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The Effect of Professional Training on In-service Secondary School Physics 'Teachers' Motivation to Use Problem-Based Learning

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Abstract. Professional training for in-service teachers is at an utmost level to improve their teaching practices. Therefore, this study aimed to assess the effect of professional training on in-service secondary school physics teachers' motivation to use Problem-Based Learning (PBL). A pre-and posttest quasi-experimental design was used to conduct the study. A two-day professional training on PBL was delivered as an independent variable, while teachers' motivation to use PBL was conceived as the dependent variable. The study involved fifty (50) in-service physics teachers (20 in control and 30 in the experimental group) from 25 secondary schools in four districts of Southwestern Uganda. Data were analyzed with SPSS v.23.0 using descriptive statistics, and paired, and independent samples t-test. The findings indicated a high statistically significant ($p<.05$) positive change and a greater motivation to use PBL among teachers who received professional training in PBL compared to those who did not receive it. It was recommended that the Government, in conjunction with school administrators, regularly organize similar training and, if possible, for all teachers national wide.

Keywords: physics teachers; problem-based learning; professional training; secondary school; Uganda

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1. Introduction

The Science policy in Uganda, which took effect in 2006, made the study of science subjects, namely: Physics, Chemistry, and Biology, compulsory for ordinary level secondary school students. According to Uganda National Examination Board (2017), the performance levels in all science subjects continue to be low, with about 55% of the candidates unable to exhibit the minimum required competency to be graded; the worst performed science subject is Physics. Ugandan Ministry of Education and Sport (2014) attached 'students' poor performance and weak knowledge acquisition to 'teachers' employment of inappropriate pedagogical skills despite the introduction of a number of programs, including the Secondary Science and Mathematics (SESEMAT) program in 2005, to enhance the quality of teaching and learning science and mathematics in secondary schools.

Traditionally, teachers use direct instruction in teaching, which does not effectively promote 'students' understanding of the subject concepts (Samsudin et al., 2019). Mineo et al. (2010) emphasized that teachers must employ innovative teaching approaches that lead to observable and measurable positive changes in 'students' learning. In this regard, professional training becomes essential for the change of attitude of teachers since innovative methods such as problem-based learning (PBL) are newer techniques in educational institutions, as observed by Singh et al. (2014). PBL is a teaching style that allows students to develop as learning engines. It is a learner-centered pedagogy where students learn the subject by experiencing the solution to an open-ended problem found in the trigger material. PBL uses complex real-world topics as classroom material and encourages students to develop problem-solving skills and learn concepts rather than simply absorbing facts (Dorimana et al., 2021).

Although using PBL as a method of instruction makes students active and enables them to develop cognitive skills (Sulaiman, 2010), the Ugandan physics syllabus does not reflect the PBL components, leading to few schools practicing it. Research by Mansor et al. (2015) showed that 'teachers' lack of experience in implementing PBL and limited knowledge of the PBL approach could contribute to their lack of motivation to use the pedagogy, which may affect the skills that students possess. Based on this background, the study set out to evaluate the effect of Professional Training on In-service Secondary School Physics Teachers' Motivation to Use Problem-Based Learning. The study was guided by one research question: What is the impact of professional training on in-service secondary school physics teachers' motivation to use Problem-Based Learning? It followed the hypothesis that there is no statistical difference in in-service secondary school physics teachers' motivation to use Problem-Based Learning between those who received professional training in PBL and those who did not.

2. Literature review

Concept of Problem-Based Learning (PBL)

Teachers and students in STEM tend to face challenges in formulating suitable classroom problems which promote critical thinking, scientific writing, communication, and problem-solving skills (Sulaiman, 2010). Classroom problems presented in textbooks tend to be well-structured with specific solutions that require the application of a limited number of rules and principles within well-defined parameters limiting 'students' involvement (Sterling, 2013). Involving students actively in classroom activities and enabling them to relate the concepts with real-life make them find their concepts that impact improving learning achievements (Mansor et al., 2015). Real-life problems are open-ended and ill-defined, with multiple solutions that require various paths to find a solution; they tend to have fewer parameters that can be manipulated and contain uncertainty about which concepts, rules, and principles that are necessary for the solution, or how they are organized and which solution is best (Christiansen, Kuure, Morch & Lindstraom, 2013). Designing such problems into learning in an authentic context is a key factor that distinguishes PBL from other instructional methods (Sterling, 2013).

