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Lower Secondary Mathematics and Science Teachers' Perceptions Towards Project-Based Learning in Rwanda

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Abstract

Project-Based Learning (PBL) teaching approach is claimed to be efficient in achieving learning outcomes related to 21st century competencies such as critical thinking, problem-solving, creativity, cooperation, and communication among others. Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) project trained Mathematics and Science teachers on using PBL approach in their teaching. The training covered 15 modules/projects aligned with the Rwanda Competence-Based Curriculum (CBC). The study investigated the perception of the teachers on PBL approach after training. A quantitative research approach was used to collect data. The participants were 120 lower secondary Mathematics and Science teachers from 62 pilot Schools (16 Teacher Training Colleges (TTC), 16 Model Schools and 30 science schools selected using purposive sampling techniques. Quantitative data were collected using a designed, valid and reliable survey. From the items' internal consistency analysis, the reliability coefficient was Cronbach's alpha of .707. Quantitative data were analyzed using descriptive statistics. The results revealed that teachers had extremely positive perception on PBL approach. Teachers perceived PBL to be more relevant to improve students' skills and hence more effective in implementing the competence-based curriculum. It is recommended to increase training and the follow-up of the trainees has to be done often in order to assess the implementation of what they have learned, and the challenges faced.

Keywords: 21st century skills; professional development; project-based learning; quality education

Introduction

PBL has a lot of potential to develop 21st century skills through involvement of students in practical projects (Bell, 2010; Han et al., 2015; Kingston, 2018). The abilities required for success in the twenty-first century, also known as transversal competencies, include critical thinking, problem-solving, cooperation, communication, and self-management (Viro, 2020). According to research, project-based learning (PBL) can be a more successful teaching style than conventional techniques (Simpson, 2011; Charlene & Czerniak, 2014). Project-based learning "seems to be equivalent or slightly better than other models of instruction for producing gains in general academic achievement and for developing lower-level cognitive skills in traditional subject matter areas," according to a highly cited review of the research compiled by Thomas & Ph, (2000). These studies offer proof that PBL has a positive impact on academic performance. Additionally, there is evidence that PBL promotes teacher and student collaboration and that it is more appealing to both teachers and students than conventional teaching techniques (Thomas & Ph, 2000). This research provides compelling evidence in

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favor of encouraging the use of project-based learning.

An important aspect of PBL implementation and project success is teachers' perceptions of the (its) practice. A project can already be condemned to failure if teachers think PBL is too difficult (Adams, 2018). Several studies look at how teachers and students perceive PBL. In one study, Farouck, (2016) used PBL to research how students learn a foreign language, the language skills that EFL students might pick up, and the potential benefits that PBL might have on the communicative readiness of EFL students. Farouck proposed that because PBL is collaborative and communicative in nature, students will become more willing to communicate. Farouck utilized a questionnaire to collect information on the participants' perceptions and experiences. PBL, according to several students, improved their readiness to communicate by boosting their confidence, reducing their fears, and developing their intrapersonal skills as well as in both receptive and productive skills. Additionally, students improved their technology skills, including their ability to use software and conduct more accurate online information collecting. In this study, students' perceptions of PBL were largely positive.

Habók and Nagy (2016) carried out a study to find out how teachers perceive PBL. Teachers answered a questionnaire that collected information on their desire for utilizing PBL as well as their perception of their role in the classroom. According to the findings of the researchers' examination, teachers prefer collaborative approaches such as PBL. The researchers discovered that educators saw themselves as motivators, molders of personalities, and conveyers of values. This is crucial to keep in mind while thinking about the teacher's function in PBL as a facilitator and guide rather than a ruler as is the case in the majority of traditional classrooms. Shifting from Traditional teaching method to modern teaching method that is today's willing in educational workplace will continue to increase.

