



Generation of Programmatic Contents by Competencies: A Technological and Systemic View of Higher Education

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This research combines the art of designing programmatic contents by competencies and the technological variable as an innovative resource in the context of higher education. The objective of this study was focused on the development of a technological system for the generation of programmatic contents by competencies in the curricular units of university careers. This research was carried out under the empirical approach; it is of an applicative type, since it generates a proposal and it was structured methodologically by phases: Phase I of approaching the manual system and user requirements was deployed under a field design in which the current situation and user expectations were described through the techniques of participant observation and meetings of experts in the area of educational technology (teaching staff of the different academic programs, heads of departments and coordinators of the Curriculum Commission), in order to carry out business rounds as a strategy of characterization and permanent consultation of the evolution of the system design to generate agreements. Phase II led to the establishment of the structural components of the prototype, and integrated the essentials from the systems theory, software engineering, and pedagogical didactic theories. Phase III was based on the methodology of system design by prototyping. As for the results, it was evidenced that the stakeholders considered feasible the use of the system to generate programmatic contents by competence, and finally the functionality of the system and the operational advantages for the generation of programmatic contents were demonstrated.

Keywords: programmatic contents, competencies, content generating system, higher education, educational innovation

INTRODUCTION

With the passage of time, man has become aware of the importance of having the appropriate, truthful, and accurate information at the right time, and its implications for the success of organizational and individual performance, to be able to make decisions and plan their actions efficiently and successfully. To achieve this, computer professionals created methods, techniques,

and procedures for information processing, thus improving them day by day. This is how computer science emerged, as the science that deals with the correct handling of information in an automated way (Griffiths, 2019; Holzinger et al., 2019; Miah et al., 2020).

Universities as organizations intend to take advantage of the opportunities provided by information technologies facilitating their functions and academic-administrative performance; in this sense, it is required to address the critical knots related to the improvement of the processes of generation, modification, and updating of the programmatic contents of the curricular units that integrate the department, in the undergraduate professional careers (Karfaa et al., 2015; Balza, 2016; Harron et al., 2017; Cabrera et al., 2019).

With the dynamization and flexibilization of the university curriculum, subject plans are constantly modified and updated in a non-automated way, and must be governed by institutional horizons, new formats, regulations, and guidelines generated in the organizational decision-making bodies, which are followed and communicated by the curriculum commissions or councils in each of them, with the idea that teachers appropriate, empower, and implement in their planning processes in a contextualized way but without the help of an automated tool that can standardize and streamline the processes of selection and renewal of the programs of each chair or subject in a short time (Castro, 2008; Chisholm, 2019; Du Preez, 2020). With the intention of promoting a new service application, this study aims to develop a system to generate contents by competencies, which has been called “Automated system for generating programmatic content” (GENCOP).

General Aspects About the Object of the Study

With a vision based on excellence, efficiency, and effectiveness, the foundations on which the work of all academic and administrative bodies in university institutions is based, we start from the need to streamline and automate the generation of the programmatic contents of the curricular units of the undergraduate careers at La Universidad del Zulia (an autonomous Venezuelan university with the largest number of students in the country), as an empirical reference, and the need for a technological tool capable of improving the processes of creation and updating of program contents, so that the teaching and research staff assigned to the chairs have access to a simple system from the user system interaction and effective in terms of response times, data storage, availability of information, avoiding redundancy and rework, in addition to promoting the real use of information and communication technologies (ICT) in instructional designs (Castro, 2008; Törnberg and Törnberg, 2018; Snegurenko et al., 2019).

Consequently, the need arises to develop a technological application for the design of programmatic contents by competency for the curricular units of the careers offered at the University of Zulia, which allows one to improve the generation of programmatic content, avoid the handling of large volumes of paper which must be archived, and thus ensure the updating

of programmatic content in a faster way, and the integrity and authorship of the designs, while shortening response times to requests made by interested parties who require them, either for a case of equivalence, academic staff entrance examinations, or any other procedures such as certification of curricular unit programs, among others (Aldarbesti and Saxena, 2014; Hsu et al., 2019).

Objectives of the Research

In relation to the approaches for the design of programmatic contents, this research has the following objectives: to develop an automated system generator of programmatic contents by competences (GENCOP) for the strengthening of the instructional management in the university institutions, to describe the processes of generation of the current instructional design and the expectations of changes in the processes of didactic planning that will be implemented in the undergraduate careers of La Universidad del Zulia as an empirical space, to characterize the operation of the current manual system and the requirements of technological and technical nature of the information system from the perspective of the users and experts, to determine the final structural components of the system according to the conception nature and scope required for the generation of programmatic contents of the subjects, representing an optimized real model or functional prototype, to design the functional prototype of the information system for the generation of programmatic contents that understands the expectations of the users, the technical and technological requirements in accordance with the established theories (according to Senn, 2012), and to demonstrate the operational functionality of the system from the tests of failures and satisfaction of the final user as a process of validation of the operability of the prototype (Gradecki and Curry, 2017).

Competency-Based Syllabus Design for the Management of Subjects

According to Harrison and DeVries (2019), instructional design as a component that facilitates curricular concretion must have a structure and functionality in accordance with the needs and characteristics of the context where the educational event takes place. In this sense, the planning of this process must be developed in appropriate educational environments that encourage the development of the personality, potentialities, and autonomy of the cognitive subject, respecting the particular way of constructing knowledge and the way of apprehension and conferring meaning, transferring it according to their mental models. For this purpose to be achieved, it is necessary to build a flexible, contextualized, and dynamic instructional design (Goncalves et al., 2015; Battistoni and Barbero, 2017).

In the light of these approaches, the specifications on teaching mediation involve the planning of the subject, being convenient in this sense, a content generation, design, modification, and adjustments that allow under a competency-based approach, a teaching practice based on competency-based planning, adapted to the study modality, under strategies that break the barriers of both space and time, thus achieving the construction of

knowledge in a more collaborative way through a system of generation of optimal and automated programmatic contents (Inciarte, 2012; Akpan, 2018).

It is important to consider that the selection and definition of the programmatic elements have direct implications in the conformation of educational spaces that ensure learning based on the basic principles of didactics by competencies, emphasizing the use of activities that facilitate self-directed learning, motivation, action, responsibility, contextualization of contents in real life, articulation between theory and practice, promotion of collaborative and cooperative work, and management of multiple representations of content and reflection, in addition to the management and use of resources of paramount importance to relate with and in virtual spaces (Battistoni and Barbero, 2017; João et al., 2020; Villarroel et al., 2020).

From these considerations, areas of interrelation between research, training, and work are created, thus, responding to this methodology, the elements that must be present in an instructional design under a conception of curriculum, management, and evaluation by competencies are shown below, which clearly evidence the learning that must be achieved and has been achieved, from the programmatic contents of the curricula of the careers that are dictated (Castro, 2008; Harrison and DeVries, 2019).

According to Espada et al. (2020), the design of an information system for the generation of programmatic contents under the competency-based approach is very useful to structure both the curricular learning units that are addressed from the didactic interaction with the participants, and the development of the educational processes themselves, the follow-up, control, continuous improvement, as well as the coexistence, the interrelation of disciplines and the incorporation of ICT (Ciriza et al., 2022).