In PBL, students learn a concept through the experience of collaborative problem solving achieved through interacting with peers and teachers to obtain a solution or clarify the problem (Christiansen et al., 2013). It was meant to guide students to become experts in their fields of study, identify existing problems, analyze them, and come up with appropriate solutions. During the implementation of PBL, hands-on and inquiry are adopted as pedagogical techniques to build appropriate behaviors necessary for successful problem solving (Sterling, 2013). In PBL, students are organized into small groups as they solve a problem, discuss the results and find the best solution (Nikmah, 2018). They do not only need instruction but also access to the world to relate the knowledge already possessed with that in the real-world setting (Sterling, 2013). The effectiveness of the use of PBL depends on several factors, including the knowledge teachers have about the whole teaching and learning process (Dorimana et al., 2021).

Teacher professional training

Improving teacher knowledge is important since teachers are the ones expected to improve 'learners' learning (Ndihokubwayo, Nyirigira, et al., 2020; Ndihokubwayo & Murasira, 2019). Carpendale and Hume (2020) emphasize the need to train teachers to sustain the content knowledge. Since students value expertise, the best teachers are the subject specialists who understand the curriculum and have excellent facilitation skills. Professional training is of great importance in such a way that: they not only provide them with the support, resources, and training needed to transform their courses to incorporate PBL and related active learning strategies; but also enables them to acquire skills in facilitating and managing group dynamics. Active learning, including the use of PBL, not only allows learners to work in small groups during class and interact with each other or their teacher (Lombardi et al., 2021) but also builds and improves teamwork (Chien, 2020). Weizman et al. (2008) pointed out that professional development and practice using PBL can help teachers develop the ability to apply their knowledge in real classroom settings, assess the effectiveness of their actions, and revise plans according to the evidence they collect and interpret. In addition, PBL pieces of training help teachers develop effective group skills and experience.

Theoretical framework

The study aimed at effecting change in knowledge of in-service physics teachers in PBL through professional training. It targeted helping teachers to be conversant with PBL knowledge and willingly applied it during the teaching and learning process to improve students' academic achievements. It was hoped that the teachers would be self-directing and innovative as they implement PBL in real classrooms with minimal supervision. PBL dwells on principles of adult learning theory which focus on motivating students, encouraging them to set their own learning goals, and allowing them to make decisions concerning their learning. Adult learning theory assumes that trainees have an existing base of knowledge and life experiences; they seek out continuous learning based on personal interests, wants, and needs; and they understand why they are learning. This theory calls for active participation and puts the learner at the center of the learning experience, emphasizing the teacher's role as purely that of a mentor; all these are key elements of PBL (Kenner & Weinerman, 2011; Prusko, 2021). Thus, the study was based on adult learning theory applicable to this study of in-service teacher training.

The motivation for the study

A recent study has shown that teachers are motivated by being provided in-service training, and such training improves their teaching practices. Oyo et al. (2017) have investigated the outcome after implementing the massive computer literacy open online courses (MOOC) through 'the teachers' e-learning portal. The authors found that Ugandan teachers get interested and improve their performance. It was found that irrespective of age, when teachers are adequately supported internally by their schools and externally by a university, they can improve their digital literacy and subsequently engage in life-long online learning. Likewise, the high percentage of teacher 'participants' completions and high volume of educational e-content generated confirm an effective, attractive, and self-sustainability for in-service teachers. Therefore, the current study proves the in-service 'teachers' change through PBL to sustain and improve classroom teaching and learning atmosphere.

3. Methodology

Research design

In reference to Creswell (2014), a quantitative cross-sectional survey design was used in this study in order to understand how professional training affects in-service physics teachers' motivation to use PBL. Such design analyzes data from a population, or a representative subset, at a specific point in time; researchers measure the outcome and the exposures of the study participants at the same time. The study was conducted among 50 in-service physics teachers hailing from four districts in the southwestern region of Uganda. The four districts included Bushenyi, Rubirizi, Mitooma, and Sheema. The schools were randomly selected from clustered districts, but the teachers who participated were selected purposively by the respective headteachers. There were two groups identified as experimental (n = 30; 60%) and control (n = 20; 40%) groups depending on whether they participated or not in the professional training in PBL organized by the authors. These participants were all exposed to both pretest and posttest.

Respondents

Among the 50 participants, 14 were from Bushenyi district, 23 from Mitooma district, five from Rubirizi district, and eight from Sheema district; 26 teachers came from Government owned schools while 24 were from private owned schools; 12 came from single-girls schools, 12 from single 'boys' schools and 31 from mixed (both girls and boys) schools; 13 were from schools which are boarding only, and 37 were from schools which are both day and boarding; 39 came from rural based schools while 11 came from urban-based schools. Among the 50 participants in the study, 34% were females while 66% were males; their age was such that 12% were in the range of 20 -24 years, 18% were 25 – 29 years, 28% were 30 – 34 years, and 32% were 35 039 years, and 10% were at least 40 years old. Sixteen percent had an experience of fewer than two years, 16% were 2 -5 years, 38% were in the range 6 – 10 years, 22% were 11 -15 years, and 8% had an experience above 15 years. Those with a diploma as their highest academic qualification constituted 6 % of the total participants, 82% had bachelor's degrees, while 12% had postgraduate degrees such as masters.