Traditional teaching approaches do not necessarily produce a wide variety of skills. Despite the implementation of Competence-Based Curriculum (CBC) in Rwanda, research shows that traditional teaching techniques are still predominating (Ndihokubwayo Kizito, 2019; Nsengimana et al., 2020). Numerous research studies have suggested that PBL has benefits in various countries. However, Lack of research and data collection prevents us from knowing how teachers view PBL after training. Understanding and applying effective teaching strategies by teachers has had a substantial impact on students' material comprehension and skill development. Teachers with expertise and experience who use effective teaching strategies help students more than those who do not. Effective professional development can assist teachers in acquiring the required pedagogical skills and viewpoints to practice effective teaching technique such as PBL. The role of the teacher in implementing effective teaching techniques must be different from that in conventional classrooms. However, data on the effectiveness or perception of teachers on PBL in Africa, notably in Rwanda, are lacking. To ascertain the results of project-based learning in African nations like Rwanda, more data must therefore be gathered.

The purpose of this study is to investigate the teachers 'perceptions on PBL approach and skills acquired after training. This will determine how it will be implemented as integrated approach to Science education.

Constructivism is the foundation of the project-based learning (PBL) approach to education (CE, 2004), which John Dewey

initially proposed at the end of the 1890s (Douglas, 2010). Dewey's educational philosophy placed an emphasis on children-centered and brought real-world problems and circumstances into the classroom. Since then, PBL has been thoroughly developed and applied to a range of academic disciplines and learning contexts. Such real-world applications have substantially improved our understanding of PBL. Previously, Bell (2010) defined PBL as a student-driven (student-centered) approach to learning in which students are required to take part in a real project by developing a question or inquiry and under the supervision of teachers in order to create a project to share with the selected audience. According to an earlier, more detailed definition, PBL is a dynamic approach to teaching in which students explore real-world problems and challenges, simultaneously developing 21st Century skills while working in small collaborative groups (Goodman & Stivers, 2010). Students solve real-world problems by asking open-ended questions, designing and carrying out investigations, researching the issue, gathering information, drawing conclusions based on the findings, and reporting results, as stressed by Çakici, (2013). PBL engages students in the problem-solving and decision-making process.

These definitions all rely on learner-centered learning processes. However, significantly fewer studies have addressed teachers' views on the efficacy of this method, the differences compared to traditional classroom activities and the ways in which teachers can capitalize on opportunities provided by 21st-century innovations.

Theoretical frame work and its application

Constructivism is the foundation of the project-based learning (PBL) approach to education (CE, 2004; Haatainen & Aksela, 2021). Krajcik, Joseph S. and Blumenfeld, (2005) found that during learning sciences research, deep understanding occurs when a learner actively constructs meaning based on his/her experiences and interaction in the world. The author highlighted that in project based learning, students actively construct their knowledge by participating in real-world activities similar to those that experts engage in, to solve problems and develop artifacts (Haatainen & Aksela, 2021). The PBL design principles, which outline the key elements of a PBL approach, have undergone numerous efforts at clarification (Haatainen & Aksela, 2021).

Methodology

This section presents the procedures followed throughout the study. It describes population, sample and sampling techniques, research instruments, research design, data collection and data analysis procedures.

Research design

The purpose of this study is to investigate the teachers' perceptions on PBL approach after mathematics and science teachers have been exposed to training as part of the Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) project. As collaborators in the RQBEHCD/project, the researchers in this study intended to investigate the participants' perceptions on the PBL approach after training by using quantitative approach and a descriptive research design.

Population, sample and sampling techniques

The population was 120 lower secondary mathematics and science teachers from 62 pilot schools, 16 teacher training colleges (TTC), 16 model schools and also, 30 Mathematics and Science for sub-Saharan Africa (MS4SSA) schools across all districts of Rwanda.

Purposive sampling technique was used to select 107 teachers to participate in the study. It is felt that the sample size is sufficient for

statistical analysis, as it is recommended that the number of subjects should be at least 30, and the more the better, if the data is to be analyzed quantitatively (Nunan & Bailey, (2009).