Considering these organizational processes, the use of ICT is considered to be relevant for the configuration of instructional designs, given their possibility of generating flexible action frameworks in the field of educational planning that lead to the improvement of efficiency in the operation of departments and administrative entities, understood as components of a system of greater organizational complexity (Goncalves et al., 2015; Esteban, 2016). Thus, depending on the nature, conception, and scope of the construction of instructional designs, it is possible to systematize such programmatic contents, a sample of which is presented in **Figure 1** (Senn, 2012; Karfaa et al., 2015).

Theory of Systems in Permanent Evolution

In the light of Von Bertalanffy's (1989) ideas, a system represents a set of objects linked by some form of interaction and interdependence. Any set of parts joined together can be considered a system, provided that the relationship between the parts and the behavior of the whole is the focus of attention, for example, a set of parts that attract each other (such as the solar system), a group of people in an organization, an industrial

network, an electrical circuit, a computer, or a living being can be visualized as a system (Carreño et al., 2015; Ahmad, 2020), this idea corresponds to the objective of the present study.

According to the previous approaches, the effectiveness of a software project depends on the detailed planning of its scope, anticipating the possible problems that may arise as the system progresses, thus preparing in advance the solutions for such problems. According to Griffiths (2019) and Von Bertalanffy (1989), the organization determines the means or techniques that will be available to the user to manage their interrelationships in a system, from their work routines and traditions that distinguish it, identifying which are the values or beliefs that exist in the organization and that in turn influence the behavior of its members and in the acceptance of technology and what it brings with it: change. For this, individuals must work together in the search for common results, in line with the mission, vision and core values of the institution from a systemic and interconnected perspective, which should be reflected in the didactic planning processes by competencies (Akpan, 2018; Guzmán et al., 2021).

It is important to note that there should be an internalization of the institutional values as a way of direction that guides the functioning of organizational human systems; this implies that the individual identifies with the university, committing to its work, and to develop a positive attitude toward the challenges assumed by the institution, demonstrating the process of transformation of educational means with the support of ICT which is visualized in **Figure 2** (Byron(s/f), 2013; Karfaa et al., 2015).

MATERIALS AND METHODS

Characterization of the Population

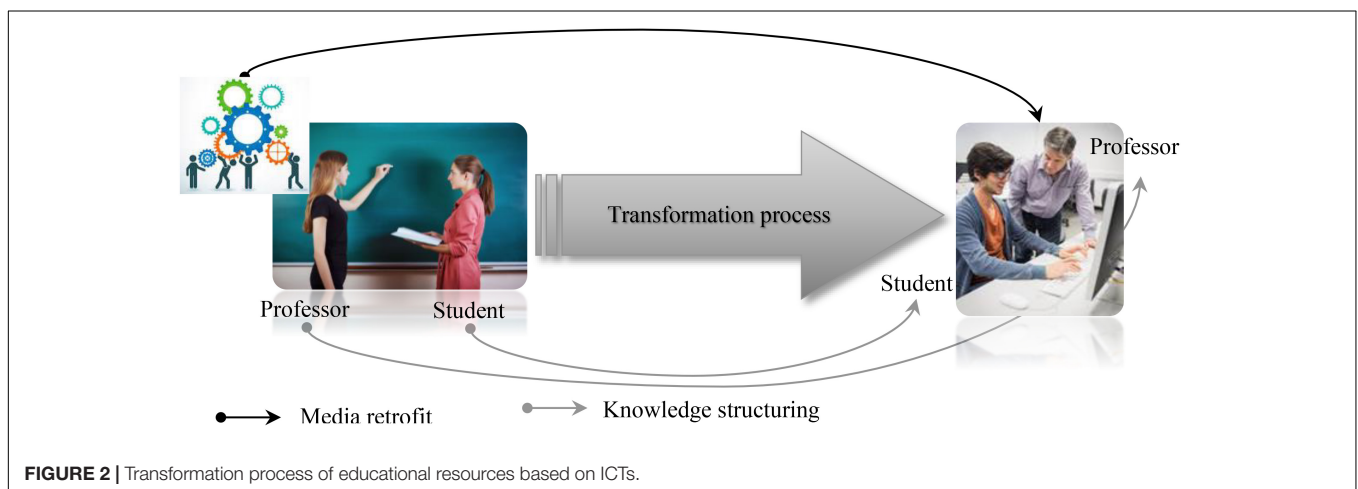
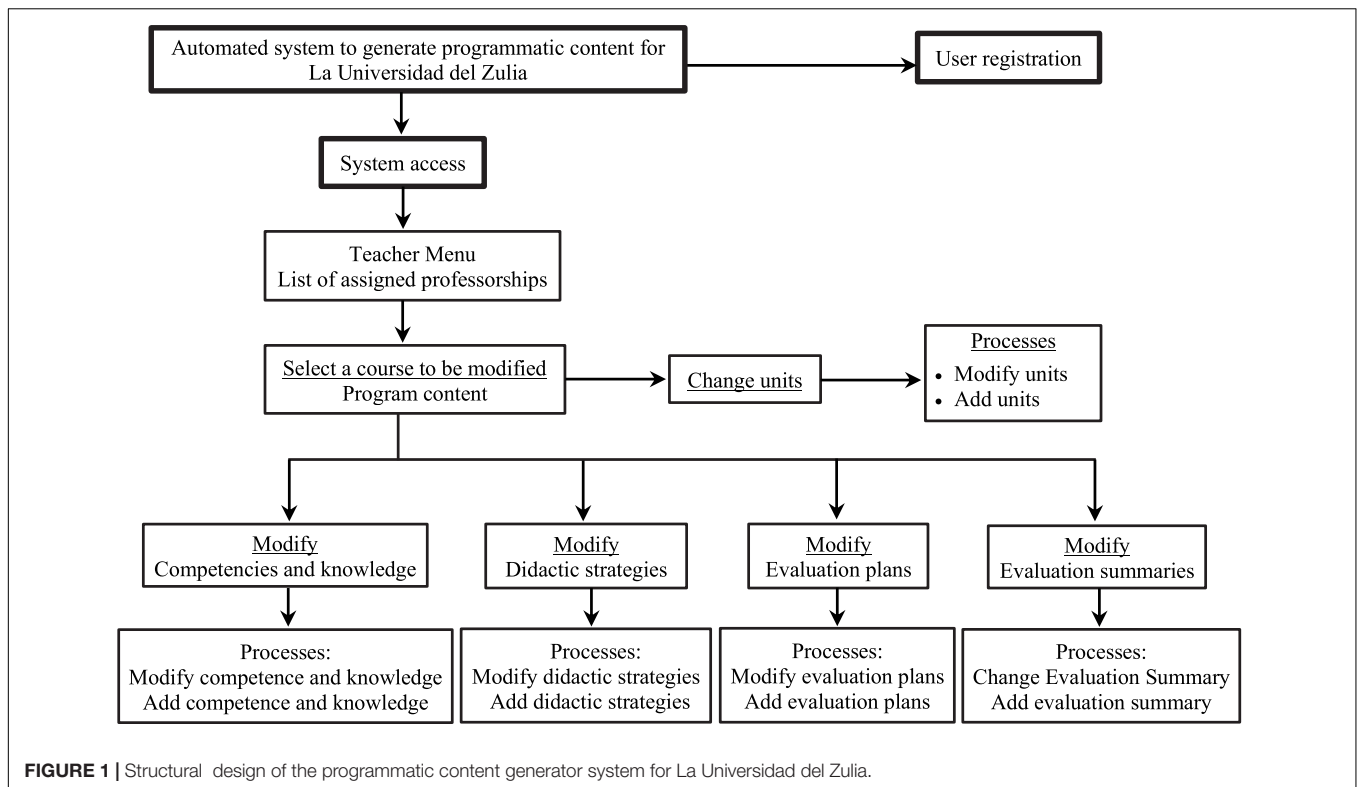
The population consisted of 30 university teachers, who hold the positions of academic program coordinators, departmental heads and active teachers assigned to La Universidad del Zulia Nucleo Punto Fijo.