Instruments

Among 50 participants, two groups were formed and identified as an experimental group with 30 teachers (teachers who participate in the professional training of PBL) and a control group with 20 teachers (teachers who did not participate in the professional training of PBL). This study used a survey questionnaire which was modified from the tool developed by Lee and Blanchard (2019) as the main data gathering tool. The modification was in such that Item 1, which initially was stated as 'The following statement best describes my training for PBL (1= none; 2 = informal; 3 = formal; 4 = informal & formal) was restated as 'I have previously had training for 'PBL'; item 2 which read as 'I have had the following amount of formal training PBL training (e.g., professional development): (1 = ≤ 1 day; 2 = 2–5 days; 3 = 6–10 days; 4 = > 2 weeks)'. All items were rated based on the scale of "1 - Strongly disagree, 2 - Disagree, 3- somewhat disagree, 4 - somewhat agree, 5 - Agree, and 6 - Strongly agree." Section A of the survey investigated 'participants' demographic information such as school of origin, ownership of the school, category of the school, type of school, location of the school, gender of the teacher, age of teacher, number of years spent teaching, and the highest level of education. Part B of the survey looked at teachers' experience with PBL (items 1 and 2), 'Teachers' general concept with PBL (items 3 - 5), 'teachers' perceived competence in practicing PBL (items 6 - 10), the perceived value of PBL to teachers (items 11 – 15), the perceived value of PBL to students (items 16 – 17), and perceived cost of implementing PBL (items 18 – 29).

Validation of instruments

The survey items, after their modification (Appendix A), were first presented to two (2) educational research experts for review to assess their relevance to the study. The difference in agreement between the two experts was compared using McNemar Test and was found to be nonsignificant (p = 1.000) hence considering the instrument valid. For reliability of the instrument, the survey was pilot-tested among ten (10) physics teachers who were also part of the final study to assess the correctness of the wordings. The results of the pilot study yielded a 'Cronbach's Alpha reliability coefficient of 0.92; hence the survey items were considered reliable.

Data collection procedures
The survey was first administered to all participants a week before the commencement of the training to determine the 'teachers' competency gap in using PBL. Results from the first testing indicated a lack of competency and negative perception about using PBL. This necessitated a training which the authors organized (see appendix B for the training schedule) and was attended by 30 randomly selected in-service physics teachers. After the training, the teachers went back to their schools with the determination to practice the knowledge and skills they had acquired. Two months after the trained teachers had gone back to their schools, a posttest (similar to the pretest) was then administered to include even teachers who had not trained.

Intervention
A two-day, six-hour professional training was then organized on 7th and 8th February 2021, at Ruhinda Secondary School-Mitooma district and was attended by 30 in-service physics teachers mentioned earlier. The main purpose of the professional training was to enhance in-service secondary school physics teachers' knowledge of what PBL is and how it can be effectively implemented in the classrooms; the following objectives guided it: (a) To provide background information on the origin and importance of PBL, (b) to provide skills on generating PBL questions, (c) To provide skills on presentation of a PBL lesson, and (d) to provide knowledge on the assessment of a PBL lesson.

The trainer for the Secondary Science and Mathematics (SESEMAT) program in the western region of Uganda served as a facilitator for the formed groups. The roles of the participants and the training leader were defined at the start of the training. Groups of five participants were constituted. In formulating PBL questions, the topic of waves was selected as agreed upon by all participants in the training based on the fact that it was among the most challenging topic to students. Since participants were taken as adult students, learning objectives were first shared with them at the start of the training, along with methods to be utilized during the course of the training. Using a projector, literature on the history and importance of PBL was then presented to the participants. During the training, specific attention was put on elaborating and refining prior knowledge of participants on PBL, engaging them in self-directed learning via hands-on activities based on the topic of waves, and regularly reflecting on how to put PBL into practice. One of the formulated questions was: "Explain how a standing wave is formed."

Data analysis
We used descriptive and inferential statistics to analyze data. Data was entered into the computer using the Statistical Package for Social Science (SPSS) software, version 23.0, to compute statistical significance. Modal responses were determined, and bar charts were used to visualize differences in the pretest and posttest between experimental and control groups. Then, a paired samples t-test was used to find out if there was a statistically significant change in the use of PBL between the pretest and postest for teachers that attended the professional training and those that did not attend the professional training across all the subsections of the survey. An independent samples test was run to determine

whether there was a statistical difference in the responses between the experimental and control groups for each of the pretest and posttest. Thus, we computed inferential statistics on the *p*-value. When this value is less than alpha significance, there is a statistically significant difference in favor of a group with a high mean score.

