Inclusive Model for the Development and Evaluation of Accessible Learning Objects for graduation in Computing: *A Case Study*

Andreza Bastos Mourão
University of State of Amazonas (UEA)
Post-Graduate Program in Informatics (PPGI)
University of Amazonas(UFAM)
Manaus, Brasil
amourao@uea.edu.br
andreza.mourao@icomp.ufam.edu.br

José Francisco Magalhães Netto
Post-Graduate Program in Informatics (PPGI)
University of Amazonas (UFAM)
Manaus, Brasil
jnetto@icomp.ufam.edu.br

***Abstract*— This research presents the case study regarding the application of the Inclusive Model of Development and Evaluation of Accessible Learning Objects. The study was realized with undergraduate students in Computer Science. Universities in a general context need to adapt within the infrastructure, technology, training and qualification of teachers in order to meet the recent demand of Students with Special Educational Needs and Disabilities. The methodology was based on Project Based Learning, with an emphasis on the interactionist theory for the production of Accessible Learning Objects and adopted the standard Shareable Content Object Reference Model, so that the material produced is compatible with any Learning Management System. The results obtained demonstrate that the proposed teaching method has achieved significant results. The classes that participated in the case study developed their skills and acquired them through the artifacts produced, applying knowledge in their internship in public schools producing of educational solutions that support education at all levels. Also, this work allowed the motivation the group work, management, meeting schedules and activities, research, meeting standards and promoting of the importance of social and digital inclusion.**

Keywords*— *Inclusive Model, Accessible Learning Objects, Students with Educational Needs and Disabilities.

1. INTRODUCTION

This research aims to contribute to the inclusive education by means of educational models that attend a recent demand of Students with Special Educational Needs (SEND). Education is committed to inclusive schooling and to the provision of effective classroom programs that value the diversity of students. In this sense, technology has been an important ally of the learning teaching process.

Recently, the market has made available a variety of educational resources, such as: software, hardware, platforms and educational support environments, thus intensifying collaboration, inclusion and mediation to be explored by teachers [1].

In face of, the constant changes in legislation, the emphasis on broadening participation, and the growing reliance on online teaching and learning techniques have contributed to improving opportunities for students with disabilities [2].

The general problem is that the world is not yet prepared to deal with accessibility. Some more advanced countries already invest in infrastructure and educational resources to meet this real need. However, Brazil is still crawling in this context despite having already in place legislation [2] instituting the inclusion of People with Disabilities (PwD), which aims to promote social inclusion and citizenship, on an equal footing. For [3] increasing the quality and scale of innovations in education, considering educational and social systems, will positively affect education itself and benefit the whole society.

A number of actions have been taken in this direction by federal government Brazilian in conjunction with schools and higher education institutions. For [5], "although school inclusion is a reality in Brazilian legislation, there is a certain difficulty in dealing with the adequacy of the special students' demands in the daily of private and public institutions." According to the systematic review realized by the author, the results suggest gaps in scientific production aimed at the presentation of broad inclusive models.

Inclusive Models are actions that have been generating significant contributions in the educational scenario. Agreements International and National of human rights, covenants, and legislation, provide definitions that focus on equity, access, opportunity, and rights [4]. Its important highlight that all students can learn, but in different ways. The teachers know how to identify students' different learning styles and ways students learn. For [4] a broad and varied methodological approach is, thus, essential in evaluating an inclusive education system and inclusive practice in schools and classrooms.

The Inclusive Model is a project that was developed in the scope of the University of State of Amazonas (UEA), located in Amazonas - Brazil. Applied in Higher Education in Computing, in Technology Course in Analysis and Development of Systems (TADS) and Degree in Computing (DC), proposed and presented in the work of [1].

In this context, this paper presents a case study to evaluate questions related to: the production process of Accessible Learning Objects (ALO); evaluation and individual or group interaction; and the result of the artifacts produced in compliance

978-1-5386-1174-6/18/$31.00 ©2018 IEEE

the standards and guidelines established by the teacher of the discipline. The data obtained by the research were analyzed from data collection that occurred through observation techniques, interviews, questionnaires, discussions and reflections with teachers, students and specialists in the area. According to [7], regular monitoring of the evolution of student performance results brings important and significant benefits to validating learning objectives.

In summary, the goal of this case study is to present the experience and results obtained by students and teachers, in relation to the use of Project Based Learning (PBL), and the Interactionist approach [8], [9] to plan, develop and implement accessible learning objetcs. After presenting and discussing the results, we present the review realized considering the techniques used in the study, as well as suggested improvements and future work.

2. Related Work

In this section, we investigated the current state-of-the-art in areas, which thar include the development of Learning Objects, Accessible Learning Objects for students with disabilities and inclusive education. The themes are related and contribute directly to the object of study.

