Project-Based Learning applied in pre-service teacher education

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Abstract

Applying, instead of merely discussing, students centered teaching methods in teacher education can be a challenging endeavor. In this work we discuss the adaptation of Project Based Learning (PBL), which in the literature is usually discussed targeting secondary-level pedagogy in developed countries, to suit the needs of adult learners attending teacher education evening classes in one of the least developed regions in Brazil. Contrasting the advice given in literature with experimental results obtained in Alagoas, we find that in comparison to teenagers, adult learners need more freedom to bring in their strongly varying backgrounds, as well as more practice in peer- and self-evaluation. We also note that an effective implementation of PBL in teacher education requires changes in the overall curriculum to avoid shortfalls in content knowledge and to foster the learner's self-efficacy to later on applying these techniques in class themselves.

Keywords: Project Based Learning, Teacher Education, Andragogy.

Resumen

Aplicar, en lugar de limitarse a discutir, puede ser una tarea difícil cuando los estudiantes están centrados en los métodos de enseñanza de la formación del profesorado, En este trabajo se discute la adaptación del Aprendizaje Basado en Proyectos (ABP), que en la literatura es controversial en cuanto a la orientación pedagógica de nivel secundaria, en los países desarrollados. En este caso en una de las regiones menos desarrolladas en Brasil debe adaptarse a las necesidades de los estudiantes adultos que asisten a clases nocturnas para formación del profesorado. Contrastando los consejos dados en la literatura, con los resultados experimentales obtenidos en Alagoas, nos encontramos con que: en comparación con los adolescentes, los estudiantes adultos necesitan más flexibilidad para poder cambiar los diversos antecedentes que ellos tienen. Así como, más práctica en mirar con atención y más autoevaluación. También observamos que la aplicación eficaz del ABP en la formación docente, requiere cambios en el plan de estudios general, para evitar deficiencias en el conocimiento del contenido. Y se requiere fomentar la autoeficacia del estudiante, para que más adelante la aplicación de estas técnicas en clase lo haga por sí mismo.

Palabras clave: Aprendizaje basado en proyectos, Formación del profesorado, Andragogía.

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I. INTRODUCTION

Project based learning (PBL) is a didactic method that is known to increase most student's engagement and foster skills [1, 2], which is an increasingly important aspect in teaching [3]. It is therefore a valuable tool in a teacher's toolbox and it discussed, in theory, in many teacher education programs. However, in Brazil it is seldom applied in a teacher education courses itself and consequently rarely adapted by the new teachers in praxis: having never experienced PBL from the learner perspective, many new teachers feel insufficiently prepared and thus refrain from applying this powerful method in class.

On the other hand, it is not as straightforward as one might assume to implement PBL in teacher education courses. While most of the literature on the topic refers to a secondary-school setting in developed countries, the situation in teacher education courses for adults in developing countries like Brazil differs in several significant ways. These aspects need to be taken into account and addressed to avoid a discouraging experience for the participants. In this work we review some of the respective literature, discuss necessary adaptations and test them in a 2nd year teacher education course on science education for future math teachers at the Instituto Federal de Alagoas in Brazil (IFAL).

Although we find that the resulting course layout was very well received by the students and exceeded our own expectations in some aspects, we also identify and discuss weaknesses of the approach that require improvement for future implementations. The remainder of the paper is structured as follows: We first contrast the specific setting for teacher education encountered in the test environment to the situation commonly assumed in literature. We then

review some of the literature with a focus on the PBL framework suggested by Carl Rogers [4], which we used as a base for the course development. After discussing the specifics of adapting and implementing the suggestions made in literature to suit the particularities of adult learners with weak educational background in evening classes, we close by discussing observations in a test course and their respective implications for embedding PBL in the Instituto Federal's teacher education course curriculum

II. IMPLEMENTING PBL IN TEACHER EDUCATION

In planning and implementing a pre-service teacher education course design based on PBL for the IFAL, we encountered not only challenges but also some advantages originating from the fact that course participants are not the teenagers in a secondary school of a developed country usually assumed in the literature [5]. Below we summarize the most important characteristics of the course setting and discuss their implications for the course design.

1) The **educational system in Alagoas**, the poorest state in Brazil, has severe difficulties, which affect both the students' own educational background as well as their future workplaces. Due to the absence of effective public policies, one major socioeconomic problems, among others, is illiteracy, affecting 24.6 % of the population, while 36.5 % are known to be functionally illiterate [6].

