TOOLS FOR FOSTERING AND GUIDING THE STATISTICS TEACHERS' REFLECTION ON THEIR OWN PRACTICE

Juan D. Godino
University of Granada, Spain
jgodino@ugr.es

Teachers need to reflect on their own mathematical practices and on the teaching and learning processes experienced to acquire and adapt their didactical knowledge. Nevertheless, this didactical analysis and reflection requires of the mastering and application of adequate conceptual and methodological tools. In this paper we present a model for the statistical and didactical training of teachers that has resulted from our experience as mathematics educator, and is based on the application of the "onto-semiotic approach" to mathematical knowledge and instruction. We also apply a set of "guidelines for didactical analysis", based on our theoretical framework, to design, implement and assess a teaching and learning process about statistics with a group of student teachers.

INTRODUCTION

In this paper, we describe the model of mathematics and didactic training for teachers that we are experimenting and in which we try to apply the suppositions assumed by the "Onto-semiotic approach to knowledge and instruction" (OSA) (Godino & Batanero, 1998; Godino, Batanero & Roa, 2005; Godino, Batanero & Font, 2007), and the didactic analysis tools derived from this theoretical framework. We will use the design, implementation and assessment of the theme, "Introduction to Statistics", from the "Mathematics and their Didactics" course in the Primary Education teacher training plan in the University of Granada, as the context of reflection.

The training cycle that we describe contemplates a period of study of the block of the corresponding content, in which a specific didactic model that teachers in training can adapt critically to their future teaching, is implemented. They also have another period of didactic study in which they have the opportunity to apply the "analysis and didactic reflection guides" to the experience of study experimented. We will show that the knowledge and the competences involved in the training cycle respond to a model of "statistics (mathematics) and didactic knowledge for teaching" which articulates and extends others from different authors.

Firstly, after justifying our methodological option of investigation of "working from the inside" and trying to connect theory with practice, we present our interpretation of the *guided reflection* within the framework of the field of investigation of the reflexive professional. To follow we analyse the "competences for didactic analysis" and we list some of the statistics (and mathematics) teachers´ specific competences. Then we describe the training cycle proposed for future primary education teachers and the corresponding didactic model.

We finish the work with some final observations on the importance of the analysis of the own study experience, supported by the use of adequate instruments in the training of the statistics teacher. This experience will be the basis to contextualize and systematize the knowledge provided by the didactic research.

COORDINATING THEORY AND PRACTICE IN TEACHER TRAINING

One component of our activity as researchers in Didactics of Mathematics and trainers of mathematics (and statistics) teachers, is the commitment to the Theory of Mathematics Education, a field in which we are contributing a theoretical framework called "Onto-semiotic Approach to knowledge and instruction" (OSA). This theoretical framework tries to articulate different approaches to the research on the teaching and learning of mathematics based on anthropological and semiotic assumptions about mathematics activity and the corresponding study processes, a model which is also applicable for statistics education.

At present we are interested in applying the OSA to teacher training (Godino, Ortiz, Roa & Wilhelmi, in preparation) and to the design, implementation and assessment of our own teaching

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php [© 2010 ISI/IASE]

practice. This is due to the fact that our experience as teacher trainers has led us to assess the importance of teaching them with the same methodology as we try to transmit to them. Since we are in charge of both the mathematics and the didactic training of the future teachers–including a subject on statistics and probability–we have the opportunity to put the theories and didactic models that at all times we consider to be the most appropriate, into practice with our students as a result of the research on teaching and learning. In this way we try to integrate the future teachers training of specific contents with the didactic training by applying the "isomorphism principle", that is, "the idea that the teachers in training should be taught in the same way as they are expected to teach" (Ponte & Chapman, 2008, p. 238).

Likewise, we try to apply the methodological and investigation strategy described by Ball (2000) "working from the inside", that is to use the practice itself as a place to study the teaching and the learning. Furthermore, we share Jaworski and Gellert´s ideas (2003) when they affirm, "We believe it is valuable to consider theory and practice not as distant poles but as reflexively connected elements of knowledgeable activity. Psychological, sociological and educational theory, even if not explicitly empirically grounded, is a human reflection on practice". (p. 832).

