Using Data Visualization Techniques to Assess Perception of Professionalism, Professional Identity and Development: A Case Study on Closed-Type Questionnaires

Vasiliki S. Fotopoulou 1 *
Dr., PhD.
E-mail: vfotopoulou@upatras.gr
https://orcid.org/0000-0002-6910-6351

Spiros D. Fotopoulos 2
Professor Emeritus
E-mail: fotopoul@upatras.gr

1 Laboratory Teaching Staff, DESECE, University of Patras (Greece)
GR-26504 Rion, Greece

2 Department of Physics, University of Patras (Greece)
GR-26504 Rion, Greece

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Corresponding author
ABSTRACT

Introduction. Professional identity, professionalism, and professional development are concepts that attract research interest over the years. The concepts are complex, multi-faceted, evolving over time, and varying depending on the pre-primary teachers’ (i.e., preschool educators’) and primary school teachers’ context. The conceptualization by teachers themselves is of particular interest.

Goal. Explore the use of artificial intelligence techniques and specifically dimensionality reduction methods, in analyzing in-service teachers’ perceptions of the three concepts as captured in closed-type questions with Likert-scale responses.

Methods of the Research. Model Likert-scale responses of closed-type questionnaire as multi-dimensional question space. Apply dimensionality reduction techniques to visualize responses in two dimensions. Translate back question distances into theoretical concepts and identify unexplored topics.

Results. The dimensionality reduction disclosed novel correlations between the concepts and their components, not previously reported in published literature, where classical statistical analysis was employed.

Conclusions. We confirm the applicability and usefulness of the dimensionality reduction method for the analysis of human responses in closed-type questionnaires. Further, we identify through dimensionality reduction two novel research questions that should be further studied in the future.

Key words: professional identity, professionalism, professional development, dimensionality reduction.

Introduction and Theoretical Background

The research interest in the conceptual approach and study of the professional development of pre-primary and primary education teachers dates back to the 1980s, where several formal or informal professional development processes were identified with reference to teachers (Campbell, 2003; Collinson & Ono, 2001; Day, 2001). Any effort at the level of educational policy that seeks to improve school education focuses on the professional development of teachers (Guskey, 2002). The enhancement of the professional development of teachers acts as a springboard that mobilizes and helps in the implementation of changes and renewal within the school framework (Campbell, 2003; Tang & Choi, 2009).

In an attempt to conceptually define the professional development of teachers, we refer to T. Guskey (2000: 16), who defines in his book “Evaluating Professional Development”, the concept of professional
development, associating it with issues of improving student learning. Specifically, professional development is defined as those activities and processes aimed at enhancing the professional knowledge, behavior, and skills of teachers, enabling them to contribute to and improve student learning.

In connection with the professional development of educators, exists also the concept of professionalism. The conceptual approach to professionalism is an extremely complex process, as various factors intervene and influence it. Freidson (2001: 12) defines the concept as follows: “Professionalism can be considered to exist when an organized profession gains the power to determine who meets the conditions to perform a specified set of tasks, to preempt and prevent all others from performing the same work, and to control the criteria by which performance will be evaluated”.

According to Furlong et al. (2000) and Leaton-Gray & Whitty (2010), three interdependent factors play a significant role in describing and composing the professionalism of educators:

1. Professional knowledge, which pertains to the knowledge utilized in the teaching context.
2. The responsible attitude of educators towards the improvement and progress of students.
3. The autonomy of the educators, through which they gain the ability to organize their work effectively.

The extension of collaboration also plays a crucial role in determining the professionalism of educators (Day, 2001; Karousiou et al., 2022). Collaboration within the school context extends to include parents, students, and individuals or groups associated with educational matters (Fotopoulou & Ifanti, 2022).

Similar conceptual challenges are identified in approaching professional identity. Several researchers conceptualize professional identity as an ongoing process, where individual self-perceptions and others’ perceptions play a significant role, concurrently shaping, making sense of, and redefining identity through personal experiences (Beijaard, 1995; Day, 2002; Flores & Day, 2006; Fotopoulou, 2020, 2023; Kerby, 1991). The formation of educators’ identity, although mentioned within the school context, is not exclusively shaped within it. On the contrary, it encompasses both professional and personal elements and characteristics of individuals (Day, 2002; A. Hargreaves, 1994;
Nias, 1989, 1996; van den Berg, 2002). Additionally, the contribution of emotions, which are part of educators’ daily school life, emerges as crucial in its formation (Day et al., 2006; Nias, 1996; Zembylas, 2003).