Ethical considerations
The research proposal was ethically cleared by the University of Rwanda Research Ethics Committee, and thereafter, an authorization letter to do research in Uganda was obtained from the Permanent Secretary-Ministry of Education.

4. Results

This study aimed to assess the effect of Professional Training on In-service Secondary School Physics Teachers' Motivation to use Problem-Based Learning. In the case of the pretest, we first considered the modal responses in each item for both the experimental and control groups (Figure 1), and the results indicated that the responses were generally similar for both groups. Most of the participants indicated that they had hardly had any training in PBL (item 1), which was mostly the reason they did not teach using PBL (item 2). They also lacked knowledge of PBL concepts in addition to low perceived competence in practicing PBL. They were not sure as to whether practicing PBL adds any value to either themselves or the students, and they also felt that practicing PBL is costly. Generally, they portrayed a low motivation to use PBL as their overall responses ranged from somehow agree to disagree.

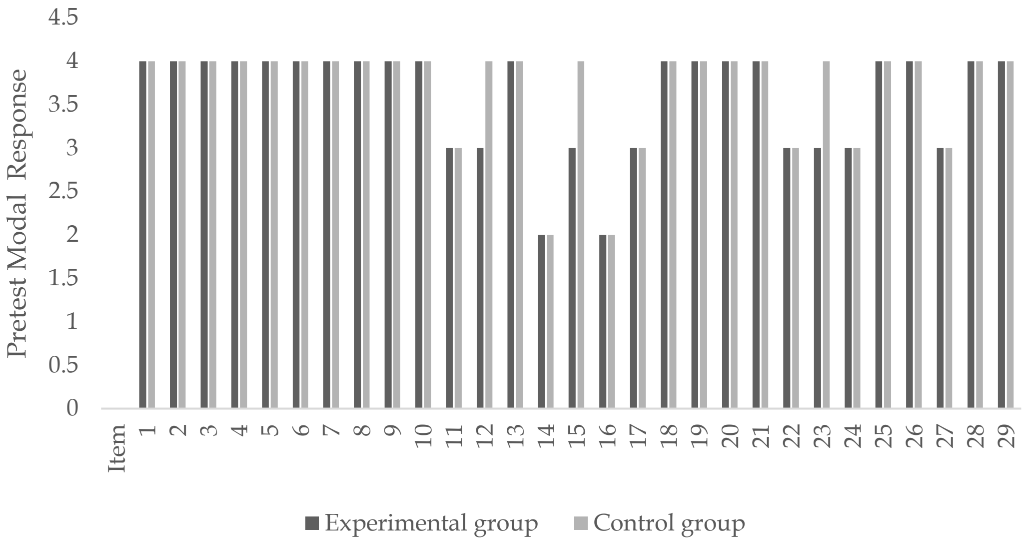

Figure 1: Modal Responses of participants in the pretest

A paired samples t-test was run (Tables 3 and 4) for the experimental and control groups.

Table 3: Paired Samples Statistics for the experimental and control groups

Item	Experimental group (N=30)				Control group (N=20)			
	Posttest		Pretest		Posttest		Pretest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	5.47	0.507	3.37	0.964	3.25	0.910	3.25	0.910
2	5.57	0.504	3.63	0.765	3.05	1.146	3.05	1.146
3	5.50	0.509	3.73	0.640	3.80	0.410	3.65	0.489
4	5.53	0.507	4.27	0.450	3.80	0.410	3.80	0.410
5	5.40	0.498	3.83	0.531	3.65	0.587	3.65	0.587
6	4.03	0.183	3.80	0.484	3.55	0.510	3.55	0.510
7	1.53	0.507	3.50	0.682	3.60	0.598	3.60	0.598
8	2.20	1.031	3.50	0.682	3.45	0.686	3.45	0.686
9	5.47	0.507	4.10	0.305	3.40	0.503	4.10	0.308
10	1.87	0.629	3.53	0.819	3.65	0.671	3.65	0.671
11	1.67	0.479	3.00	0.910	3.00	0.973	3.00	0.973
12	5.30	0.466	3.13	0.629	3.30	0.923	3.30	0.923
13	5.37	0.490	3.80	0.484	3.90	0.308	3.90	0.308
14	1.53	0.507	2.10	0.481	2.10	0.553	2.10	0.553
15	5.40	0.498	3.27	0.640	3.85	0.587	3.85	0.587
16	1.40	0.498	2.23	0.679	1.95	0.224	2.30	0.733
17	1.57	0.504	2.97	0.320	2.75	0.550	2.90	0.447
18	5.57	0.504	4.03	0.183	4.00	0.000	4.00	0.00
19	5.50	0.572	4.10	0.403	4.05	0.224	4.05	0.224
20	5.63	0.490	4.03	0.414	4.00	0.324	4.00	0.324
21	5.63	0.490	4.07	0.254	3.95	0.224	3.95	0.224
22	1.57	0.568	2.83	0.461	2.85	0.489	2.85	0.489
23	2.03	0.615	3.37	0.490	3.55	0.510	3.55	0.510
24	1.63	0.490	2.70	0.535	2.95	0.224	2.95	0.224
25	1.90	0.712	4.07	0.254	4.10	0.308	4.10	0.308
26	1.77	0.626	3.47	0.776	3.45	0.605	3.45	0.605
27	1.53	0.507	3.10	0.662	3.50	0.513	3.50	0.513
28	5.60	0.563	4.03	0.183	4.05	0.224	4.05	0.224
29	2.57	0.774	3.90	0.548	3.95	0.224	3.95	0.224