Sample and Sampling

To collect necessary information from a finite population made up of academic program coordinators and department heads, curriculum committee coordinators, among others, in this sense, the sample of 30 teachers was considered to be non-probabilistic and the sampling carried out was intentional under the modality of experts or informed criteria (Nasheeda et al., 2019; Shishakly et al., 2021).

Instruments and Procedure

To study the design of program contents, a questionnaire-type evaluation instrument was used, consisting of structured questions with several response alternatives. The response alternatives were evaluated as follows: totally agree (TA), agree (A), neutral (N), disagree (D), and totally disagree (TD); such verification was carried out in order to record

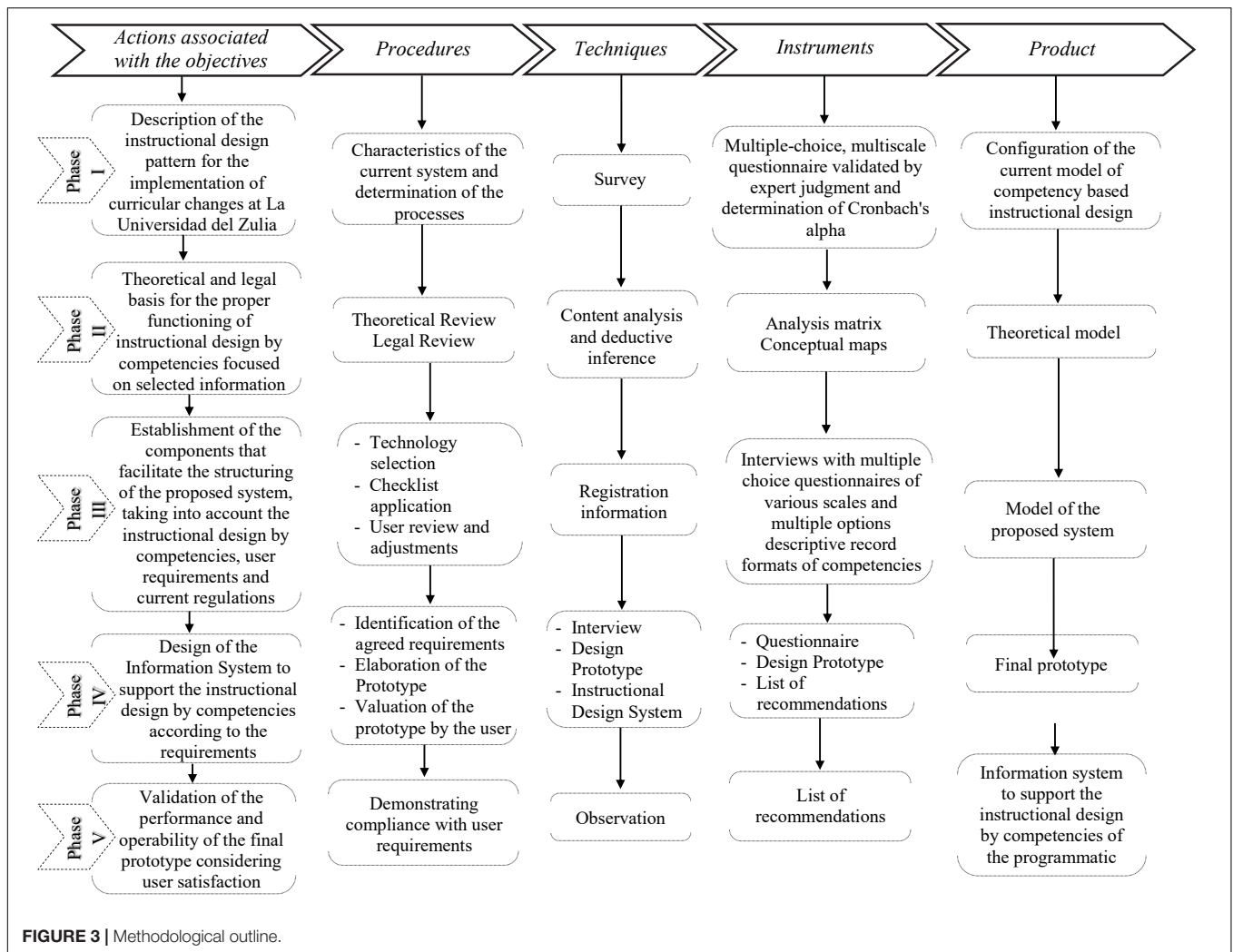


and know the requirements for the construction of the technological application. With these data, a matrix with indicators was constructed to evaluate the programmatic contents by competencies for the academic programs offered by the Nucleo LUZ Punto Fijo, through a technological tool under the guidelines of Pressman (2002) and Senn (2012). Therefore, to assert the validity of the content of the questionnaire, the questions were validated through expert judgment, where five experts in the educational area and four in the technological area intervened, where each one responded individually to the options of each question.

Validity and Reliability

Therefore, to assert the validity of the content of the questionnaire, the questions were validated through expert judgment, where five experts in the educational area and four in the technological area intervened, where each one responded individually to the options of each question.

The reliability of the instrument was estimated from the determination of Cronbach's alpha statistical parametric whose results showed 0.818% reliability. According to Hernández and Mendoza (2018), the reliability of a measurement instrument refers to the degree to which the repeated application of the instrument on the same subject produces the same results. For



this measurement, the Cronbach's alpha formula was used: $\alpha = \frac{k}{k-1} \left[1 - \frac{\sum Si^2}{St^2} \right]$ through a spreadsheet from the SPSS software, and its result was $\alpha = 0.818$ for the reliability analysis. In attention to the comparison made by Ruiz Bolívar (2002), the instrument has a high reliability; therefore, the results derived from the instrument are valid and reliable.