It is evident that all three concepts (professional development, professionalism, and professional identity) are complex and multifaceted. The individuals' contribution, perceiving and interpreting them differently, is crucial, influenced by the context in which they are embedded. In turn, this contributes to the feedback and even the redefinition of these concepts at a theoretical and research level.

Ifanti and Fotopoulou (2010, 2011) conducted a study on the perceptions of pre-primary (pre-school) and primary school education teachers in the prefecture of Achaia, Region of Western Greece, Greece regarding three concepts through a closed-type questionnaire with 26 questions. The primary information gathered from the completed questionnaires were analyzed using classical statistical methods, leading to the aforementioned published research findings.

The usual practice of analyzing similar data using standard statistical tools yields significant results and conclusions. **The aim of this paper** is to explore the applicability of additional analysis methods to derive novel results.

The **research question** is formulated as follows: Can artificial intelligence techniques and dimensionality reduction methods for visualizing the answer space in two dimensions in particular, enrich the analysis and broaden the research findings?

The structure of the paper is as follows: Section 2 describes the questionnaire used as a research tool and the approach to visualization (dimensionality reduction) for the collected data. Subsequently, Section 3 presents the results of applying the visualization method, while Section 4 focuses on the analysis of the findings and discussion. Finally, Section 5 addresses general conclusions and future research directions.

**Procedure and Methods**

This study is based on the responses of educators to questions, as specified in the following studies: Ifanti and Fotopoulou (2010, 2011), Fotopoulou (2013). Table 1 presents the 26 questions that the n=342 participants in the research answered on a four-point Likert scale.
The questions were organized into four sections (groups of questions) concerning the views of educators in the sample regarding the concepts and parameters that shape them.

Table 1

<table>
<thead>
<tr>
<th>Question Group</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 Questions related to the professionalism of educators</td>
<td>1. The educator contributing to the development of ethical and social values of students</td>
</tr>
<tr>
<td></td>
<td>2. Professional knowledge.</td>
</tr>
<tr>
<td></td>
<td>3. The extent to which the educator is allowed to implement appropriate teaching methods</td>
</tr>
<tr>
<td></td>
<td>4. Collaboration with colleagues, parents, students</td>
</tr>
<tr>
<td></td>
<td>5. Pedagogical interest and concern for the student and their progress</td>
</tr>
<tr>
<td>Q2 Questions related to the professional development of educators</td>
<td>6. The need for continuous education and training</td>
</tr>
<tr>
<td></td>
<td>7. Participation and/or attendance of scientific events (e.g., conferences, workshops).</td>
</tr>
<tr>
<td></td>
<td>8. Collaboration with colleagues</td>
</tr>
<tr>
<td></td>
<td>10. Personal research and study on education-related topics.</td>
</tr>
<tr>
<td>Q3 Dealing/Managing challenges/issues in the school context by educators</td>
<td>11. Turning to colleagues to discuss the problem</td>
</tr>
<tr>
<td></td>
<td>12. Contacting individuals in the broader school environment that are perceived to be related to the issue (e.g., parents).</td>
</tr>
<tr>
<td></td>
<td>13. Referring to other sources of information (e.g., printed material, internet).</td>
</tr>
<tr>
<td></td>
<td>14. Relying on personal and professional experience.</td>
</tr>
<tr>
<td></td>
<td>15. Reporting the relevant issue to the school administration or other education officials (e.g., School Counselor).</td>
</tr>
<tr>
<td></td>
<td>16. Approaching individuals directly related to the issue (e.g., students).</td>
</tr>
<tr>
<td>Q4 Conditions of your workplace, how much do they affect you?</td>
<td>17. Changes in education.</td>
</tr>
<tr>
<td></td>
<td>18. Enhancement of students’ learning skills.</td>
</tr>
<tr>
<td></td>
<td>20. The number of children in the class.</td>
</tr>
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<td></td>
<td>21. Administration of the school unit.</td>
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<td></td>
<td>22. Collaboration with colleagues.</td>
</tr>
<tr>
<td></td>
<td>23. Collaboration with parents.</td>
</tr>
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<td></td>
<td>25. Improvement of relationships with students.</td>
</tr>
<tr>
<td></td>
<td>26. The behavior of students.</td>
</tr>
</tbody>
</table>

To facilitate the analysis below, the four groups of questions are referred to as Q1, Q2, Q3, and Q4. Each question is assigned
a corresponding color code (red, green, yellow, blue) indicating the group to which it belongs. The color convention is also followed in the subsequent diagrams.