In the OSA some socio-cultural-anthropological assumptions are adopted (Bloor, 1983; Wittgenstein, 1953) about mathematics (statistics) and some socio-constructive (Vygotsky, 1934) and interactionist suppositions (Blumer, 1969; Coob & Bauersfeld, 1995) about learning, from which a didactic model for the study of these contents is derived. Operative elements are also being developed to analyse the different dimensions and facets to be taken into account in the teaching and learning processes, that is, the epistemic (institutional meanings) cognitive-affective, (personal meanings), instructional (interactional and mediational) and curricular/ecological dimensions.

It is a question of making the notions of mathematics practise (statistics), epistemic and cognitive configuration, didactic configuration, normative dimension and didactic suitability (Godino et al., 2007), operative, by using the "guides" to recognize mathematics (statistics) objects and processes, didactic interactions, norms and meta-norms that support and restrict the study processes and to assess the didactic suitability of the same. These guides provide tools for analysis and didactic reflection (in the curricular planning phases, implementation in the classroom, learning assessment and didactic suitability) which the teachers' and researchers' educators can apply. These duly adapted guides can be useful for the teacher at any level.

REFLECTION ON THE TEACHING PRACTICE

The value of the reflection on the experience as a means to stimulate learning has been emphasized over many decades. Schön (1983) described the reflection as a "continuous interaction between thought and action" (p.281); and described the "person who is carrying out the teaching practice" as the person who "reflects on the comprehensions which are implicit in the action itself, makes them explicit, criticizes, restructures and applies them in the future action" (p. 50).

In a review of the models about reflection which have been described, Rogers (2001) found a more common definition of reflection as the process which permits the learner to "integrate the comprehension achieved into his own experience in order to enable him to make better choices or carry out better actions in the future in addition to stimulating the overall efficacy". Llinares and Kainer (2006) emphasize that, "Reflective practice offers a view of how student teachers learn about teaching and provide information about changes in their mathematics teaching. Student teachers' reflection is a key component in this view of learning and it is assumed that one learns through reflecting on one's experience" (p. 437).

In recent papers of different fields the concept of "Guided Reflection" has been introduced as an innovative process of investigation in which the person doing the teaching practice is assisted by a guide by using a self-investigation, development and learning process using reflection. This has been done in order to be totally effective. Furthermore, in the teacher training field we find references in which there are reports of research where specific techniques of "guided reflection" are developed and experimented.

In this paper about teacher training we expand the meaning of the expression "guided reflection" to include not only the reflection in the period of induction to the teaching practice in the schools but also in the period of academic education. On the other hand, we think that the reflection on different aspects and moments of the teaching practice have to be carried out by

means of the support not only of the trainer in his role as tutor or supervisor but also "the guide" or help should make reference to a system of indicators or guidelines which attract our attention to critical aspects of the these practice. These guides should provide a structure for the reflection which is understood in a holistic, articulated, guided, critical and cooperative way.

COMPETENCES FOR THE TEACHER´S DIDACTIC ANALYSIS AND REFLECTION

The term competence has penetrated deeply into the discussion on mathematics (statistics) education, above all in the areas of curricular development, teaching practice and assessment, where "teaching by competences" is often spoken about. In this context, competence is the faculty of mobilising a set of cognitive resources (knowledge, abilities, information, etc.) in order to face a family of situations adequately and efficiently.

In other previous papers (Godino, Batanero y Font, 2007) we have attributed the holistic character which the pedagogical/curricular approach attributes to the notion of competence, to the notion of knowledge. From a pragmatic point of view, to know, implies the competent use of the objects which make up knowledge, the ability to relate these objects to each other, that is, to understand and to apply them to the solution to the problems. Likewise, in teacher training research, the expression "mathematics knowledge for teaching" (Ball, Lubienski & Mewborn, 2000), where "knowledge" is also used in the above mentioned holistic sense, has been widely used.

In the Final Report of the Tuning Project (González & Wagenaar, 2003) the competences have been understood as "to know" and "to understand" – theoretical knowledge in an academic field-, "to know how to act" – a practical and operative application to the knowledge of certain situations – and "to know how to be" - values as an integrating part of the way how to perceive others and live in a social context-. The instrumental competences (tools for learning and training) are found in the general competences (or transversal competences) included in the above mentioned report: Analysis and synthesis; Organisation and planning; Basic general knowledge; Basic knowledge of the profession.