From Table 3, it is observed that the mean values between the pretest and posttest, especially for the experimental group, were really different (inclined more to agree in posttest than in pretest strongly), and this difference was statistically significant ($p < 0.00$) for almost all items (Table 4) and the effect size for most of the items was high ($d > 0.8$). However, these results were almost similar and nonsignificant for the control group in almost all items (Figure 2), and as a result, a paired samples T-test could not be computed for this group but was instead computed for the experimental group.

Table 4: The paired samples t-test and effect size values for the experimental group

Item	Paired Differences					t	df	p	d
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
1	2.10	1.09	0.20	1.69	2.51	10.52	29	0.00	1.9
2	1.93	0.79	0.14	1.64	2.23	13.49	29	0.00	2.5
3	1.77	0.82	0.15	1.46	2.07	11.84	29	0.00	2.2
4	1.27	0.58	0.11	1.05	1.48	11.89	29	0.00	2.2
5	1.57	0.63	0.11	1.33	1.80	13.71	29	0.00	2.5
6	0.23	0.43	0.08	0.07	0.39	2.97	29	0.01	0.5
7	1.97	0.85	0.16	2.28	1.65	12.67	29	0.00	2.3
8	1.30	1.21	0.22	1.75	0.85	5.90	29	0.00	1.1
9	1.37	0.62	0.11	1.14	1.60	12.17	29	0.00	2.2
10	1.67	0.99	0.18	2.04	1.30	9.18	29	0.00	1.7
11	1.33	0.80	0.15	1.63	1.03	9.10	29	0.00	1.7
12	2.17	0.75	0.14	1.89	2.45	15.89	29	0.00	2.9
13	1.57	0.68	0.12	1.31	1.82	12.64	29	0.00	2.3
14	0.57	0.73	0.13	0.84	-0.30	4.26	29	0.00	0.8
15	2.13	0.73	0.13	1.86	2.41	16.00	29	0.00	2.9
16	0.83	0.65	0.12	1.08	0.59	7.05	29	0.00	1.3
17	1.40	0.56	0.10	1.61	1.19	13.61	29	0.00	2.5
18	1.53	0.51	0.09	1.34	1.72	16.55	29	0.00	3.0
19	1.40	0.68	0.12	1.15	1.65	11.37	29	0.00	2.1
20	1.60	0.56	0.10	1.39	1.81	15.56	29	0.00	2.8
21	1.57	0.57	0.10	1.35	1.78	15.10	29	0.00	2.8
22	1.27	0.64	0.12	1.51	1.03	10.85	29	0.00	2.0
23	1.33	0.71	0.13	1.60	1.07	10.27	29	0.00	1.9
24	1.07	0.64	0.12	1.31	0.83	9.13	29	0.00	1.7
25	2.17	0.75	0.14	2.45	1.89	15.89	29	0.00	2.9
26	1.70	0.95	0.17	2.06	1.34	9.78	29	0.00	1.8
27	1.57	0.82	0.15	1.87	1.26	10.50	29	0.00	1.9
28	1.57	0.57	0.10	1.35	1.78	15.10	29	0.00	2.8
29	1.33	0.76	0.14	1.62	1.05	-9.63	29	0.00	1.8