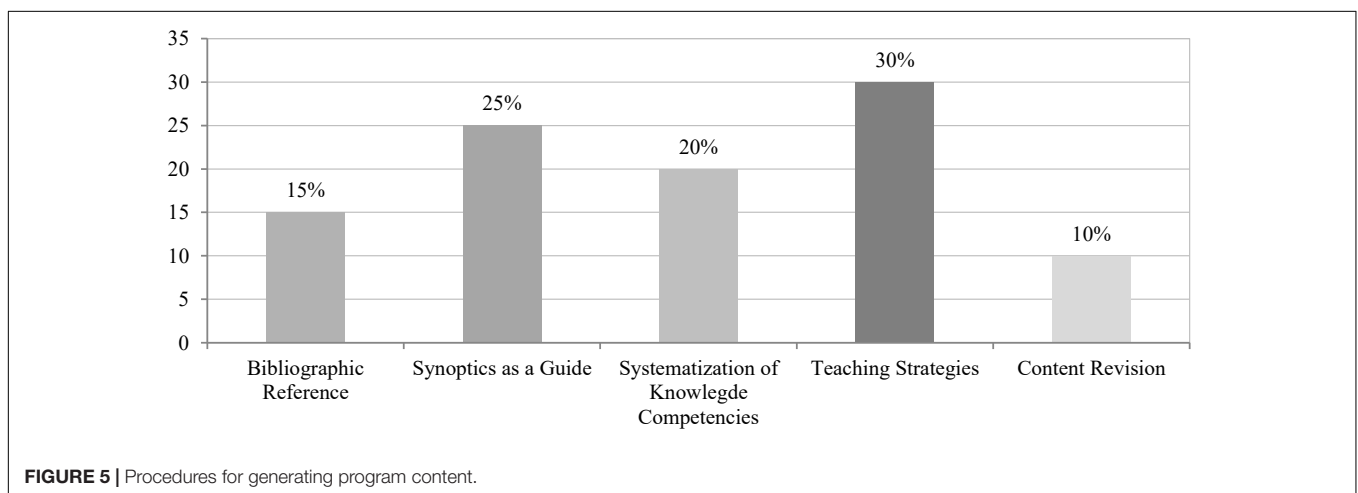
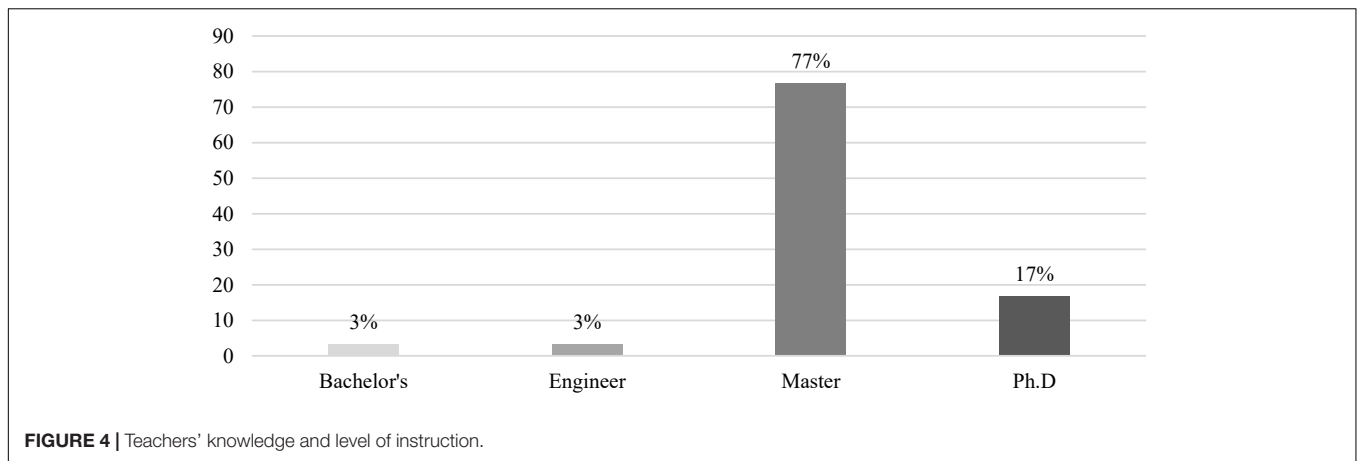
Research Design and Methodological Route

The research design is a predominant field, non-experimental transectional type, according to Hernández and Mendoza (2018). From this perspective of research design, a methodological route was developed that allows the integration of the methodology of social research with the methodology of technological research for the generation of systems, as shown in Figure 3.

This route is made up of five phases: in the first phase of the methodology, the manual system was approached in addition to the requirements of the users, in which the processes of generation of the Syllabus design for the application of the curricular changes of La Universidad del Zulia were de-scribed.

To collect necessary information from a finite population made up of academic program coordinators and department heads, curriculum committee coordinators, among others, in this sense, the sample of 30 teachers was considered to be non-probabilistic and the sampling carried out was intentional under the modality of experts or informed criteria (Nasheeda et al., 2019; Shishakly et al., 2021).

Once the informants were selected, they were approached with the idea of characterizing the current system and describing the input requirements, for which a strategy was used to collect empirical data, working meetings between experts from the systems area and the educational area with the researchers (Marin et al., 2021) and the application of a closed questionnaire with a Likert scale and five response options. The results recorded in a notebook and the processed data from the questionnaire from descriptive statistics allowed one to make decisions about the requirements and desirable attributes in the system and those demanded according to the user's expectations, as well as characterizing the manual system, technical, technological components, needs, and the socio-affective feasibility of the system (Leal, 2005; Aldarbesti and Saxena, 2014).



Next, in phase II, the structural components were established where the most relevant aspects of the theory established from the computational and educational area were integrated in order to define the final structural components, more appropriate according to the conception, nature, and scope of the system to be developed. It was therefore deemed convenient to represent the real model (mechanical or traditional), with the optimized design (created model) under which the design of programmatic contents by competencies corresponding to the curricular units of La Universidad del Zulia should work, and at the same time juxtapose it with the ideal or theoretical system (Laguna et al., 2016; Surian and Sciandra, 2019; Kusumasari et al., 2020).

In this sense, Senn (2012) argued that functional prototypes should be regenerated for technological applications in the systems, following an evolutionary conception also called business wheel, which allows successive meetings and meetings to reach consensus on partial aspects of the design in attention to the technical-operational and managerial-functional agreements; based on this it was the key to the definition of the components and structures that made up the design of the final information system, considering the current manual system, the existing legal framework, the user's requirements, and the review and analysis of the technology both available and adequate in

agreement with the users, so the business wheel strategy was very useful in the design of the system prototypes, its continuous improvement, and the formulation and recursive readjustment of the proposed system model (Salas, 2019; Ahmad, 2020; Canto et al., 2022). Finally, the design of the instructional system application was developed, which was supported by the prototype system design methodology comprising four basic processes that were optimized recursively until the operational validation of the constructed prototype (Senn, 2012; Kim et al., 2020).