The following are included in the systemic competences (skills which give a global vision in order to manage the whole performance): To put the knowledge into practice; Research abilities; Learning ability (learn to learn); Adapting to new situations; Design and project management.

The specific competences are divided into two big groups: those related to the disciplinary education–disciplinary and academic competences (to know)–and professional training-professional competences.

These general and specific competences can be set in the case of the mathematics (statistics) teacher where we can call competence of "analysis, synthesis and didactical action", that is, to analyse the teaching and learning processes, to combine the complex of knowledge provided by Mathematics (Statistics) Education and act adequately in the design, implementation and assessment of the teaching practice itself.

The teacher should have statistics (mathematics) competence, that is, to know and to be able to apply the statistics (mathematics) practice necessary to solve the problems which usually appear in the classroom. However, from the teaching and learning point of view the teacher should also be able to analyse the statistics (mathematics) activity carried out when solving the problems by identifying the objects and meanings involved so as to enrich his/her performance and contribute to the development of his/her professional competences.

One of the key tasks of the teacher is the selection and adaptation of problems - situations that promote the contextualization of the contents, its application and practice. The problems cannot be excessively specific/isolated but should permit the articulation of the different statistics (mathematics) competences and so, have a globalizing nature. However, it is not enough to have "rich situations" but also to advance towards the organisation of didactic configurations and trajectories (Godino, Contreras & Font, 2006) which are adequate from an epistemic, cognitive and instructional point of view. To do this the teachers and the students' potential role, the resources and the interaction patterns in didactic systems must be taken into account.

The organisation and the management of all these resources by the teacher requires the development of competences of analysis of statistics (mathematics) objects and meanings which are included in the teaching to foresee conflicts of meanings and possibilities to institutionalise the

knowledge implied. So, it is therefore necessary to select problems whose solution includes competences from different blocks of disciplinary content (arithmetic, geometry, measurement, stochastic, algebraic reasoning), other curricular areas (science and the society) and in a special way which promote the articulation between the competences on the specific content and its didactics.

TRAINING CYCLE ON STATISTICS AND ITS DIDACTICS

The development of the competences mentioned is a complex challenge for the teacher trainers due to the diversity of dimensions and components to be taken into account, particularly the students own knowledge of the statistics content.

To follow, we describe a *training cycle* that we are trying out in the training of future teachers which includes the following types of situations–problems and phases:

1. Problem solving in accordance with a social – constructive – interactive didactic model and in particular problems which in the past took part in the creation of mathematics (statistics) knowledge.
2. Epistemic-cognitive reflection on objects and meaning included in problem solving, including items and responses in assessment tests.
3. Analysis of class interactions, orientated towards the recognition of acts and meaning processes.
4. Analysis of teaching resources, including the curricular orientation, textbooks and manipulative and technological material.
5. Analysis of the system of norms which condition and support the study and learning activity.
6. Evaluation of the didactic suitability of processes of mathematics (statistics) study.

In these situations a didactic trajectory which contemplates the following phases or moments is implemented:

- Presentation of the instructions
- Personal exploration
- Cooperative team work to elaborate a shared reply.
- Presentation and discussion
- Institutionalization for the trainer, explaining the knowledge intended.
- Personal study of documents of papers selected, supported by individual and group sessions.

In an extended version of this paper (Godino & Batanero, 2009) we present an example of the training cycle mentioned based on the design and implementation of a subject on “stochastics” for future primary education teachers. We also use this example to describe the “Didactic Analysis Guides” which make the suppositions and the theoretical notions of the OSA, operative. Figure 1 summarizes the types of analysis that the statistics (mathematics) teacher should be able to carry out. The afore mentioned “Guides” are described in the extended version of this paper at http://www.ugr.es/local/batanero/.