The 342 responses to the 26 questions constitute the input data for our study. We consider that each question is represented through the responses of the educators, meaning the identity of the question has a signature of 342 numbers, i.e., the Likert scale responses. For example, a (partial) signature for the first question is [3 5 5 3 5 4 4 4 4 5 5 5 4 ...].

In mathematical terms, each question is described by a vector of 342 components, and thus the questionnaire is represented in a 342-dimensional space (342D), where all questions are located. In block diagram, the process of processing the responses is summarized below:

**Figure 1**
*The Stages of the Processing Process*

The main stage of the process is the third one, where the projection of the input space (342D) into fewer dimensions occurs. Dimensionality reduction is necessary for several reasons. Indicatively, we mention that: (a) The structure of the data is revealed, which remains hidden in the initial multidimensional space, and its actual dimensionality may be much smaller, (b) The efficiency of data mining techniques is improved, and (c) The possibility of “visualization” is provided, i.e., dimensionality reduction to 2D. Visualization creates a representation in the plane (2D) or space (3D) that can be perceived by humans. It transfers the extraction of relationships from the mechanical to human perception and thus constitutes a high-level processing.

In the present study, we choose dimensionality reduction methods from the field of artificial intelligence (Hinton & Roweis, 2002; van der Maaten & Hinton, 2008; van der Maaten, 2013; van der Maaten, n. d.). In all cases, the transformation from the initial to the final space satisfies certain criteria, so that the initial and final arrangement remain as similar as possible. We opt for the t-SNE (t-Distributed Stochastic Neighbor Embedding) method. Additionally, for result validation, we use...
the NC-MDS (non-classical multidimensional scaling) method (Hinton & Rowes, 2002; van der Maaten & Hinton, 2008; van der Maaten, 2013; van der Maaten, n. d.). The two choices are complementary, as NC-MDS provides overall information, while t-SNE provides neighborhood information. The processing was repeated 1,000 times with different initializations, and the representation with the best reliability, i.e., lower loss (t-SNE) and stress (NC-MDS), was retained.

Results

The questions are presented in two-dimensional scatter plots. Note that in all cases the diagram axes are abstract and do not have specific units. Only the relative positions of the data as distances on the 2D diagram have qualitative and quantitative value. Comparing distances on different diagrams does not provide any additional information. In all cases we retain the original color code mentioned in Table 1.

Question Set Diagrams

Figure 2 shows the scatter plot of the 26 questions. The visual representation allows us to identify three points of interest, which will be of concern below:

1. The four groups of questions as originally identified are separable, with no intersections of the surfaces they cover (dotted line ellipses in the t-SNE plot).
2. A discrepancy is detected with respect to the representation of question #16 in both the t-SNE diagram and NC-MDS. Although it belongs to group Q3 (yellow), it is located between groups Q1 (green) and Q2 (red).
3. The arrangement of the questions reveals the relevance of the groups and the adjacent points between them: Question #6 of group Q2 (green) is close to Q1 (red) in both the t-SNE and NC-MDS diagram, while question #8 of Q2 (green) is close to groups Q3 (yellow) and Q4 (blue) in the t-SNE diagram. Visually, it can be seen that group Q1 (red) is adjacent to Q2 (green) and Q2 (green) is adjacent to Q3 (yellow), while Q4 (blue) is farther away from all of them.
In Figure 2 above, the distance used in calculations is the Euclidean distance. To enhance and verify the accuracy of the relative
positions depicted in Figure 2, we conducted experiments with different distance metrics, namely Chebychev and Hamming ones. Although the plots may not be identical, the relative positions, which are of interest here, do not exhibit significant differences.

**Diagrams by Group of Questions**

Although the basic relationships between the questions is revealed by Figure 2, the diagrams of the questions in each group provide distinct and possibly additional information that needs to be analyzed. For these reasons, the individual question diagrams are provided below. The numbering of the points in these charts is as in Table 1.

**Group Q1**

Figure 3 shows that the (relative) distances between the questions of group Q1 are quite large, which means that the questions of the group are “independent” i.e. the participants perceive the respective elements of professionalism as indeed distinct (e.g. “professional knowledge” and “cooperation”). We observe in both diagrams the large distance between questions #1, #2 and #4.