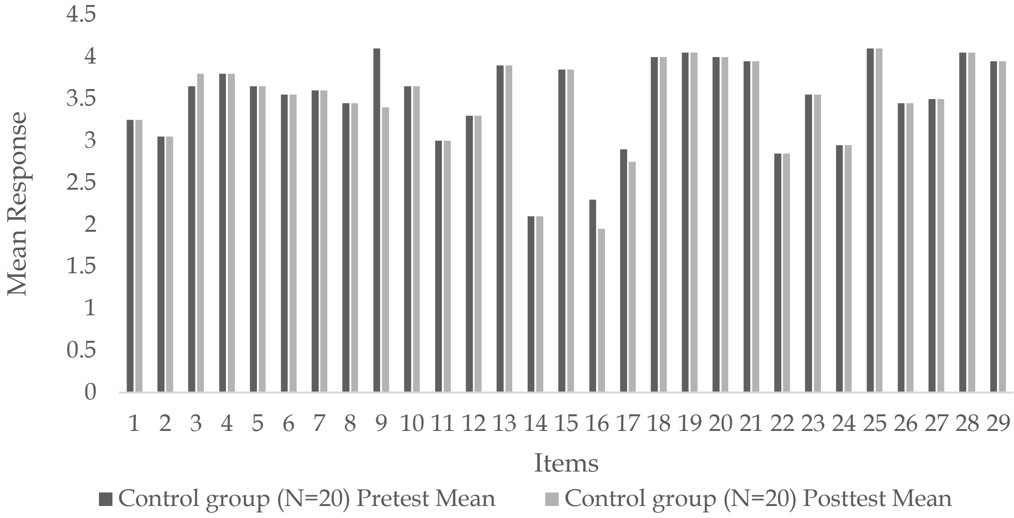

Figure 2: Mean responses between the pretest and posttest of the control group

The difference in the posttest responses between the experimental and control groups can be visualized in Figure 3, where the modal response for each item was represented using a bar group.

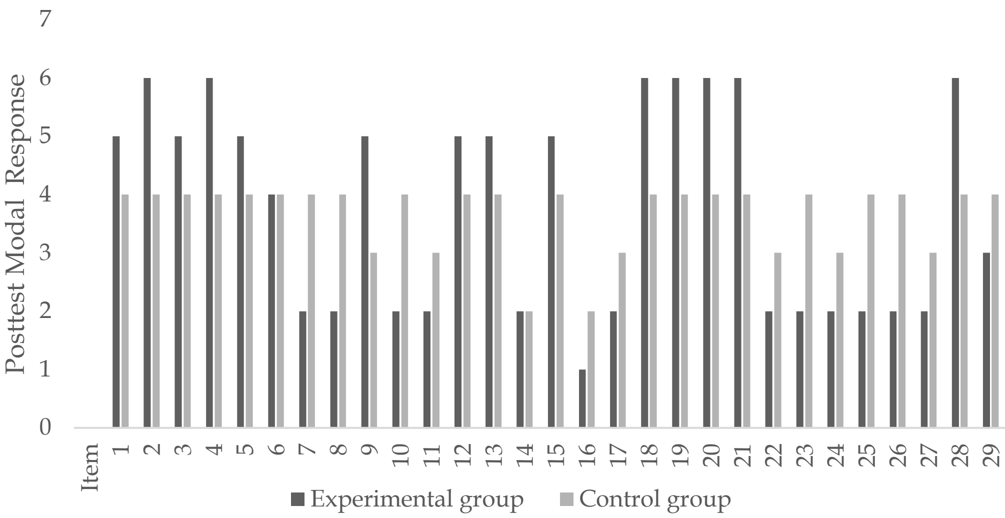

Figure 3: Posttest modal responses of both the experimental and control groups

It can be seen from Figure 3 that even though the control group's responses rotated around somewhat agree for most of the items (implying little motivation to use PBL), the responses for the experimental group were in the range of agreeing to strongly agree to mean that this group had high motivation to use PBL.

5. Discussion of results

Professional training motivates teachers to use PBL. It was found from the pretest that the teachers lack training in PBL; thus, they lack knowledge of the PBL concept and do not use PBL as an instructional approach since they perceive it as costly. The findings indicated that for the control group, the 'participants' responses in both the pretest and posttest were generally similar (Table 4 and

Figure 2) and maintained a somewhat low motivation toward using PBL. From Table 4, it is observed that attending the professional training increased in-service physics teachers' motivation to use PBL since there was a positive shift in all items. In addition, findings in Table 5 indicate that the change was statistically significant ($p < 0.05$) with a high effect size (d > 0.8). This positive effect could be related to the fact that during the training, these teachers were exposed to what PBL is all about, how it is implemented and assessed, and its advantages in enhancing 'students' understanding of various concepts as well as being aware that using PBL is actually not time-consuming as pointed out by Salam et al. (2009) and Weizman et al. (2008).