Macedo in [10] presents a significant contribution to teams or developers working on the development of Accessible Learning Objects. The objective of this work is to guide and support teachers in the elaboration of digital didactic materials with characteristics and functions of accessibility. The guidelines presented are the result of the analysis and the convergence of "Universal Design Principles", with the "Content Creation Recommendations Accessible Web" the World Wide Web Consortium (W3C) and the "best practices for production applications and accessible content" in the Instructional Management Systems (IMS) guides. Tests were carried out with teachers who developed Learning Objects, and who followed the recommendations and adapted their plans, methodology and resources to the contents that were developed. In this paper the author presents accessibility guidelines to treat: text, image, audio, tables and graphics.

Passerino [11] in your study presents an approach that defines, step by step, the development of an accessible learning object, considering the inclusive perspective. Also, was realized the validated the Accessible Learning Objects involving students with visual limitation.

Abdellaoui [12] presents the design of an accessible learning object model using an ontological approach and compatible with the IMS-Access specification. The researchers discussed a common problem in e-learning systems: accessibility. From their point of view, making learning content accessible by providing adaptation for several types of disabilities will help in the process of creating accessible e-learning systems. In this way, the paper highlights the importance of creating technological solutions that support inclusive education.

Batanero in [13] explores the relationship between accessible learning object and accessible web content. The study was conducted to find out the required accessibility of metadata that must necessarily be included in a learning object to attend the accessibility levels. In this way, the main contribution is the ISO/IEC 24751 standard to describe the process of using an accessible online education system, which considers the student needs and preferences and contains accessibility objects metadata for learning objects.

The main aim the study of Queiros [14] was to propose a development process for learning object that took into consideration aspects of software engineering, innovative approaches and business process management. This way, their used the Plan, Do, Check, and Act phases from the PDCA cycle, and storyboard tools. The proposed process also made use of elements from the agile methodology Scrum to manage the project and case study.

Restrepo [15] in your study, present the challenge of teaching to create accessible learning objects to higher education teachers. This way, conditions are presented to teachers, to facilitate the understanding of the barriers faced by students with disabilities. In doing so, this study resulted in new educational materials demanding creative ways to plan, develop, distribute, and evaluate them. Your paper integrates software innovation and management approaches, for the development of learning objects. The process proposed in this research was applied in a case study in which two health-related learning object were developed. In summary, are discuss the limitations that currently exist for the total autonomy of teachers when creating or validating accessible contents, as well as the limitations.

In this same context, the study conducted by Boyle [16] states that learning object development projects should begin with an analysis of student needs. The result of this analysis serves as the basis for the design and development process.

Saleh and Farouk [17] presents an attempt to estimate the levels of attitudes and practices for the e-learning course, the main research sample being composed of students with disabilities. The authors describe that e-learning can offer great opportunities for students with disabilities

Borges et al [18], in yours study, emphasize the importance of the Participatory Design (PD) in the production of High Assistive Technologies (HAT) to assist people with disabilities, supporting the teaching and learning process. The adaptation was based on the results of the systematic review, from which methods, techniques and technologies are derived to support the development of educational technologies for PwD, including the user from the beginning of the design process. The method was validated by a case study involving a child with cerebral palsy, caregivers, therapists and educators. This way, an educational assistance technology was developed to support the child in the literacy process.

Nganji et al [19] explores the personalization of learning materials for students with multiple disabilities in virtual learning environments. In addition, the authors state that existing learning environments are not all inclusive, particularly for people with multiple disabilities. However, the authors hope that developers of e-learning systems will be encouraged to design fully inclusive virtual learning environments.

The above mentioned works present significant contributions to this case study, since they show experiences and results involving learning objects, accessibility, study involving students with disabilities and models of inclusive education.

For [29] the teaching of programming concepts to students of Computer Science course has been a major challenge, because students often have difficulty understanding the subject, leading to a high dropout rate. At our institution, was the dropout rate and the index de students with disabilities, which led us to think of pedagogical strategies to attend both needs.

In doing so, the use of Learning Objects, Gamification, Dojo and Active Methodology has gained visibility in higher education, and in this way, its have been used as strategies of teaching and learning, with the objective of attending to all the students independent of their disabilities.

In face of, this work has as a difference of the above mentioned works, wich present an approach educational and the results achieved with classroom practice by means of an inclusive model. Therefore, we conducted a case study with two class of the Computation, using a active methodology to teach accessible learning objects concepts, with the objective of validating the inclusive model proposed by [1]. The study presents the results achieved by students from the standpoint of teacher which conducted all process and by experts involved in the evaluations.

3. Case Study

This case study is classified as a structured research method [20], which was applied in two educational contexts, to contribute with learning and pratices individual and group, of students matriculate in higher education courses in Computing.