Intervention

Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) project trained 120 mathematics and science teachers described in the population on the use of PBL approach in their teaching. The training covered 15 modules/projects, developed by UR/CE and REB team, linked to mathematics, biology, physics, and chemistry learning outcomes aligned with the competency-based curriculum (CBC). Participants were subdivided into 2 groups - a mathematics-physics group and a biology-chemistry group. The training took place at GS Cyahafi, Nyarugenge district, and took two months from 20th September, 2022 up to 20th November, 2022.

The module 'Introduction to PBL' (designated PBLGI01) was delivered to both the mathematics/physics and biology/chemistry groups. The contents covered by the mathematics/physics group were:

- Robotics I: Introduction to Robotics (PBLMP02).
- Robotics II: Introduction to Virtual Robotics (PBLMP03)
- Robotics III: Robotics applications (PBLMP04)
- 3D Printing, I: Introduction to 3D object design (PBL MP05)
- 3D Printing II: Introduction to 3D printing (PBLMP06)
- 3D Printing III: 3D printing Applications (PBLMP07)
- Solar energy and solar lantern (PBLMP08)
- House installation (PBLMP09)
- Sensors with Microbit (PBLMP10)

and those covered by the biology-chemistry group were:

- Water purification (PBLBC02)
- Saponification project (PBLBC03)
- Kitchen garden project (PBLBC04),
- Beeswax products: Lotion, Shoes polish, Vaseline, Candles (PBLBC05),
- Food processing: Cheese, Yogurt, Cake (PBLBC06).

Research instruments

The researchers designed a valid and reliable questionnaire to collect quantitative data. The first part of the questionnaire covered the participants' demographic characteristics – gender, group in which they are registered in the training, cohort, type of the school and subject they teach. The remaining part covered five-point Likert scale items that elicited the participants' views on their perception of PBL. The questionnaire was checked by experts and educational researchers from UR/CE in collaboration with REB and the internal consistency analysis was checked yielding a reliability coefficient or Cronbach's alpha of .707. After the training, the participant teachers in this study completed the survey online. Descriptive statistics were used to analyze quantitative data with aid of SPSS v.25 and Excel, whereby tables of mean, standard deviation, percentages and graphs were generated. The survey was online-delivered to the teachers at the end of training on PBL approach and a time slot was available for them to complete the survey.

Data analysis

The quantitative approach was used to carefully examine the data that came from the investigation. An excel spreadsheet and SPSS were used to capture and analyze the data. Descriptive statistics were used to analyze data including mean, standard deviation, percentages, graphs and frequencies.

Results

In all, 107 lower secondary mathematics and science teachers from 62 schools across all districts in Rwanda, who were trained on using PBL approach in their teaching, participated in the study. The majority (83 or 77.6%) of teacher participants were males, with a minority (24 or 22.4%) being females. The participants were subdivided into two groups, mathematics-physics group and biology-chemistry group as shown in Table 1.

The research question focused on the teachers' perceptions on PBL approach. A five-point Likert scale items survey was used separately to collect data from Biology-Chemistry group and Mathematics-Physics group. The distribution of participants by gender is presented in Table 1.

Table 1 Distribution of participants by Gender and subject groups

Group	Female	Male	Total
Biology/Chemistry	17	40	57
Mathematics/Physics	7	43	50
Total	24 (22.4%)	83 (77.6%)	107

The teachers' perception has been investigated on basis of their appreciation on PBL projects' relevance to improve student's skills. Each group worked on five PBL projects during the training. An overview of the findings from study on teachers' perception of the project-based learning methodology are presented in the Tables that follow. Table 2 and Table 3 shows the ratings of the two groups on agreement to statements about the relevance of elements of the training for improving students' skills and learning outcomes.