In 2012, the PISA study [7], conducted by the OECD, revealed that Alagoas' students not only have the lowest educational level in all three subject areas tested by the study (mathematics, reading and science) in the whole country, but that for all three areas their results are even below the respective score in any of the 65 countries and economies around the globe participating in the study[8].

While these numbers describe the current situation of 15 years old students, some of the course participants, as will be shown below, have left schools more than 10 years ago, when the educational system was even worse.

Consequently, the content knowledge [9] of future teachers originating from this environment is rather low and their own pedagogical experiences usually limited to ex-cathedra teaching. We furthermore noted the cultural phenomena that students hesitate to assume responsibility for their own learning. Within the given limitations, the course design had therefore to allocate sufficient time for the students to adapt to the unfamiliar responsibilities and procedures related to PBL.

We also saw the need for several theoretical lessons on how to structure and write project related documents such as reports, workplans or even meeting minutes.

2) Almost all "licenciatura" (teacher education) course participants at IFAL are **working adults** with family obligations, attending the course in evening classes. Due to competing duties at work, home and university, their course attendance is sometimes irregular and marked by fatigue, as observed in an earlier work by Togni and Carvalho [10].

Under the given conditions, we assumed that the participants had relatively little time for class work or project meetings outside the scheduled lessons.

While this was a significant hurdle for some of the participants, it turned out to be less of an obstacle than expected. In contrary, out of school meetings of project groups, e.g. on weekends, compensated partially for missed lessons in the evening classes. We learned that in comparison to teenagers, adult learners with multiple obligations benefit from a greater freedom to allocate their time, as long as deadlines and objectives are clearly communicated.

A second important factor is that the students were adults, meaning that one must also pay attention to the learning characteristics of this period of life [11], as well as the different kind of relationships they develop with fellow students and the teacher. Malcolm Knowles [12, 13] identifies the prerequisites for a successful formal learning situation with adults (andragogy) as: establishing a climate of mutual respect for each other's experience; involving the learner in the planning and evaluation of her instruction, clearly explaining the purpose and relevance of the learning objectives, and teaching problem-centered rather than content-oriented. Since adult learners are intrinsically motivated and self-directed, PBL thus appears to be even more suitable for adults than for teenager.

We therefore designed the course layout such that the students were encouraged to incorporate their professional experience and personal interests, which John Dewey [14] called aptly 'dawning capacities', in their project work.

Relative to younger secondary-level learners, a much greater importance in the course design was laid on self- and peer-evaluation; already for the practical reason that a fair evaluation of project work is one of the greatest challenges the new teachers will face when applying PBL later on in class.

3) Although trained as math teachers, recent research shows that the new teachers will be also employed to teach science subjects such as physics, chemistry, and at times biology [15]. In a pre-course survey, a majority of the participants indicated a low to no interest in science subjects compared to math.

Teachers with negative **attitude towards science** can have a highly demotivating impact on their science-interested students, thus adding to the already problematic lack of scientists and engineers in South America [16]. The course therefore also aimed at connecting the student's personal interests with science topics in order to improve their attitude towards science.

III. PBL IN THE LITERATURE AND ITS APPLICATION

Phyllis Blumenfeld and coworkers defined project based learning as "comprehensive approach to classroom teaching and learning that is designed to engage students in investigation of authentic problems"[17]. While they focus on the motivational effect that real-world problems may

have on children, PBL offers another, maybe even more important feature, by encouraging learners to contribute to the project and thus to their own learning with their specific knowledge, experience and skills. The individual learning process thus automatically builds on the student's current educational development, which, according to David Ausubel, is an important precondition to facilitate meaningful learning [18].

In another work, Ausubel [19] lists as further requirements for meaningful learning that learning objectives are relevant to the learner, and that the learner is willing to relate it to her cognitive structure. In the given case of adult learners with a large variety in their respective vitas, both professionally and private, the best solution to account for this broad range of interests and backgrounds was to give students a greater freedom in choosing their project topic, while at the same time providing a clearly defined common objective.

Carl Rogers was a psychologist who stressed the need of learner-centered teaching, because, as he argues, "A person learns significantly only those things that are perceived as being involved in the maintenance of or enhancement of the structure of self"[20]. His assumption of the intrinsically motivated learner corresponds well with Malcolm Knowles description of an adult learner discussed above. Carl Rogers also expresses his conviction that "the only man who is educated is the one who has learned how to learn, how to adapt and change, the one who knows that no knowledge is secure"[21], a concept which today is commonly framed as "lifelong learning " of adults throughout their worklife. Since his theories seem more compatible with andragogy than *e.g.* frameworks originating in constructivism with focus on child development [5], we based the course design on the Roger's "project method"[21], which he defined by the following characteristics:

1. In order to facilitate self-initiated learning, the student needs to face a problem that he recognizes as relevant for himself.
2. The teacher's responsibility is to provide adequate resources.
3. Students sign a contract detailing the project and learning objectives.
4. Students work in learning facilitating groups.
5. The teacher builds a positive environment, providing assistance and guidance without restricting independent learning.
6. The teaching approach makes use of simulations of real-world situation.