In this study, the perspectives proposed by [20] and [21] were considered, considering the use of the case study method in the field of educational research. For Creswell, Hanson, Plano, and Morales [23], Yin [20], Merriam [21] and Stake [22] are considered seminal authors who provide procedures that assist educational researchers in conducting case studies. Providing in this way, the concepts and definition of the dimensions necessary to conduct this study.

The research is empirical and has as objective to investigate students during the development process of the learning objects. According to [24], Learning Objects are digital sources that can be used for more active teaching approaches.

The purpose of the study is to contribute to the enrichment of the process of teaching and learning in the classroom and to the engagement of teachers and students in an inclusive educational process. Therefore, the main objective of this case study is to explore, describe and explain the methodology and results obtained, aiming to improve the Accessible Learning Objects development process, as well as to generate new artifacts, methods, strategies and techniques, that contribute to the inclusive model proposed.

In face of, the case study was carried out based on the Inclusive Model, idealized and implemented through an educational project. The application of the project occurred in the courses of Degree in Computing, in the discipline of Advanced Topics (seventh semester) and Technology in Analysis and Development of Systems, in the discipline of Multimedia Systems (fifth semester).

This research has a methodological approach where the researcher is the main interested in the investigation. The data obtained by the research were analyzed through data collection that occurred by means of observation techniques, interviews, questionnaires, discussions and reflections with teachers, students and specialists in the area.

Therefore, the project was consolidated based on the teacher's lesson plan, using the interactionist paradigm [8], [9] and the active methodology project based learning. The study shows the experience acquired by upper-level students in computing by using technologies to solve cases related to the area of computing and education, meeting standards and guidelines for accessibility.

In doing so, it is possible to analyze and evidence the skills and competences obtained by the students, based on established project goals and planning.

This study is presented as a pedagogical tool capable of analyzing and evaluating the scenario, analyze the evidence, generate arguments, identify the results and propose solutions. Contributions will reflect on teachers' pedagogical practices and the challenging situations that students are subjected to in academia and the job market.

The Inclusive Model was developed by means of a project, divided into five processes: the planning process, the development process, the validation process, the monitoring and control process, and the closure process. These processes were adapted to attend the three stages defined for the development of the Acessible Learning Objects defined by [1]. Figure 1 shows the life cycle defined for the project.

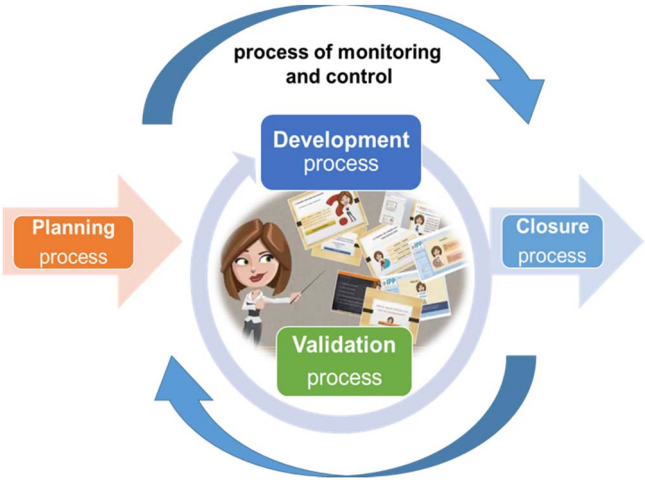

Fig. 1. Life cycle of the Inclusive Model, proposed by [1].

With regard to monitoring and control process, it was realized by the professor of the discipline, defined as project manager, that controlled all the variation occurred during the process. The variations were identified based on the timing and scope defined in the planning. The teacher makes sure that deliveries are aligned with the scope of the project, adapt the changes and confirm the expected level of quality of work that is in progress. Groups and teacher maintains communication to align deliveries and realization of activities.

The methodology used for the development of the Inclusive Model in accordance with [1] was specified in three stages, which correspond respectively the planning, development and validation processes show in Figure 1, described below:

1) *First Stage - Planning*: initial stage of project opening, responsible for the definition of the pedagogical approach (interactionist paradigm), preparation of the lesson plan (by instructional unit), project schedule (including accessibility items to be implemented) and pedagogical design (Storyboard Technique).

2) *Second Stage - Development:* stage responsible for the definition of the model used and the tool for developing accessible learning objects, in accordance with accessibility standards and guidelines.

3) *Third Stage - Validation:* stage responsible for evaluations of: learning, teaching, accessibility and usability, which was realized with specialists in the area of education, informatics in education and usability.

The closing process is the last step of the project, responsible for the completion of the project and formalization of the delivery of the artifacts, after the last adjustments requested.

First of all, the students were trained through theoretical classes, where it was presented tools, besides prototypes, standards, guidelines, models of repositories to store Learning Objects and accessibility requirements, to be implemented in the model. Next, was show the project and its respective processes, composed of a set of activities (Figure 2).