This required the establishment of its components; in this sense, the interview was used as a technique to select and integrate the user's requirements and the modules that make up the technological application, as indicated in Phase II. After obtaining this information, a prototype of the functional design was built, illustrating both the interaction screens, the structure and exchange of information flow and the further technical purpose of the system, in order to allow the end user to interact with it, facilitating the adjustment to the proposed system, speeding up the overcoming of deficiencies and maximizing the virtues of the system integration (Padrón, 2016; Clarke, 2020). Such verification was carried out using observation and a checklist, in which any failure was recorded in order to overcome it and in turn strengthen the adaptations

of the system to the user's requirements, optimizing the process of generating programmatic content, ensuring the technical-technological operability (**Figure 3**).

RESULTS AND DISCUSSION

Results of the Questionnaire

The following are the questions asked to the teaching staff of La Universidad del Zulia Núcleo Punto Fijo in reference to their experience as teachers in this House of Study: the curricular units taught and their experience at the time of generating programmatic contents of the courses they teach.

In this way, De Aguiar (2007) in his research proposal for the structuring of programmatic contents of the technical subjects of the hotel and restaurant career at the Experimental University of Táchira found results that are consistent with those presented in this research, since they corroborate the use of descriptive methodologies characterized by the selection and specialized search of documentary information for the construction of program content. This made it possible to show that the use of virtual platforms is the means where the teacher and the student can interact in the development of the modules and subjects of the hotel and restaurant career, consolidating the teaching-learning process through ICT, and managing to restructure the programmatic contents, in the houses of study at the university level. The results of this research are consistent with those presented by the authors (Arrieta et al., 2019).

Figure 4 shows the academic training of the teachers, where 77% are masters in the area of education, having the training to manage the teaching-learning processes, in terms of the components of instructional design specifically in mediating strategies, stating that the interest should be placed on them; these results are consistent with those found by Kusumasari et al. (2020). In turn, knowledge and disciplinary knowledge must be mediated to obtain satisfactory results, which demonstrates the ability of teachers with graduate studies to perform their functions within the LUZ Punto Fijo Nucleo in addition to imparting knowledge to students of the curricular units in different academic programs.

In this sense, **Figure 5** shows that 30% of the teachers, at the moment of generating the programmatic content, design, and implement mediating strategies in the teaching-learning process that allow them to obtain satisfactory results, while 25% use the synoptic as a guide from which the global structure of the content is visualized, 20% use the systematization of knowledge competencies to be achieved in each curricular unit, 15% consult bibliographic references related to the area of interest, while only 10% review other program contents already generated by the same university and other institutions.

Also, the above results are in agreement with the research of Kim et al. (2020) and Silva et al. (2019), confirming the theories of systematization of knowledge competencies using ICT. The methodology was quantitative, where the data were treated through a test-type evaluation instrument that demonstrates its validity, highlighting that 30% affirms that it is necessary for university institutions to implement strategies in their

educational system to generate programmatic content through the design of didactic strategies in order to improve the level of development of curricular units by competency.

In relation to **Figure 6**, the response alternatives indicate that most of the teachers are in total agreement and closely linked to the need to automate the academic process for the generation of programmatic content, thus allowing the evaluation of the teacher's potential and its importance within the teaching-learning process, where the programmatic content by competency favors student evaluations and the changes they would bring about (Goncalves et al., 2015; Battistoni and Barbero, 2017).

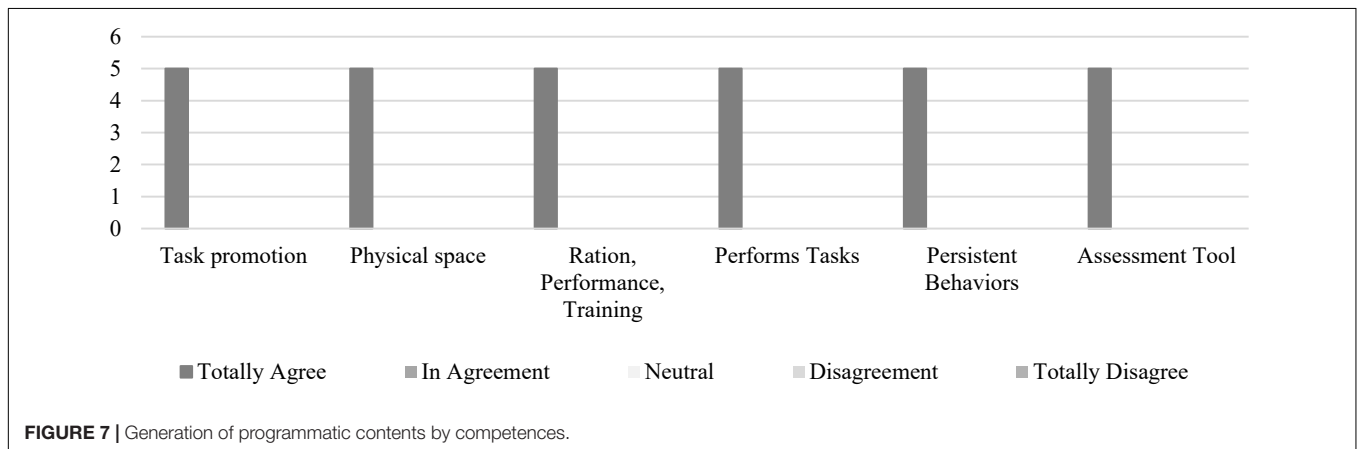
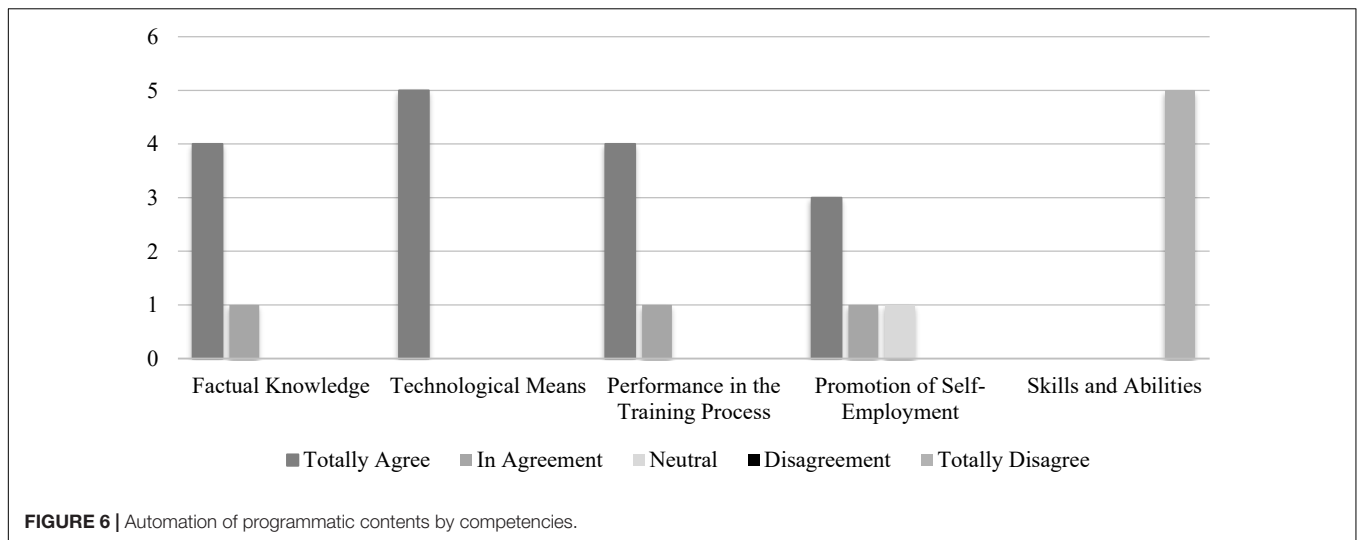
However, in the indicator skills and abilities, all interviewees are in total disagreement to create the content of a complex subject (Jack and Higgins, 2019). Likewise, when contrasting the above evidence with the research of González et al. (2020), it is possible to corroborate the theory of automating the academic process of programmatic content by means of resources for creating and editing programs using ICT.