**Figure 3**

*Scatter Plot of the Q1 Group Questions by t-SNE (left) and NC-MDS (right)*

**Group Q2**

From Figure 4, it can be similarly inferred that the (relative) distances of the questions in group Q2 are large. This finding means that the questions in the group do not have any particular proximity, hence they are “independent” and therefore also express separate concepts, as before.
Group Q3
As can be seen from Figure 5, question #11 is in the middle of the others while questions #14, #15 and #16 are very far apart. Question #12 is quite close to #11 compared to the others. This means that the signatures for questions #11 and #12 are similar.

Figure 5
Scatter Plot of the Q3 Group Questions by t-SNE (left) and NC-MDS (right)

Group Q4
A regularity in dispersion is also observed in Figure 6. There are three pairs, namely (#25, #26), (#20, #24), and (#22, #23), which are (relatively) close to each other.
Discussion

The application of the visualization method facilitated the straightforward validation of the constitution of the three concepts (professional identity, professionalism, and professional development).

The participants’ answers confirm the theoretical studies on which the creation of the questionnaire was based. Through the answers to the four groups of questions, the participants distinguish the separate concepts (Figure 2) and the separate elements that constitute professionalism, professional development and professional identity (Figure 3–6). The application of the method additionally detected in a simple and quick way possible correlations between individual questions, which need further analysis for their interpretation. We further discuss there in the following.

**Question #16 (Q3)**

Question #16 (Q3) presents a very interesting finding due to its position far away from group Q3, where it belongs. It is between groups Q1 and Q2. The wording of the question #16 “Do you approach the person or persons directly involved in the issue (e.g.: student(s))” refers to ways of dealing with an issue in the school context and refers to the collaboration between teacher and student. The wording “Collaboration with colleagues, parents, students” (#4) and “Pedagogical interest and concern for the student and his/her progress” (#5) refer to manifestations of professionalism, but include both the concept of collaboration (#4)
and the concept of the student (#5). It is found that in order to address an issue, the participating teachers seek the approach of the person directly involved, especially the student. They recognize the essential importance and contribution of working with students and seek to enhance communication with them. In light of this, the responses to the three questions have a consistency, which further enhances the validity of the findings and can be interpreted as revealing a general positive tendency and attitude of teachers around the concept of collaboration, which they evaluate positively in each case or manifestation in the educational context.

Groups Q1 and Q2 include questions related to the concept of cooperation. Cooperation is identified as a common parameter of the individual characteristics of each of the three concepts studied in each group separately. Therefore, one could be led to the conclusion of a broader grouping of groups Q1 and Q2 and partly of group Q3 with the concept of cooperation as a common reference point.

In addition, the questions of group Q3 focus on exploring the resolution of issues that the teacher is called upon to address and define the professional identity. The questions in this group relate to the resolution of issues either through the personal effort of the teacher (#13 and #14) or from the workplace or wider context through approaching individuals among whom there is a hierarchy (#11 and #15) and possibly requiring the activation of a relevant administrative process (see e.g.: #15) to resolve the problem.

Clearly, question #16 has a different approach to the proposed problem-solving process, as it involves working with the student, and for this reason it is perceived of being different from Q3 and conceptually belongs to different groups of questions with a different focus.

The significance of the finding lies in the fact that the teachers in our sample act in a way that enhances and promotes collaboration with the student, and has a positive impact on enhancing the professionalism of the teachers themselves. The congruence of our findings with those from the published literature (see e.g. Darling-Hammond, 2000; Sachs, 2000, 2001) leads to the conclusion that teachers in our sample appear to be aware and informed about issues of professionalism. Furthermore, in the discussion of teacher professionalism, collaboration with students is emphasized, as it is perceived as mutually beneficial (e.g. Hargreaves, 1994; Webb et al., 2004; Whitty, 2008).
Question #6
Question #6 of group Q2 is close to group Q1. Question #6 addresses the need for ongoing education and training as part of the concept of professional development and receives responses that are close to the concept of professionalism. This correlation does not directly follow from the theoretical background of questionnaire construction and is therefore considered an interesting finding to be further investigated in the future.

Question #8
Question #8 of group Q2 is close to groups Q3 and Q4. This question (#8) relates to collaboration with colleagues for the professional development of the teacher and receives responses that are close to the Q3 and Q4 groups that refer to the formation of professional identity and in particular to operating and problem-solving conditions, where collaboration with colleagues is also considered (indicatively: #11, #15 and #22). As above for question #16, the responses show a consistency, which further supports the validity of the findings.