Regarding the information and strategies, as well as the deadlines, have been described by means of a schedule in which all teams followed. The management and monitoring of activities and compliance with deadlines remained under the responsibility of the teacher researcher. The class was divided into groups of three students, where each had a defined role in the context of the project.

As shown in Figure 2, the Inclusive Model was developed through a project defined using the PBL approach, whose teaching method is widely used [25]. This teaching methodology was defined in the planning stage. This choice was motivated by being considered a dynamic approach when used in the classroom. In this approach students explore real-world problems and challenges and acquire a specific knowledge. It is a teaching method in which students acquire the knowledge and skills to investigate and respond to a problem or challenge, motivating them from the beginning to the end of the process.

One of the main features of PBL is that it is process oriented. To [28], adopt this approach is only effective when it is ensured that the process steps are managed and conducted in alignment with each other.

The project life cycle introduced in Figure 1, was defined based on the project approach, making use of Project Management Body of Knowledge (PMBOK®), considered as a Guide to Project Management of Project Management Institute (PMI), and its in 6th edition [26].

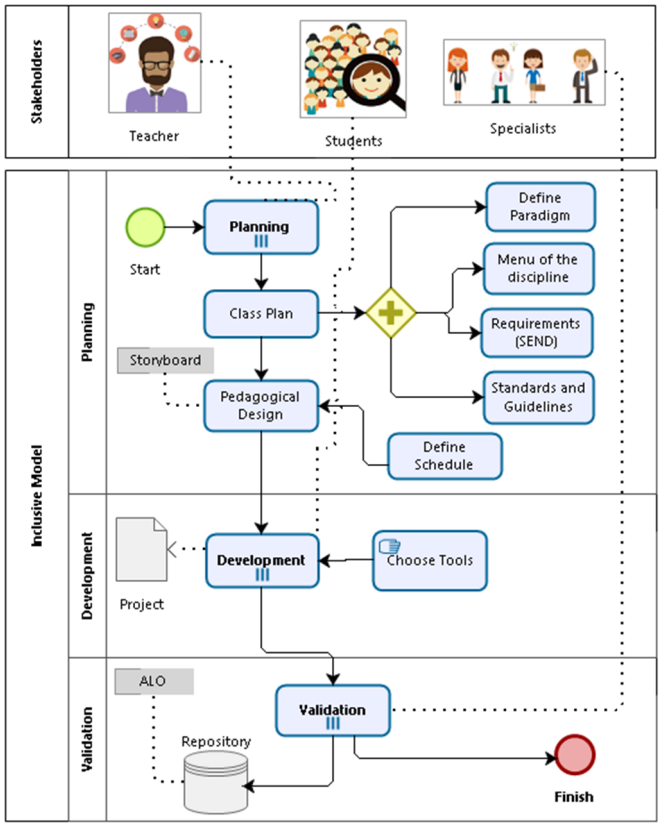

Fig. 2. Stages of the Inclusive Model proposed by [1].

In the planning stage, interested parts were identified as: Stakeholders, composed of: university, teacher, students, and specialists in the following areas: education, usability and computer in education. The interested parts in the project or stakeholders can impact or be impacted by a project decision, activity or results of project [26].

In this context, the teacher is the project manager responsible for assigning tasks, controlling and monitoring all processes, delivering artifacts and performing interventions when necessary. In this sense, the educational interventions are orientations made by the teacher in the school activities with the objective of creating in the teaching and learning process possibilities of constructions that promote the student's learning.

During the process there were two interventions. The first one was realized in the planning stage to make adjustments to the schedules, activities, tools, standards, accessibility guidelines and storyboards. The second intervention occurred in the development stage, performing the first validations in accordance with the requirements defined in the planning stage. Allowing the students to make the adjustments before the final validation of the specialists, were realized evaluations between groups, and between teacher-group.

The items were defined according to the requirements presented, such as: theme or instructional unit, the general and specific objective of the lesson, duration, program content, methodology, evaluation form and bibliographic reference. The schedule of activities was developed together with the students, considering the institutional calendar. This way, the dates and

deadlines for delivery, development, testing and project evaluations were defined in accordance with the regular period of the course, and considering the accessibility requirements of the project.

Regarding the pedagogical design elaborated were used of the storyboard technique, and was developed in accordance with the programmatic content described in the teaching plan of the discipline. In this way, the scenes were created according to the established script.

With regard to use of the storyboarding technique allowed the student to obtain a project view and implementation. For the development of the scenes, pictures and evaluations, the students consulted with specialists in the area. Teachers contributed to the educational objectives and strategies used, thus allowing clarity in the definition of the instructional sequence. Figure 3, below, represents the navigational model of the scenes, created in the *StoryboardThat* tool, available on the web in free edition. The storyboard refers to the discipline of Programming Logic, whose content is Algorithms (Narrative Description, Flowchart and Portugol).