Finally, in **Figure 7**, the results obtained are contrasted with a research carried out on formative evaluation by Romero et al. (2017), where it is possible to corroborate that they are consistent with those proposed in this research, confirming the theory of formative and shared evaluation, through the acquisition of teaching competencies regarding communication and the use of ICT. These results validate the teacher-student interaction through evaluative media and instruments in the generation of competency-based content (Goncalves et al., 2015; Battistoni and Barbero, 2017).

CONFIGURATION OF THE PROPOSAL

The design of the technological application, according to Senn (2012), contains the elements that establish how it will meet the requirements identified during the analysis of the same, the specific data relevant to the system must be clearly specified, the flow of information and interaction of the data tables to generate the expected reports according to the modules (Aldarbesti and Saxena, 2014; Pasi and Sengers, 2020). It should also indicate its exact location on the paper, display screen or other medium. Usually the anticipated shape or visualization of the expected performance of the system upon completion is represented graphically. Similarly, it is important to note that the research reaches the applicative level where the plane of the practical nature of the research is privileged, in the sense of offering a solution to real problems (Padrón, 2006). Before developing the codification of the application, it is important to be clear about what it is desired to obtain as a final product, therefore, the design is part of the structural elaboration of the information of each of the existing processes and functions in the process of generating programmatic contents in the context of the Universidad del Zulia, Núcleo Punto Fijo. This section presents the fundamental aspects that served as the basis for the design of the interactive application as a strategic information support (**Figure 8**).

It also shows the entity-relationship (E-R) model, which defines the data from the relationships, entities, and attributes,



in turn allows designing a conceptual scheme of the database graphically through a diagram and the interrelation of the information flow, that is, it relates and interconnects the data in the most direct and effective way to ensure the system outputs or reports, generation of the programmatic content by processes, components, and functions (Thomer and Wickett, 2020; **Figure 9**).

After developing the phases related to the needs and processes required to carry out the effective development of the interactive application for the elaboration of programmatic contents by competencies, some of the screens of the final prototype are shown in **Figure 10**.

System testing consists of the functional evaluation of the application, which is performed in order to find errors and determine fault judgment. These tests allow verifying that the application under development meets the functional requirements, and also simulate the input of valid and invalid data to evaluate the efficiency of the final system (Gutiérrez et al., 2007; Lyazat et al., 2017). The screenshots shown constitute the functional operational demonstration of the system and its reports for the programmatic content generator system by competencies corresponding to the

curricular units of the careers offered by the Nucleo LUZ Punto Fijo, in the perspective of a functional prototype that was presented for validation to a panel of experts in the computational area and to the final users (Kusumasari et al., 2020).

Security tests were performed, which consisted of verifying the protection of information (illegal access). The application has two types of accesses, i.e., one as administrator and the other as user; the administrator is able to delete, modify, add subjects with their respective indicators, users, one also has access to view reports, therefore, the user has the permission to create, modify, and delete subjects or curricular units. Performance tests were also carried out which allowed one to evaluate the functionality and congruence of the data presented by the application according to what was established by Kusumasari et al. (2020) and Gutiérrez et al. (2014).

About the stress tests it is possible to say that they are designed to confront the programs in the presence of abnormal situations. The stress test is executed by a system in the presence of an abnormal frequency or volume of resources. The person applying the test tries to overload the application in order to

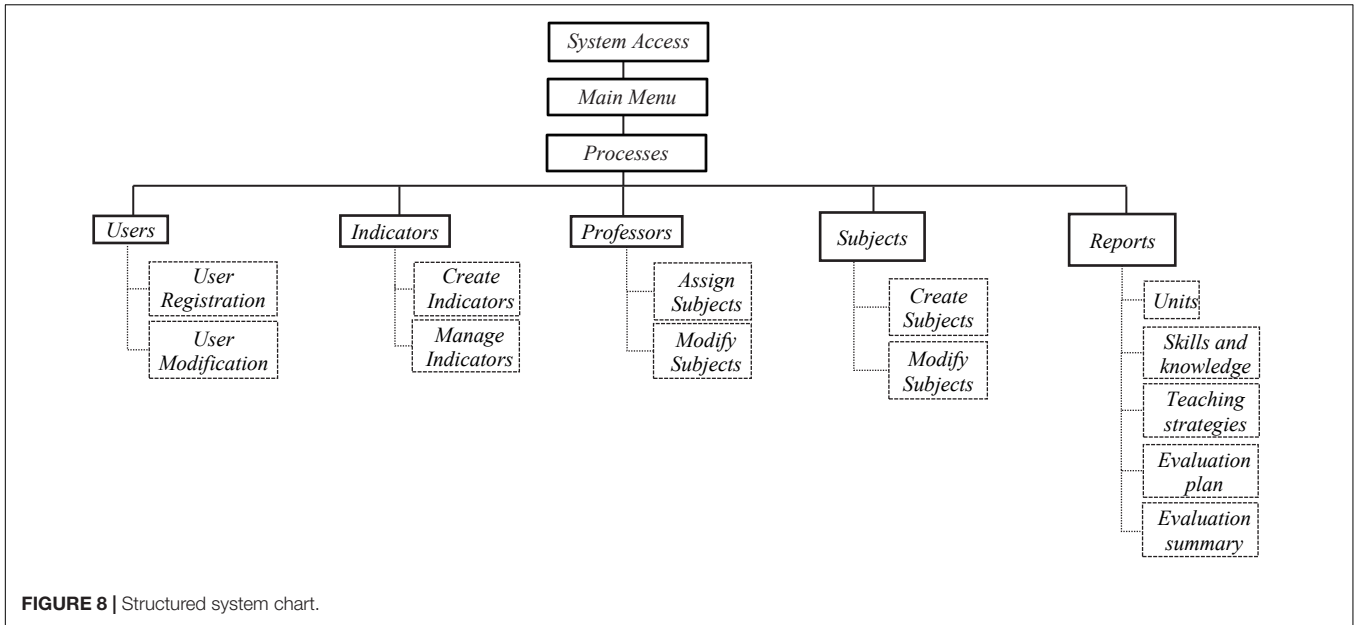


FIGURE 8 | Structured system chart.