The first item in this list, which is also stressed by Malcolm Knowles for the effective teaching of adults, has been addressed by giving the course participants the freedom to choose their own research topic. The only given constrain was that the project has to produce a tangible educational resource for teaching science at a secondary school.

This allowed each student to make use of her particular educational and professional background.

Although the teacher offered the use of the university's laboratories also outside the regular school hours, the responsibility for providing the required resources lay with the students. This included the search of related literature as well as the material to build and test the educational product. Violating the second point on Rogers, list was intended to hone the students' ability to find and select material for teaching – an important teacher skill. Due to group's feedback and a vivid exchange of sources among students, the groups succeeded in finding the required literature as well as low-cost solutions for their educational product.

Rogers' framework includes a contract between the teacher and the learner about the project and learning objectives. We incorporated this in the course design by simulating the process required for project funding by a research agency. The student's had to write and sign a brief project proposal, a slightly more detailed work plan with a definition of the deliverable, as well as to file a final report.

Teaching the course participants how to structure and write such documents costs several hours from the course's time budget, but it also provides students with valuable additional skills.

The forth item on Rogers' list, the building of project groups, was also left to the students, as long as each group had no more than 4 members. Since the students take classes together for more than a year, the groups structured very rapidly and no frictions within the groups was observable for the teacher over the period of the course. Similarly, the teacher also limited the interference with the group work mainly to enforcing the deadlines for and giving feedback on the documents and presentation produced by the groups.

Later on, when the course participants apply PBL in their own teaching, they will face the difficulty to assess the project work and give students a fair mark for their individual contributions. To train this specific skill, each student had to assess at two occasions the project presentations of all other groups. Additionally, each group had to reflect on its own work (self-evaluation) in the group's final report. In order to avoid distortions in these peer and self-evaluations observed by Hye-Jung Lee and his co-worker [22], we provided an evaluation guideline with the assessment criteria ahead of the project presentations.

According to Oswaldo Frota-Pessoa's [23] suggestion, each group gave a class presentation on their progress and presented their respective project deliverable, a tangible didactic tool, in a small science fair which also marked the course end. In comparison, adult learners seem to appreciate this form of communicating their results to peers more than younger students. This became particular evident when one group, on its own initiative, submitted their results, and, upon acceptance, enthusiastically presented them at a local conference.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

In 2013, the course design described above was implemented and tested in a 2nd year pre-service teacher

education course on science education for future math teachers at the Instituto Federal de Alagoas in Brazil. None of the students had previous experience with PBL. In order to get a better understanding of the participants, their situation and their view on the course layout, we employed a pre-course questionnaire and conducted semi-structured interviews at the course end (after the final presentation yet before the participants knew their individual marks). Additionally, we evaluated the written material produced by the groups, namely their project description, work plan, meeting minutes, presentations, peer-evaluations for presentations and final reports.

The 6 groups developed the following educational resources for teaching science at a secondary level:

1. A solar powered water heater
2. A board game for teaching math
3. A low-cost distiller for chemistry classes
4. A wind turbine to generate electrical energy
5. An electromagnetic cannon
6. A filter to generate portable water from rainwater [not completed]

Interestingly enough, the participants' financial limitations in providing material to build educational resources, which was one of the students primary concerns at the beginning of the course, was transformed by the students into an innovation driver. All groups found ways to employ low-cost materials and focused on smart and sustainable use of resources, thus making the educational resources they developed easier to reproduce by other teachers in the region.

To provide a better insight, we will discuss the results gained from the experimental test class from three different perspectives, namely those of the teacher giving the test class, the participating students and an external observer qualitatively evaluating the data collected during the test course.

IV.A From the teacher's perspective

The students' commitment exceeded by far the expectations, most of them investing more time outside school than during the class. Some students with an irregular attendance at class surprised at the project presentations with good, work intensive results that were mainly obtained during group meetings outside the university. In the classroom, the atmosphere was marked of mutual respect and participation.