In Biology-Chemistry group, 70% of respondents agree/strongly-agree or appreciated the water purification project as relevant to improve students' skills and only 23%

Table 2 Distribution of teachers in the Biology-Chemistry group indicating their agreement/disagreement to statements about the relevance of the training for improving students' learning

Project Components	Teachers who agree/strongly-agree project is relevant (%)[1]	Teachers who disagree/strongly-disagree project is relevant (%)	Teachers undecided
Water purification	40 (70%)	13 (23%)	4 (7%)
Saponification	51 (89%)	4 (7%)	2 (4%)
Kitchen garden	54 (95%)	0 (0%)	3 (5%)
Beeswax products	51 (89%)	3 (5%)	3 (6%)
Food processing	51 (89%)	3 (5%)	3 (6%)
Mean	49.4 (86.6%)	4.6 (8%)	3 (5%)

[1]Percent in parenthesis

Table 3 Distribution of Mathematics-Physics teachers indicating their agreement/disagreement to statements about the relevance of the training for improving students' learning

Project Components	Teachers who agree/strongly-agree project is relevant (%)[1]	Teachers who disagree/strongly-disagree project is relevant (%)	Teachers undecided
Robotics application	45 (90%)	3 (6%)	2 (4%)
3D printing applications	35 (70%)	14 (28%)	1(2%)
Solar energy and solar lantern	48 (96%)	2 (4%)	0 (0%)
House installation	50 (100%)	0 (0%)	0 (0%)
Sensors with Microbit	47 (94%)	3 (6%)	0 (0%)
Mean	45 (90%)	4.4 (8.8%)	0.6 (1.2%)

[1]Percent in parenthesis

indicated that it's not relevant, while 7% percent were undecided. With regard to saponification, 89% of the respondents found the project relevant, 7% found it not relevant and 4% of respondents missed this question. The kitchen garden project was considered by 95% of respondents as relevant while 5% missed this question. Beeswax product project was appreciated by 89% of respondents as relevant while 5% said that it is not relevant. Similarly, 89% of respondents found food processing project as relevant while 5% found it as not relevant. 6% missed this question.

In Mathematics-Physics group, 90% of respondents appreciated Robotics application project as relevant to improve students' skills and only 6% said that it's not relevant. 4% percent missed this question. 70% of respondents found 3D printing applications project as relevant, while 28% found the project not relevant and 2% of respondents missed this question. The Solar energy and solar lantern project was considered by 96% of respondents as relevant while 4% missed this question. House installation project was appreciated by 100% of respondents as relevant while 0% said that it is not relevant. 94% of respondents found Sensors with Microbit project as relevant while 6% found it as not relevant. With no missing question.

Data obtained from survey given to 107 respondents among the two groups; Biology-Chemistry group and Mathematics-Physics group to investigate perception of participating teachers on how PBL projects are relevant to promote skills in students demonstrated that the average of teachers (mean) of 86.6% and 90% respectively to the groups agreed that projects are relevant to promote skills in students.

From the findings that have been presented, it shows that projects were generally viewed favorably by participants. Teachers considered the project to be a very effective approach for students to study science and mathematics (Çakici, 2013; Almulla, 2020). Teachers see PBL as beneficial (Wongdaeng & Hajihama, 2018; Haatainen & Aksela, 2021). Additionally, teachers had extremely positive perception on PBL approach and agreed with previous researchers who found

the project-based learning as an effective teaching and learning model in mathematics and sciences (Simpson, 2011; Czerniak, 2014).

Conclusion

This study aims to investigate the perception of the teachers on PBL approach after the RQBEHCD project training in Rwanda secondary schools. In order to achieve this, an analysis of the study's data was conducted, and the findings have been recorded. Overall, the data showed that the participants' (teachers') perception of the project was that it was successful and at least 70% of the participants have a positive perception of the various components of the training as the data the two groups indicate they perceive all the components of the training as relevant for improving students' learning. The results agreed with that of previous research (Adams, 2018; Nasution et al., 2021) who also found that teachers and students have positive perceptions of Project Based Learning training activities.

Recommendations

In view of the findings of the study, the following recommendations are made:

- Mathematics and Science teachers should be encouraged and supported to integrate PBL approach into CBC so that projects may be assigned to time table. This would make PBL implementation easier and will assist and support CBC;
- training in PBL implementation should be increased and follow-ups should be made to support teachers and address their difficulties;
- more research on the use of PBL should be carried out not only in mathematics and sciences, but also in other subjects**.**

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