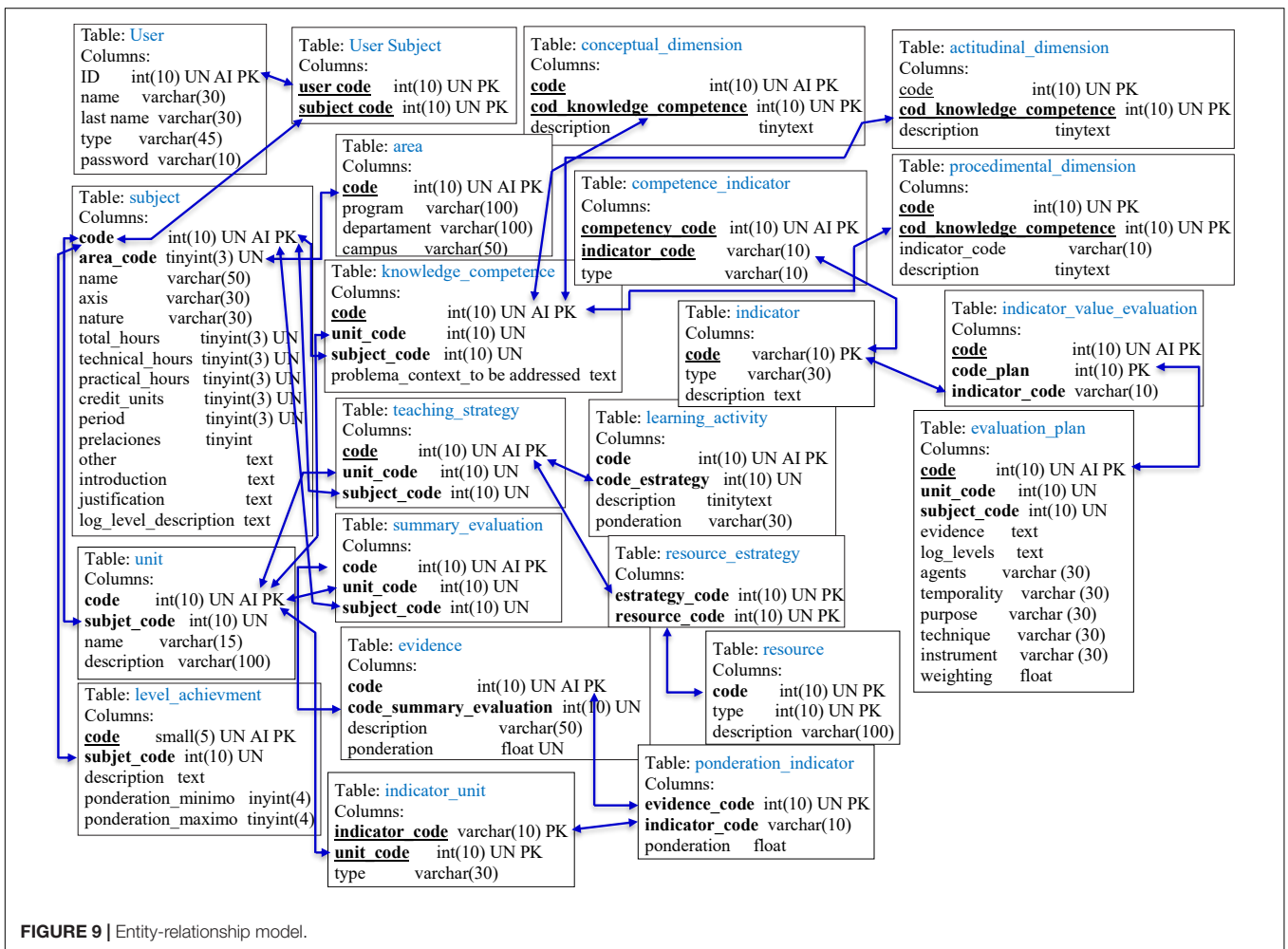


FIGURE 9 | Entity-relationship model.

record its response or behavior and in this case, the application in the prototype version withstood the overload to which it was subjected.

CONCLUSION

Once the most significant findings have been analyzed and considering the objectives set out at the beginning of this research, it can be concluded that:

The curriculum design focused on competencies represents a challenge compared to traditional models, since it requires creative efforts from teachers oriented to the design of formative learning and assessment strategies, as well as a change in the student's attitude, where each person is projected to be a promoter of his or her own development and can continue to lead his or her future formative process.

The valuation of knowledge, presented by the competency model, contrasts with the traditional evaluation by results or achievements only; in this sense it transcends from

