simultaneously.

On the one hand, we must know the objective if the training, as well as the training and outcome requirements. In my view, outcome requirements should be divided into two parts: we must handle the outcome requirements required by the training and the outcome requirements expectable in terms of society separately. While in the former case, we can consider the requirements regarding the given training program (for example, we do not necessarily expect the same knowledge of statistical techniques from a law, economics or engineering student), i.e. we refer to statistical literacy not in general but in professional terms; in the latter case we may indicate that a student is also a member of society, thus they need to have a statistical literacy expectable from a citizen by the time of becoming an adult. At the same time, the question emerges about what can be expected as general statistical literacy.

The ideal outcomes of statistical literacy on basic level will be

- the ability of searching for statistical data and the meaning of data,
- usage of statistical databases,
- ability of basic comparison and visualization of data,
- knowledge of the statistical key figures

On intermediate level, the knowledge of research methods and basic ability of research, as well as carrying out small researches are added to this list.

After the statistics courses, we need to save the statistical knowledge. It is a real problem that students do not have to use statistics between the statistics exam and the writing of the dissertation. After the outcome of the course, professional and general statistical literacy level can only be increased successfully in the mid and long term if there is an opportunity to apply statistics in the subsequent phases of the training program.

In addition, it is necessary to develop a positive attitude to statistics in students for maintaining the level of statistical literacy. Psychological and educational researches have proven that a positive attitude results in the application of something more gladly and more frequently; furthermore, according to studies on financial literacy, a positive attitude goes together with higher literacy level (Vaatstra and De Vries, 2007). In terms of statistics, we can interpret this in the following way: if we arouse positive experiences in the students and we make them like statistics, they may have higher statistical literacy further on.

It can also contribute to the success in increasing statistical literacy if we know who we teach: what level of entrance knowledge we can build on, and what characteristics students have. According to Gould's (2010) research, statistical data have different meanings for today's students than for students 5-10 years ago. One of its possible reasons may also be considered as the problem of X-Y, and Z generation. This age group has special characteristic (Wolberg and Pokrywczynski, 2001) and can be efficiently taught with different methods (Nimon, 2007). Based on this, it is practical to gear the teaching methods to the students. For this, however, the results of the international statistical and general teaching methodology researches need to be known. In addition, teachers' further training in teaching methodology can also be necessary. For example, in Hungary, a considerable part of teachers in engineering, law and economic higher education did not study teaching methodology during their earlier studies. Students' learning may be influenced by the quality of the teacher and the program offered. However, teaching and teacher quality do affect study behavior and therefore student achievement (Verhoeven, 2009, Den Brok, et al. , 2004) .

For increasing statistical literacy, we must consider to what extent the teaching material can be applied in practical life, and clarify the role of computers in statistics education in the e-world. It is very important that we teach a statistical way of thinking. We need to teach and use examples from real life. It also means the illustration of the courses and the usage of huge databases from real researches. In this way the students could see the point of statistics more efficiently.

The usage of IT tools is crucial, but, at the same time, our aim is to teach a statistical way of thinking and not a program or platform!

### **3. Teachers/researchers**

Simultaneously with students, it is also necessary to improve the statistical literacy of non-statistician teachers and researchers. According to a research, in psychologist training the choice of chart type (e.g. pie or bar) used for illustration among teachers depended on what illustration technique they were taught previously.

In researches, the choice of applied methods is also influenced by two factors: on the

one hand, which method was earlier taught or known, on the other hand, what analysis methods are presented in professional articles in the given field of analysis.

The models applied in economic analyses and their predictions are often far from reality, and the models did not predict the economic crisis. As a consequence, several authors (Kim et al, 2006) emphasized the shortcoming of the methodology and the necessity of its renewal. However, the blaming related to modeling – aside from one or two cases – should not be addresses to statistics but the analyst him/herself. This is because in the majority of these models, either the theoretical model itself was not perfect, or the applied statistical methodology was misused, as a result of the fact that researcher did not check the application conditions or disregarded them. Consequently, the accurate knowledge of the application conditions of used statistical methods is necessary; furthermore, it would be necessary to broaden the methodological repertoire known by researchers: for instance, by getting familiar with new methods of analysis and adopting approaches used in other research fields.

In the course of teaching, it is important that whichever subject we teach, we need to show the main related data and data sources, as well as to show the students the main data of our country related to the given topic (e.g. extent of national debt) and locate ourselves in international context. Since statistics can properly describe a phenomenon only if its measurable features are managed to be properly grasped, it is necessary to touch upon the relation of the concepts of the given topic and the statistical definitions.

The improvement of statisticians' literacy is also important; however it clearly refers to the improvement of own professional literacy. In terms of general statistical literacy, the development of teaching methodology and learning about new trends need to be emphasized.

#### **4. External persons**

Universities have a so-called third mission, according to which they live in symbiosis with their environment, they help organizing and developing local economy with both researches and consulting. This role also includes that higher education does something for improving the statistical literacy of the external world. Why is it needed? When statisticians say something, publish research results, in several cases people do not understand what we say, and we do not understand what they do not comprehend, i.e. communication is not proper. With its improvement, we can do much for increasing statistical literacy. As for the form of communication, it can happen directly through programs or indirectly through the media and offline teaching through internet portal.

For increasing external actors' statistical literacy, external actors (secondary school, population, media) has to be taught and supported.

Furthermore, it is important that research results are known not only by academic life but integrated into the real world: in economic planning and decision making.

#### **5. Suggestions**

In addition to facing the mentioned problems, higher education can contribute to improving statistical literacy with other tools as well. In what follows, I list some additional suitable tools, indicating the target group.

**Additional tools increasing statistical literacy**

Tools	Target group
Organizing scientific programs and holding conference presentations	Academic sphere and researchers
Building up relationships between universities and research institutes	Academic sphere and researchers
Starting a blog or a Facebook/Twitter site which contains interesting statistical things (mistakes, news, results, small examinations)	Academic sphere and researchers
Developing real huge databases on which we could apply statistical techniques in courses.	Academic sphere and researchers
Organizing and moderating a dispute between universities and research institutes. Developing a recommendation for statistical teaching, and the methodology of statistics teaching	Academic sphere and researchers
Organizing presentations or sets of presentations live or via media.	citizens
Collecting sites, essays, documents on statistical literacy.	Everybody
Organizing presentations or sets of presentations live or via media.	everybody
Organizing presentations or sets of presentations live for young people	secondary school students
Organizing teaching methods training programs and a portal.	Teacher, researchers
Organizing statistical competitions (poster or case study) on national and international levels	university students
We recommend developing a new course called "Everyday Statistics". The aims of this course are to develop statistical literacy and to absorb the view. The course would be independent of the training program.	university students
Involving talented students in research programs	university students
An article series, in which we explain the phenomena of the real world and present them based on data	citizens, media
Holding statistical further trainings	secondary-school teachers, media
Presenting research results	decision makers

**6. Conclusion**

In conclusion, higher education needs to exploit its multiplier role, thus it can do something for the improvement of statistical literacy of its students, teachers and researchers, as well as the external world (population, media, decision-makers, public education, etc.). For this, however, existing problems and challenges must be faced. It can considerably contribute to increasing statistical literacy if we bring statistics closer to people and users.

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