The set of guides indicate a reflection cycle which should begin with the reconstruction of a reference meaning by consulting textbooks, experiences and previous research. This study will provide a bank of activities and a description of the teaching practice (operational and discursive) entailed when carrying out these activities which are relative to the context to which the planning is orientated. The analysis of “mathematics (statistics) in action” which we propose should be an instrumental competence of the teacher by enabling him/her to recognise the complexity of the objects and meanings involved in the mathematics (statistics) activities, to foresee potential conflicts, and to adapt them to the abilities of his/her students and the learning objectives.

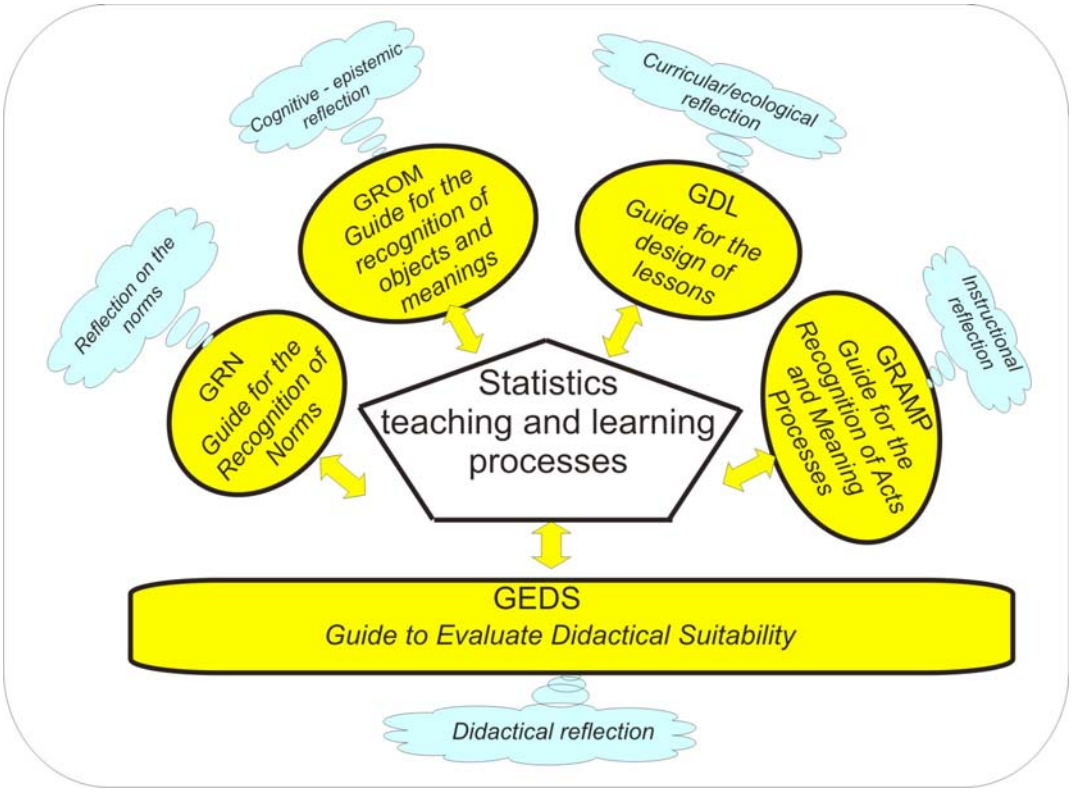

Figure 1. Didactic training based on guided reflection

The training model described agrees with and develops the two primary objectives for teacher training proposed by Hiebert, Morris and Glass (2003). The first refers to the fact that the teacher "becomes mathematically proficient", where mathematics "proficiency" is interpreted as the simultaneous and integrated acquisition of five types of competences: conceptual comprehension, procedural fluidity, strategic competence, adaptive reasoning and productive aptitude (Kilpatrick, Swafford & Findell, 2001). The second objective is focused on preparing the teacher to prepare his own students to reach proficiency. The "analysis and didactic reflection guides", proposed, make up a system of tools for teachers to learn to learn from their own experience, both in the initial training phase and in the permanent one.

ACKNOWLEDGEMENTS

Paper carried out in the research project, SEJ2007-60110/EDUC. MEC-FEDER.

REFERENCES

Ball, D. (2000). Working on the inside: Using one's own practice as a site for studying teaching and learning. In A. E. Kelly & R. A. Lesh, (Eds.), *Hadbook of Research Design Mathematics and Science Education* (pp. 365-402). London: Lawrence Erlbaum.