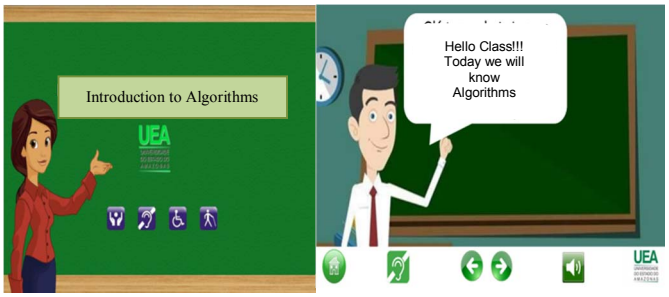

Fig. 3. *Storyboard* of the Accessible Learning Object: Algorithms by [1].

In accordance with the planned, the developed storyboard was introduced to the teacher and other groups for critical feedback. After the suggestions, the model passed by improvements and followed to the development stage.

In the development stage, the students conducted researched and had theoretical classes regarding the models used to develop Learning Objects, repositories, standards and accessibility guidelines. In doing so, the use of the ADDIE Model (Analysis, Design, Development, Implementation and Evaluation) [27] was defined as a reference for the development of the inclusive model, in accordance with its structure and characteristics. According with stages described by [1], were followed the five steps of the ADDIE model and adopted the SCORM and IMS standards.

Initially, the Visual Class was the authoring system defined by teachear and wich the institution has the software license. The tool is an authoring software and create Learning Objects for the standard Web and eXtensible Markup Language (XML) [1]. In a second moment, the choice of the tool were suggested by the group, but with the teacher's approval. Therefore, if there were no impediments of license and standards, the tool was released for to use.

In the validation stage, the specialists acted by completing an ALO evaluation questionnaire, which included items related to: learning, teaching, usability and accessibility requirements. They also contributed their points of view based on analysis, criticism and suggestions, allowing students to make the final corrections in learning objects. Figure 4 show the students exposition the objects.

Fig. 4. Students of the class TADS.

After the presentation, the questionnaires were applied with teachers, specialists and students who self-assessed and evaluated the other groups. Figure 5 shows students and teacher after the final presentation of objects.

Fig. 5. Students of the class TADS and Teacher researcher.

4. Results and Discussions

Considering the stages realized in the previous sections the results were obtained, as explained in this section.

For the accomplishment of this work, the case study was used according to Yin [20], as a research strategy and the data were analyzed qualitatively. The qualitative investigation requires that the researcher be flexible, able to observe and interact with the participants. In this way, the case study is presented as a research strategy that includes a method that covers specific approaches to data collection and analysis [13].

With regard to PBL active methodology, this allowed to stimulate an active attitude of the student in search of knowledge and not merely informative as is the case of traditional pedagogy.

Infact the methodology enabled teachers and students to followed a process established through stages to fulfill the

delivery of the inclusive model. This way, it was possible to meet the schedule defined in the planning stage, monitoring and controlling the deliveries and realizing the pedagogical interventions.

The data collection was based on the observation, analysis and evaluation of the teacher of the discipline, interview and questionnaires realized by specialists, interaction and accomplishment of tasks, group work, decision making and results obtained by the teams involved in the project.

From the stand point of diagnostic and mediator, a constant evaluation allows the teacher to identify the progress and difficulties of each student or group of students. This way, the teachers' performance and pedagogical intervention in the teaching and learning process brought significant results.

In face of the data analysis, the results obtained from the teacher's point of view considered the two classes involved: DC and TADS, as previously mentioned.

*A. The class of **Degree in Computing**, considering the following steps, obtained the following results:*

- At the **Planning stage**, the students did not present difficulties regarding the understanding and elaboration of the model and adequately filled out the model of the lesson plan available. They inserted the accessibility requirements in accordance with the standards and guidelines presented by Macedo [10]. As for the timeline, all steps were met within the expected, except the development stage that there was a need to extend one week. As to elaboration of the pedagogical design, the students felt no difficulty with stoyboard technique and they complied the goal.
- At the **Development stage**, the class used the authoring tool: Visual Class, because the students had familiarity and experience. The difficulty presented in relation to the tool is related to the limitation of resources that are offered by it. The accessibility guidelines were used appropriately; the groups focused on specific deficiencies and followed the corresponding standards. The following media were used: audio, text, tables, moving images, graphics. There were interventions to make small adjustments..
- At the **Validation stage**, it was found that some groups presented difficulty in programming, and the insertion of accessibility requirements, as well as the adequate distribution of content. These difficulties were corrected through pedagogical intervention. After the last corrections the objects were conducted for the validation with specialists. In this sense, they expressed their criticisms and suggestions for improvements. Regarding the items of usability and accessibility they recommended that be realized in parallel and in accordance with the standards. About the content, all the Accessible Learning Objects was approved, but they emphasized the importance of including evaluation in the artifacts, as a function of the feedback, in this question only 80% complied the delivery.