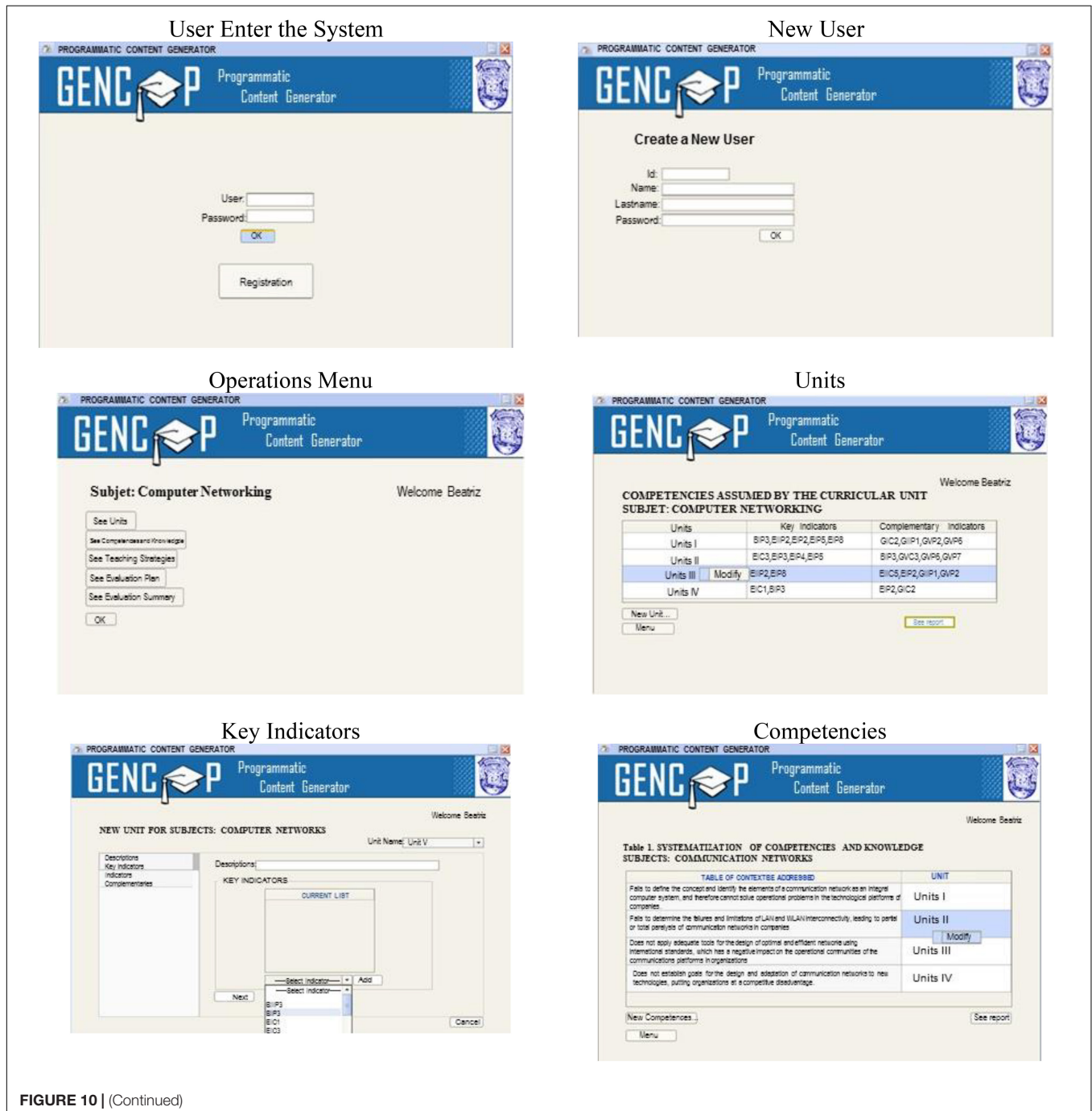


FIGURE 10 | (Continued)

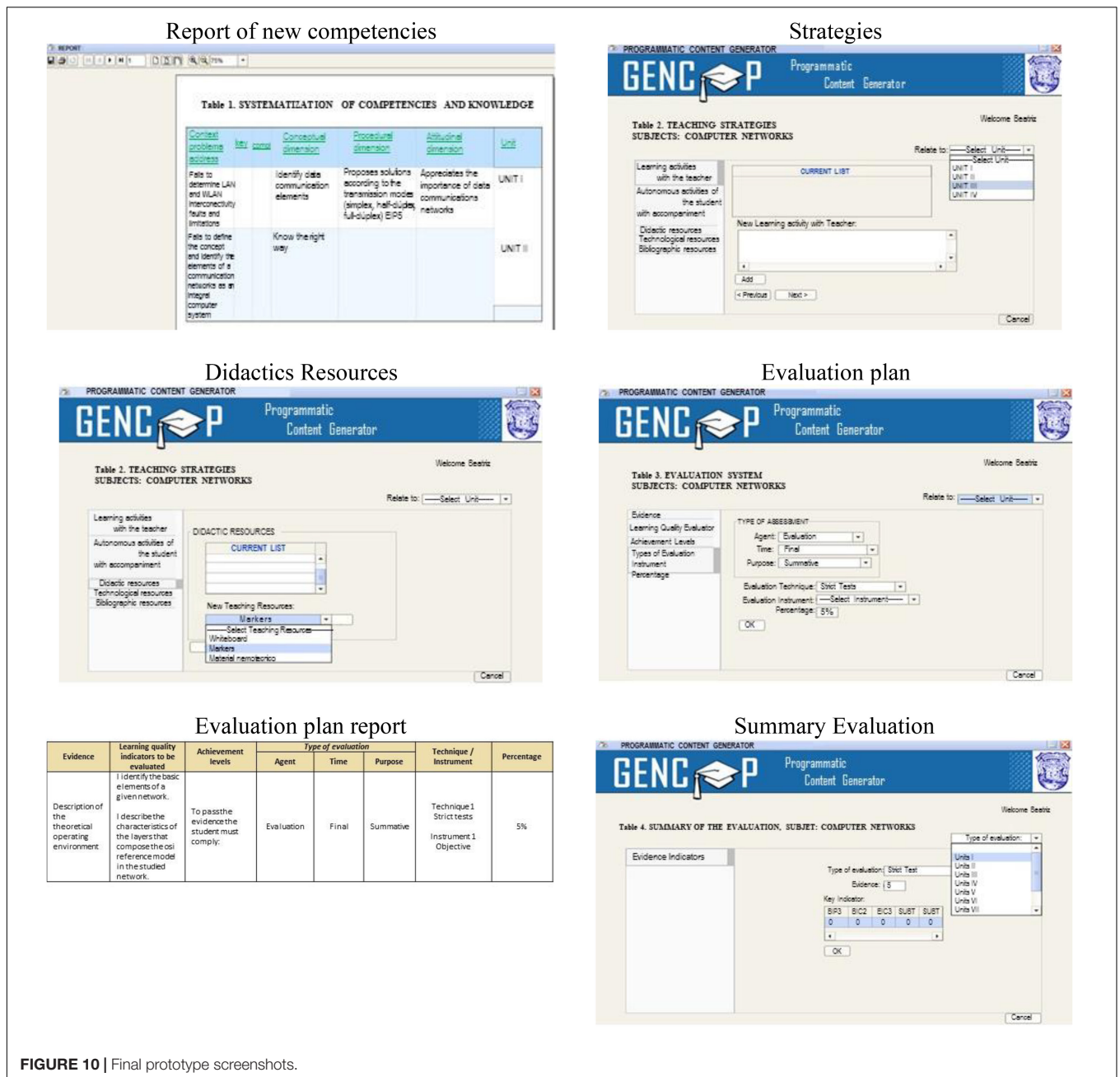


FIGURE 10 | Final prototype screenshots.

this to approach the valuation of learning processes, also considering the context, new actors, new and varied evidence, and motivational and communication aspects. The use of the system ensures the incorporation of all planning components in the management of programmatic content, since its 23 tables or databases contain all the information related to competency-based planning, facilitating the interrelation of information in the processes of generating programmatic contents.

In any automation system, a theoretical foundation is necessary to scientifically support the research of those who always play the role of a software analyst and developer, in

addition to instructing and training those to whom the system is directed. Therefore, the articulation of the theoretical system allowed establishing the foundations that served as a basis for the development and construction of the programmatic content generator system as a strategic information support from the postulates of Senn (2012), Von Bertalanffy (1989), and Senn (1998).

Considering the processes that are carried out within the Universidad del Zulia, Núcleo Punto Fijo, specifically in the curriculum department, it is necessary to update the requirements of management, consultation, generation, and modification of information, to make

viable the dynamicity and scalability of the system in order to automate the entire process of generation and loading of programmatic contents. As a final product, a model (functional prototype) of the system was designed through a rigorous structuring of the processes, requirements, and requirements that the department currently has, according to the needs and expectations of the beneficiaries, expressed in the empirical data collected, in order to meet the expectations of the end user.

Finally, it is necessary to train teachers for the optimal use of the automated system and all those who are linked to the process, since the procedure is still handled manually. It is also important to design that the functional prototype can be used as a support tool for the work carried out in the Curriculum Commission, and from there, its use can be extended to the academic programs, departments, and other entities that make up La Universidad del Zulia, and it is susceptible to be used in any educational institution with similar characteristics and with the necessary adaptations.

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DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

FM-G carried out the research, conceptualization, writing, and layout. AS-N developed the methodology, review for adjustments, final editing, and application management. LF carried out the adjustment to the journal's standards, revision, and translation. FM-G and AS-N were responsible for final revision, financing management, and carried out the supervision of tasks. BP developed the review and technical adjustment of the final version. All authors contributed to the article and approved the submitted version.

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