Questions #11 and #12
Questions #11 and #12 of Q3 are shown quite close together, which means that similar responses have been given for two problem-solving options: “Reach out to colleagues to discuss the problem” (#11) and “Contact people in the wider school environment who you think are relevant to the issue (e.g., parents)” (#12). This illustration highlights two elements, which interpret on the one hand the closeness of the responses and on the other hand the impossibility of combining the two questions into one. The first element is that the participants recognize the contribution of collaboration and the advantages that result from it in the school context and in particular in managing issues in the daily school routine. The closeness of the responses suggests that teachers are positively inclined to use the possibility of collaboration with a wide range of stakeholders to address the issue.

Combining the two questions into one is not correct, as they conceptually refer to two different and ultimately dichotomous sets of actors (colleagues and the wider school environment). In light of this, it is a finding that needs further investigation whether this differentiation, which has emerged from the theoretical foundation of the questionnaire,
actually exists or is a logical construct and teachers make equal use of the available communication options with all actors in the school environment.

**Conclusions**

In this paper we explored whether artificial intelligence techniques and dimensionality reduction (“visualization”) methods in particular, can enhance classical statistical analysis of questionnaires. We used as a case study a closed-type questionnaire with answers on a numerical Likert-type scale. We applied the visualization method to analyze 342 responses to 26 questions on professionalism, professional development and professional identity of pre-primary (preschool) and primary school teachers. The visualization method was simple and fast.

Through the dimensionality reduction, we identified two new research questions for the given case study, relating to the concept of teachers’ collaboration to solve issues. These questions are a starting point for further research in the field and constitute a first direction of future work. In this sense, the research hypothesis is confirmed.

A second research direction concerns the further application of the visualization method to other forms of questionnaires from the field of pedagogy and more broadly from the Humanities and Social Sciences.

**ADHERENCE TO ETHICAL STANDARDS**

**Ethics Declarations.** All procedures performed with the permission of the participants who participated in the research for the processing and analysis of their data. All experimental procedures with human participation in the study complied with the ethical standards of the Helsinki Declaration of 1964.

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**Author’s Contribution.** Vasiliki Fotopoulou: Conceptualization, Methodology, Formal analysis and investigation; Writing original draft preparation, review, and editing; Management activities to annotate (produce metadata), scrub data and maintain research data; Resources, Preparation of tables, Verification, whether as a part of the activity or separate of the overall replication/reproducibility of results/experiments and other research outputs; Spiros Fotopoulos: Supervision, Conceptualization, Methodology, Formal analysis and investigation; Writing original draft preparation,
review, and editing; Resources, Preparation of tables, Programming, Software development, Verification, whether as a part of the activity or separate of the overall replication/reproducibility of results/experiments and other research outputs.

**Consent for publication.** The authors approve of this submission and, conditional upon the decision made by the editorial board from the peer-review process, consent to the publication of the current work. The work has not been, nor has it been submitted to other journals in consideration for publication.

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**References**


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### АНОТАЦІЯ

**Вступ.** Професійна ідентичність, професіоналізм і професійний розвиток – поняття, які протягом багатьох років привертають увагу дослідників. Вони є складними, багатогранними, еволюціонують з часом і змінюються залежно від контексту роботи педагогів закладів дошкільної освіти (тобто вихователів) та вчителів початкової школи. Особливий інтерес викликає концептуалізація самих вчителів.

**Мета.** Дослідити використання методів штучного інтелекту, зокрема методів зменшення розмірності, для аналізу сприйняття педагогами, які підвищують кваліфікацію, трьох концепцій, зафіксованих у запитаннях закритого типу з відповідями за шкалою Лайкерта.

**Методи дослідження.** Моделювання відповідей за шкалою Лайкерта в анкеті закритого типу як багатовимірного простору запитань. Метод зменшення розмірності для візуалізації відповідей у двовимірному просторі. Метод переведення відстані між запитаннями в теоретичні поняття та метод виявлення недосліджених тем.

**Результати.** Зменшення розмірності дозволило виявити нові кореляції між поняттями та їх складовими, про які раніше не повідомлялося в опублікованій літературі, де використовувався класичний статистичний аналіз.

**Висновки.** Підтверджено застосовність і корисність методу зменшення розмірності для аналізу відповідей людей в анкетах закритого типу. Крім того, визначено два нових дослідницьких питання, які потребують подальшого вивчення в майбутньому.

**Ключові слова:** професійна ідентичність, професіоналізм, професійний розвиток, редукція розмірності.