*B. The class of **Technology in Analysis and Development of Systems**, considering the following steps, obtained the following results:*

- At the **Planning stage**, students presented difficulties in understanding, modeling, completing and inserting the accessibility requirements in the lesson plan. The difficulty presented is related to the fact that wich their skills and competences are directed to computational and non-educational areas. In this way, the pedagogical intervention was necessary to provide the knowledge and to work the deficiencies presented. Therefore, there was a delay of two days in the schedule, aiming at the successful accomplisment of the activities. Considering the pedagogical design, the students did not difficulty with storyboard technique, but they requested the use of other techniques, which they had experience. This way, was used the prototyping techniques and Mockups.
- At the **Development stage**, the class used the Visual Class, Scratch, Unity Engine, and Alice authoring tool. The students opted for the use of other technologies because the limitations presented by the Visual Class tool, especially in the programming question. Therefore, the students were authorized to use other technologies, because they had familiarity with the tools. They adequately used the accessibility guidelines, selecting the appropriate media to the context, and were realized small interventions with the objective of aligning contents and evaluations.
- At the **Validation stage**, the number of interventions was smaller, specifically to assist in the search of the specific technological to support the types of disability. They did not present difficulties in the implementation of the requirements of accessibility and the distribution of the contents and they stood out in the programming of the objects. Therefore, the ALO developed in this class presented excellent usability, evaluation and feedback of the contents worked and availability.

Data analysis considered the evaluative items applied in the two courses involved in the case study. In this sense, the direct observation and the performance evaluation questionnaires of the students were considered.

Concerning analyze both classes from the teacher's point of view, it was evidenced that the Degree in Computing class excelled in the planning stage, regarding the preparation of the lesson plan and completion of the stage, obtaining 100% of success. In this same analysis performed with the TADS class, we can emphasize the difficulty presented by the group in the planning stage, which required the intervention and the addition of two days in the schedule, thus obtaining 60% of success.

The Degree in Computing group in the development phase presented difficulties in the use of the tool, and with the programming aspect, where interventions were necessary to support the progress of the activity. However, the TADS class was skilled at using the tools, delivering the artifacts and improving the objects, resulting in an small number of errors.

Regarding the stage of validation of the objects the DC group, realized adjustments related to the availability of content,

and accessibility in accordance with the evaluation item. The negative point of this class was the lack of skill with the technological tools. However, the TADS class met the requirements defined in the lesson plan, being in compliance with accessibility.

Analyzing both courses, experts felt that the following adjustments were necessary: improving ALO in the concept of teaching and learning, adapting them to objectives and instructional content, ensuring granularity and reuse. In terms of usability, the emphasize improvement points were simple and intuitive objects that promote learning facility and error tolerance. As for accessibility, it is necessary to improve the information overload, the adequacy of the content in sign language and make them compatible with assistive technologies.

This case study sought to evidence student performance throughout the Accessible Learning Objects development process. Showed the collaboration between teams, the exchanged experiences, the learn by pratice, promoted inclusive education through interaction and socialization, and at the end of the process deliver an artifact that meets the proposed inclusive model.

To validate the project, was realized evaluations of: context, input, process and artifact evaluation of ALO.

At the context evaluation, were checked, if the variables social, organizational and contextual associated with the need to develop accessible learning objects were investigated. In the same way, that the input evaluation sought to perform the comparison of inputs and alternative means to meet the needs identified and in accordance to the context defined. Whereas the evaluation of the process evaluated in a formative way the planning, design, development and validation of the Accessible Learning Objects. As well as, the efforts and achievements that were acquired and exercised at this stage.

The evaluation of the artifact allowed the realization to criticize and summative judgments regarding the quality, usefulness and value of the learning objects and infrastructures that support them.

Evaluations are key factors in consolidating the case study. In this way, this study allowed to emphasize the posture, the commitment, and the stimulus that the learning based on projects, can promote in a classroom. The classes with an inclusive approach, besides promoting a valuable educational project, helped in the socialization, promoted a social and digital concern, and contributed to the construction of group knowledge.

Students started to identify the needs presented by some of their peers, thus suggesting improvements in the educational system, and supporting the use of new technologies to support the inclusive teaching and learning process.

It is a hard work to reform the entire education system, to invest and to make students and teachers aware of the importance of including people with disabilities in all areas. In this sense, it is important to create conditions, structures and spaces for promote diversity of students. It is necessary to transform not only the infrastructure of educational institutions, but the attitude, posture and mentality of educators, and the school community in general, to learn to live naturally with differences.