Our participants indicated their willingness to continue using PBL during teaching and follow the appropriate procedures for its implementation. This agrees with Shakoor et al. (2013) in their study about the effect of in-service training on science teachers' working capacity and performance at the secondary level. They found that successful completion of in-service training has a positive and far-reaching impact on professional competence as it improves science curricula implementation and raises science 'teachers' attitudes towards the teaching profession. In the same line, Dorimana et al. (2021) found out that most participants, after attending the training, acknowledged having acquired knowledge such as simulation with the PBL process, researching learning topics, and active discussion of how research materials are applied to solve problems. This knowledge acquisition significantly changed 'teachers' initial negative perceptions of PBL and motivated them to apply its principles in real-life scenarios (Zaidi et al., 2010). This motivation, according to Singh et al. (2014), was such that most participants, after attending professional training, were interested in changing their role from teacher to facilitator and were generally more enthusiastic about adopting PBL. Talvio et al. (2016) also observed that if teachers are motivated and feel competent in teaching a particular pedagogy, they will find ways to include the necessary content in their teaching. Likewise, Iqbal et al. (2020) collected data from TVET teachers in South Asia and found a significant effect of in-service training and motivation on job performance.

Our results were in line with adult learning theory. Ndihokubwayo, Uwamahoro, et al. (2020) trained teachers on the usability of PhET simulations and YouTube videos for physics classrooms and later found the effect on 'students' performance (Ndihokubwayo, Uwamahoro, et al., 2020a) and conceptual understanding (Uwamahoro et al., 2021) of geometric optics. We can there say that the quality of education can be improved by prioritizing teaching methods and how teachers spend time in their classrooms, as observed by Junejo et al. (2018). Therefore, our results imply that Ugandan secondary school teachers were unaware of PBL but showed interest in its use. They should continuously implement it in the classroom to improve students learning outcomes.

6. Conclusion and recommendations

The use of active learning methods, including PBL during instruction, has become a norm at almost all levels of education across the globe. In this study, it was found that teachers generally have low motivation for the use of PBL. However, those teachers who attended the professional training in PBL (experimental group) had increased knowledge of PBL concepts, were more competent in those PBL, had a greater perceived value for PBL, and generally looked at implementing PBL as being less costly, as compared those teachers who did not receive the professional training (control group). This study was limited to only 50 in-service secondary school physics teachers (30 in experimental and 20 in control groups) selected from just four districts in southwestern Uganda, and the professional training in PBL was limited to only two days. Therefore, it is recommended that more PBL training should be regularly organized for all teachers, including school administrators. Such pieces of training should be funded by the Government where possible for the affordability of all. Teacher education institutions should design their curricula in such a way as to prioritize advanced methods of teaching, including PBL. It is hoped that the insights derived from the study should form a valuable baseline for conducting a longitudinal study to determine the extent to which PBL impacts student achievements, especially those in science, technology, and mathematics.

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7. References

Carpendale, J., & Hume, A. (2020). Content representations to support out-of-field physics teachers. *Physics Education*, *55*(6), 065021. https://doi.org/https://doi.org/10.1088/1361-6552/abaf16

Chien, C.-W. (2020). 'Undergraduates' Learning on Elementary School English Education through Problem Based Learning in Scenario Analysis. *Current Issues in Education*, *21*(1), 1–17. https://acces.bibl.ulaval.ca/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=144942914&amp%0Alang=fr&site=ehost-live

Christiansen, E. T., Kuure, L., Morch, A., & Lindstraom, B. (2013). *Problem-Based Learning for the 21st Century* (1st ed.). Aalborg University Press. https://doi.org/ISBN: 978-87-7112-117-9

Creswell, J. W. (2014). *Research Design* (4th ed.). SAGE Publications Pvt. Ltd. https://doi.org/ISBN: 978-1-4522-2609-5

Dorimana, A., Uworwabayeho, A., & Nizeyimana, G. (2021). Examining Mathematical Problem-Solving Beliefs among Rwandan Secondary School Teachers. *International Journal of Learning, Teaching and Educational Research*, *20*(7), 227–240. https://doi.org/10.26803/ijlter.20.7.13

Iqbal, N., Khan, M. M., Mohmand, Y. T., & Mujtaba, B. G. (2020). The Impact of in-Service Training and Motivation on Job Performance of Technical & Vocational Education Teachers: Role of Person-Job Fit. *Public Organization Review Volume*, *20*, 529–548. https://doi.org/https://doi.org/10.1007/s11115-019-00455-3

Junejo, M. I., Sarwar, S., & Ahmed, R. R. (2018). Impact of in-service training on performance of teachers a case of STEVTA Karachi region. *International Journal of Experiential Learning & Case Studies*, *2*(2), 50–60.

Kenner, C., & Weinerman, J. (2011). Adult learning theory: Applications to non-traditional college students. *Journal of College Reading and Learning*, *41*(2), 87–96. https://doi.org/https://doi.org/10.1080/10790195.2011.10850344

Lee, H., & Blanchard, M. R. (2019). Why Teach With PBL ? Motivational Factors Underlying Middle and High School Teachers' Use of Problem-Based Learning. *Interdisciplinary Journal of Problem-Based Learning*, *13*(1).