Ball, D., Lubienski, S. T., & Mewborn, D. S. (2000). Research on teaching mathematics: The unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of Research on Teaching* (pp. 433-456). Washington, D.C: American Educational Research Association.

Bloor, D. (1983). *Wittgenstein. A social theory of knowledge*. London: The Macmillan Press.

Blumer, H. (1969). *Symbolic interactionism: Perspective and method.* Englewood Cliffs, NJ.: Prentice-Hall.

Cobb, P., & Bauersfeld, H. (Eds.) (1995). *The emergence of mathematical meaning: Interaction in classroom cultures*. Hillsdale, N.Y.: Lawrence Erlbaum A. P.

Godino, J. D., & Batanero, C. (1998). Clarifying the meaning of mathematical objects as a priority area of research in mathematics education. In A. Sierpinska & J. Kilpatrick (Eds.),

Mathematics Education as a Research Domain: A Search for Identity (pp. 177-195). Dordrecht: Kluwer, A. P.

Godino, J. D., & Batanero, C. (2009). Formación de profesores de matemáticas basada en la *reflexión guiada* sobre la práctica. In, L. Serrano (Ed.), *Tendencias actuales en la investigación en Educación Estocástica* (p. 9-34) Melilla: Universidad de Granada, Facultad de Educación y Humanidades. Online: http://www.ugr.es/local/batanero/.

Godino, J. D., Batanero, C., & Font, V. (2007). The onto-semiotic approach to research in mathematics education. *ZDM. The International Journal on Mathematics Education, 39*(1-2): 127-135.

Godino, J. D., Batanero, C., & Roa, R. (2005). An onto-semiotic analysis of combinatorial problems and the solving processes by university students. *Educational Studies in Mathematics, 60*(1), 3-36.

Godino, J. D., Contreras, A., & Font, V. (2006). Análisis de procesos de instrucción basado en el enfoque ontológico-semiótico de la cognición matemática. *Recherches en Didactiques des Mathematiques, 26*(1), 39-88.

Godino, J. D., Ortiz, J., Roa, R., & Wilhelmi, M. R. (In preparation). Models for statistical pedagogical knowledge. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching Statistics in School Mathematics. A Joint ICMI and IASE Study.* New York: Springer.

González, J., & Wagenaar, R. (2003). *Tuning educational structures in Europe. Final Report. Phase one*. Bilbao: Universidad de Deusto. Online: http://europa.eu.int/comm/education/policies/educ/tuning/tuning_es.html

Hiebert, J., Morris, A. K., & Glass, B. (2003). Learning to learn to teach: An "experiment" model for teaching and teacher preparation in mathematics. *Journal of Mathematics Teacher Education, 6*, 201-222.

Jaworski, B., & Gellert, U. (2003). Educating new mathematics teachers: Integrating theory and practice, and the roles of practicing. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick & F. K. S. Leung (Eds.), *Second International Handbook of Mathematics Education* (pp. 829-875). Dordrecht: Kluwer Academic Publishers.

Kilpatrick, J., Swafford, J., & Findell, B. (2001) (Eds.), *Adding it up: Helping children learn mathematics.* Mathematics Learning Study Committee, National Research Council.

Llinares, S., & Krainer, K. (2006). Mathematics (students) teachers and teacher educators as learners. In A. Gutiérrez y P. Boero (Eds), *Handbook of Research on the Psychology of Mathematics Education: Past, Present and Future* (pp. 429-459). Rotterdan: Sense Publishers.

Ponte, J. P., & Chapman, O. (2008). Preservice Mathematics Teachers' Knowledge and development. In L. English (Ed.), *Handbook of International Research in Mathematics Education* (pp. 225- 236). New York, NY: Routledge.

Rogers, R. (2001). Reflection in higher education: A concept analysis. *Innovative Higher Education, 26*, 37–57.

Schön, D. (1983).*The reflective practitioner: How professionals think in action.* New York, NY: Basic Books

Vygotsky, L. (1962). *Thought and language*. Cambridge, MA.: MIT Press.

Wittgenstein, L. (1953). *Philosophical investigations*. New York: The MacMillan Company.