According to experts [1], [4], [6], [14], [15], [18], [29], the inclusive models developed support the learning of students with and without disabilities and allow social and digital inclusion to occur naturally in the classroom.

Finally, the Accessible Learning Objects are the result of collaborative work realized with great competence and dedication by students of the UEA motivated by the idea of benefiting students with disabilities.

5. CONCLUSIONS

This paper presents a case study realized with students of the Higher Education in Computing: Technology Course in Analysis and Development of Systems and Degree in Computing, matriculate in the discipline of Advanced Topics and Multimedia Systems of UEA, located in Manaus, Amazonas, Brazil. The students of the Degree in Computing declared that they intend to apply their knowledge in their discipline of teaching internship, collaborating and practicing in the process of teaching and learning at public schools.The students of TADS affirmed that they have never had experience of implementing or thought about developing educational applications or systems, and they felt motivated to develop new artifacts.

The case study was realized with the purpose of validating the Accessible Learning Objects development project proposed by [1]. Also, show the defined processes, the use of the PBL active methodology, the experience and performance obtained by the students, the autonomy, collaboration and interaction provided during the process.

The project allowed the consolidation and use of different models and tools, to be used in accordance with instructional objectives, teaching strategies, standards and accessibility guidelines. This way, if the processes defined in the Inclusive Model are followed suitably, the ALO development results in a traditional classroom will bring positive impacts and contributions to inclusive education.

In the planning stage, it was verified that the pedagogical material inserted in the activities is in accordance with the educational objectives appropriate to the age group and target audience of the proposal. In the development stage, it noticed some limitations in relation to the Visual Class software, because when required some functionality, resulted in the use of new strategies and content adaptations and evaluation formats. In the validation stage, the relevance of the application of the questionnaires and the involvement of the specialists was verified, which allowed the Accessible Learning Objects to be evaluated with expertise. The qualities and limitations presented were considered, with the objective to improve the process, and the use of specific tools depending on the type and level of disability presented. The qualitative data generated served as a reference for ALO improvements. The problems or limitations identified in the Accessible Learning Objects were resolved.

It can be observed that the educational and computational concepts could be identified and absorbed throughout the design stages. The practices promoted interaction, collaboration,

formulation of strategies, compliance with deadlines, monitoring and control of activities, definition of roles, design, implementation, evaluation and testing of artifacts produced. The concern with quality, standards, availability, reuse, and granularity were predominant factors from the beginning to the end of ALO development.

The results demonstrate that the students' abilities and competences were acquired and improved, and could be applied in the course during their practices. It also opens borders for students in the area of technologies to develop applications focused on the educational context, in particular the inclusive.

As future work, we plan to use instructional and computational design in Accessible Learning Objects development. We intend to use the concepts of disruptive innovation in the process, thus using requirements engineering.

In another aspect, we also plan that Accessible Learning Objects can be developed by computing teachers. In doing so, another case study, in search of empirical evidence under the teaching perspective. Besides that, apply the model in an inclusive classroom, composed of students without disabilities and with disabilities, to obtain results of the proposed inclusion models according to a new paradigm and format.

ACKNOWLEDGMENT

We would like to thank the University of State of Amazonas (UEA) located in Manaus, Amazonas, Brazil, for the support for realization of the doctoral research project, which this paper belongs.

REFERENCES

[1] Mourão, Andreza Bastos; Netto, José Francisco M.. (2016). "Inclusive Model of Development and Assessment of Accessible Learning Objects for Higher Education in Computing". In: Brazilian Congress of Informatics in Education (CBIE) - Uberlândia – MG.

[2] Brasil-C. Decree nº 13.146, July, 6th, 2015. (2017). Provides for the Brazilian Law on the Inclusion of Persons with Disabilities. Available in: http://www.planalto.gov.br/ccivil_03/_Ato2015-2018/2015/Lei/L13146.htm. Access in: January, 20 th, 2017.

[3] Peter Serdyukov, (2017) "Innovation in education: what works, what doesn't, and what to do about it?", Journal of Research in Innovative Teaching & Learning, Vol. 10, Issue: 1, pp.4-33.

[4] Forlin, C., & Chambers, D. (2013). Inclusive education for students with disability part two: A review of the non-government sector in Australia, research report prepared by the Australian Research Alliance for Children and Youth (ARACY) for the Australian Government Department of Education, Employment and Workplace Relations. Canberra.

[5] Brasil-C. Decree nº 13.146, July, 6 th, 2015. (2018). Provides for the Brazilian Law on the Inclusion of Persons with Disabilities. Available in:http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2015/lei/l13146.htm. Access in: Janaury, 20 th, 2018.

[6] L. Luque, L. de Oliveira Brandão, E. Kira, A. Alves and F. Brandão. (2017). Inclusion in computing and engineering education: Perceptions and learning in diagram-based e-learning classes with blind and sighted learners, 2017 IEEE Frontiers in Education Conference (FIE), Indianapolis, IN, 2017, pp. 1-8.