While the PBL approach was well received by the students, the conceptual knowledge of the underlying physical or chemical effects and processes often stayed superficial. The knowledge acquisition on the subject stopped often at the very level that was needed to build the educational resource, and the broader context of the project's topics was hardly explored by the students – even though this was encouraged for the writing of the project related documents. Some of these issues might be successfully addressed by relocating the specific course earlier to the first half of the undergraduate curriculum and then continuing the use of PBL throughout the teacher education program.

IV.B From the student's perspective

In the semi-structured interviews conducted with the course participants after the final presentation, five categories of comments made by the students stood out:

1) Connecting educational and social reality:
   ""The construction of the [solar powered water] heater improved the condition of my family because it has brought some electricity saving. Today we wanted to bring the heater [to the presentation in class], but it is already installed in my home and my wife is now using it." (Group 1);
   "We chose to develop a wind generator because in our state there are innumerous houses without electricity, especially in the countryside …" (Group 4);
2) Gain in procedural knowledge[24]:
   "In the beginning we did not know what a project was, we couldn't make evaluations of our own work or the work of others, after all, we are used to be judged by others, and we did not know how to make a presentation […] With the PBL methodology we created something new [a board game to teach math] and presented the project in an academic congress. With the teacher's support we are writing our first article of many we intend to do" (Group 2);
3) Self-efficacy:
   "When the teacher told us we could choose any subject to study I was paralyzed, not knowing what to do […] In the beginning it was difficult, but together with my colleagues… […] I also had to help some of my colleagues how to learn" (Group 3);
4) Giving and receiving feedback:
   "I had the responsibility to criticize myself and criticize the work of others. This is a hard work because we are not used to giving and receiving criticism. I was afraid that my colleague would get upset with my feedback, but, over time, we were seeing this as a useful evolution of our learning. Criticism, over time, became more natural" (Group 4);
5) Confidence to use PBL in class:
   "Based on the [short] time we've been working with PBL, I don't feel myself prepared to teach with this methodology. I think we need more subjects taught with this method …" (Group 4).

IV.C In the external researcher's perspective

There were no observable dropouts with respect to the discipline or to projects, which were chosen and developed entirely by the students. With the exception of one group (water filter), the projects were completed and evaluated positively.

Nevertheless, students showed deficiencies in conceptual knowledge as well as problems in completing the final reports with the information obtained from the meeting minutes. We observed that most students were inexperienced in basic methods to structure documents about their work.

There were also significant differences between groups, their work approaches, in-group communication [25] and activities carried out:

Some groups, such as group 4, which had a regular class attendance, consisted of members who were committed to the project and produced good documentation. But the group members had to realize half way through the course that their goals were unachievable within the given timeframe. In contrast, another group (group 2) had set for itself clear and achievable goals. They also consisted of committed members, who, though not always present in class, progressed rapidly, and even tested the prototype of the game they developed with students at an elementary school (one of the members has been working in this school as math teacher). Yet another group (group 1) consisted of silent workers. Although their project planning observed in the classroom seemed to be weak and making only slow progress, this group demonstrated a high commitment to their work, held frequent meetings at student's homes and obtained excellent results in the end.

While in general the course participants developed a positive attitude towards PBL, they did not consider themselves sufficiently prepared to implement this methodology in their future professional activities. A single course in the curriculum using the PBL approach appears therefore insufficient to really move the participants to apply this didactic method themselves.

IV. CONCLUSIONS

Adult learners attending evening classes after work indeed demonstrate different learning behavior and a larger variety of individual backgrounds when compared to regular secondary level schooling situations. We nonetheless found that by adapting the suggestions in the literature on pedagogy to andragogy, PBL can be a very effective didactic tool to help students in teacher education to

- assume responsibility for their own learning,
- train self- and peer evaluation,
- develop procedural knowledge, and
- connect teaching content with social context.

On the other hand, we also noted some shortcomings in the course design, as for example the relative low level of content knowledge and conceptual knowledge students gained during the course. The feedback received from the students indicates that one PBL based course alone is insufficient to prepare and motivate the future teachers to adapt PBL in their own teaching.

Addressing these issues would require adaptations not only in the course design alone but also in the curriculum in which the course is embedded.

While we focused in this work on the students in a teacher education program, one needs to note that a wider adaptation of PBL and similar didactic methods in the context discussed above also depends on the teacher trainers, not only their students. A successful implementation of PBL – especially for adult learners – requires respect for and appreciation of the knowledge, skills and background that learners bring into class. Since an overly dominating teacher role suppresses the learning process of the very skills PBL aims to foster, a different kind of relationship between learner an trainer is required, which at times may not coincide with local customs and culture. Even though this aspect might make it more difficult, the results obtained by this study make us confident that these efforts are worthwhile.

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