[7] Malvezzi W. R., Mourão A. B. and G. Bressan. (2010). Learning evaluation in Classroom mediated by technology model using fuzzy logic at the University of Amazonas State. IEEE Frontiers in Education Conference (FIE), Washington, DC, 2010.

[8] Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

[9] Piaget, J. (1976). The grasp of consciousness: Action and concept in the young child. Cambridge, MA: Harvard University Press.

[10] Macedo, Claudia M.S, Ulbricht, Vânia R. (2012). Accessibility Guidelines for the Development of Learning Objects, Procedia Computer Science, Volume 14, 2012, Pages 155-162.

[11] Passerino, L., & Santarosa, L. (2008). Autism and Digital Learning Environments: Processes of Interaction and Mediation. Computers & Education, 51, 385-402.

[12] Abdellaoui, H., Ben Mohamed, M. A., Bacha, K., & Zrigui, M. (2013). Ontology based description of an accessible learning object. 2013 4th International Conference on Information and Communication Technology and Accessibility, ICTA 2013.

[13] Batanero, C., Karhu, M., Holvikivi, J., Oton, S., & Amado-Salvatierra, H. R. (2014). A method to evaluate accessibility in E-learning education systems. Proceedings - IEEE 14th International Conference on Advanced Learning Technologies, ICALT 2014.

[14] Queiros, L. M.; Da Silveira, D. S.; Da Silva, C. N.; Vilar, G.: (2016) LODPRO: learning objects development process. In: Journal of the Brazilian Computer Society. v. 1, n. 22, pp. 1—9, 2016.

[15] Restrepo, Emmanuelle Gutiérrez Y, Carlos Benavidez, and Henry Gutiérrez. (2012). The Challenge of Teaching to Create Accessible Learning Objects to Higher Education Lecturers. Procedia Computer Science 14.Dsai, 2012.

[16] Boyle, T.; Cook, J.; Windle, R.; Wharrad, H.; Jeeder, D.; Alton, Rob.. (2006). An Agile method for developing learning objects. Proceedings of the 23rd annual ascilite conference: Who's learning? Whose technology? Sydney, Australia, 2006.

[17] Saleh A. F. M. and Farouk A. F. A.(2013). Students with Disabilities Attitudes towards E-Learning Courses in Developing Countries. Fourth International Conference on e-Learning. Best Practices in Management, Design and Development of e-Courses: Standards of Excellence and Creativity, Manama, 2013, pp. 253-257.

[18] Borges L. C. L. F., Araujo M. R. R., C. Maciel and E. P. S. Nunes, (2016). Participatory design for the development of inclusive educational technologies: A systematic review. IEEE Frontiers in Education Conference (FIE), Eire, PA, 2016, pp. 1-9.

[19] Nganji, J. T., & Brayshaw, M. (2015). Personalizing learning materials for students with multiple disabilities in virtual learning environments. Proceedings of the 2015 Science and Information Conference, SAI 2015, 69–76.

[20] Yin, R. K. (2002). Case study research: Design and methods. Thousand Oaks, CA: SAGE Publications.

[21] Merriam, S. B. (1998). Qualitative research and case study applications in education. San Francisco, CA: Jossey-Bass.

[22] Stake, R. E. (1995). The art of case study research. Thousand Oaks, CA: SAGE Publications.

[23] Creswell, J. W., Hanson, W. E., Plano, V. L. C., & Morales, A. (2007). Qualitative research designs selection and implementation. The Counseling Psychologist, 35(2), 236-264.

[24] Penteado, B. E., Tiosso, F., & Carlos, S..(2016). Eliciting features to build collaborative learning objects. IEEE Frontiers in Education Conference (FIE), Eire, PA, 2016.

[25] Robert Pucher, Martin Lehner. (2011). Project Based Learning in Computer Science: A Review of More than 500 Projects. Procedia - Social and Behavioral Sciences, Volume 29, 2011, Pages 1561-1566, ISSN 1877-0428.

[26] PMI, Project Management Institute. (2017). PMBOK®: Guide to the Project Management Body of Knowledge. 6ed., Pennsylvania: PMI, 2017.

[27] Branch R. M. (2009). Instructional Design: The ADDIE Approach. Springer Science and Business Media, LLC.

[28] A. N. Rodrigues and S. C. dos Santos. (2016). A framework for applying problem-based learning to Computing Education," 2016 IEEE Frontiers in Education Conference (FIE), Erie, PA, USA, 2016, pp. 1-7.

[29] Begosso, L. R., Begosso, R. H., & Paulo, S.. (2016). An approach for the use of Learning Objects in teaching Computer Programming concepts. In 2016 IEEE Frontiers in Education Conference, October 2016.