Lombardi, D., Shipley, T. F., Bailey, J. M., Bretones, P. S., Prather, E. E., Ballen, C. J., Knight, J. K., Smith, M. K., Stowe, R. L., Cooper, M. M., Prince, M., Atit, K., Uttal, D. H., LaDue, N. D., McNeal, P. M., Ryker, K., St. John, K., van der Hoeven Kraft, K. J., & Docktor, J. L. (2021). The curious construct of active learning. *Psychological Science in the Public Interest*, *22*(1), 8–43. https://doi.org/10.1177/1529100620973974

Mansor, A. N., Abdullah, N. O., Wahab, J. A., Rasul, M. S., Nor, M. Y. M., Nor, N. M., & Amnah, R. (2015). Managing Problem-based Learning : Challenges and Solutions for Educational Practice. *Asian Social Science*, *11*(4), 259–268. https://doi.org/10.5539/ass.v11n4p259

Mineo, R. M., Fazio, C., & Tarantino, G. (2010). An Inquiry-Based Approach to Physics Teacher Education: the Case of Sound Properties. *Eaching and Learning Physics Today: Challenges.* https://www.semanticscholar.org/paper/An-Inquiry-Based-Approach-to-Physics-Teacher-the-of-Mineo-Fazio/6026b6d2eb95cb1b80d1955982f27c1bfca9ff6c

Ndihokubwayo, K., & Murasira, G. (2019). 'Teachers' training college 'learners' expectations for their future teaching. *LWATI: A Journal of Contemporary Research*, *16*(2), 1–10. https://doi.org/https://www.ajol.info/index.php/lwati/article/view/185978

Ndihokubwayo, K., Nyirigira, V., Murasira, G., & Munyensanga, P. (2020). Is Competence-Based Curriculum well Monitored ? Learning from Rwandan Sector Education Officers. *Rwandan Journal of Education*, *5*(1), 1–12.

Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2020a). Effectiveness of PhET simulations and YouTube videos to improve the learning of optics in Rwandan secondary schools. *African Journal of Research in Mathematics, Science and Technology Education*, *24*(2), 253–265. https://doi.org/10.1080/18117295.2020.1818042

Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2020b). Usability of Electronic Instructional Tools in the Physics Classroom. *EURASIA Journal of Mathematics, Science and Technology Education*, *16*(11), 1–10. https://doi.org/https://doi.org/10.29333/ejmste/8549

Nikmah, I. L. (2018). The Implementation of Problem Based Learning to Improve 'Students' Learning Achievements. *International Education & Research Journal*, *4*(3). https://doi.org/E-ISSN No : 2454-9916

OYO, B., KALEMA, B. M., & BYABAZAIRE, J. (2017). MOOCs for in-service teachers: The case of Uganda and lessons for Africa. *Revista Española de Pedagogía*, *75*(1), 121–141. https://doi.org/10.22550/rep75-1-2017-14

Prusko, P. T. (2021). Shaping the Futures of Learning in the Digital Age Helping STEM Students Thrive: Adult Learning Pathways. *Current Issues in Education*, *22*(1), 1–6.

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., Fratiwi, N. J., Zulfikar, A., Muhaemin, M. H., Hermita, N., Mansur, Wibowo, F. C., Supriyatman, Malik, A., & Costu, B. (2019). Optimizing Students' Conceptual Understanding on Electricity and Magnetism through Cognitive Conflict-Based Multimode Teaching (CC-BMT). *Journal of Physics: Conference Series*, *7*(1204). https://doi.org/10.1088/1742-6596/1204/1/012027

Shakoor, A., Ghumman, M. S., & Mahmood, T. (2013). Effect of In-Service Training on the

Working Capacity and Performance of Science Teachers at Secondary Level. *Journal of Educational and Social Research*, *3*(3), 337–342. https://doi.org/10.5901/jesr.2013.v4n3p337

Singh, A., Saxena, A., Bhambani, P., Nema, S. K., Gaur, R., & Ambey, R. (2014). Faculty Perception and Attitude on Problem Based Learning (PBL) in Medical College from Central India. *British Journal of Medicine & Medical Research*, *4*(9), 1836–1843. https://doi.org/https://doi.org/10.9734/BJMMR/2014/4659

Sterling, D. R. (2013). How to Develop a Problem-Based Science Unit Manual. In *Virginia Initiative for Science Teaching and Acheivement*. Virginia Initiative for Science Teaching and Achievement (VISTA).

Sulaiman, F. (2010). 'Students' perceptions of implementing problem-based learning in a physics course. *Procedia-Social and Behavioral Sciences*, *7*(C), 355–362. https://doi.org/10.1016/j.sbspro.2010.10.048

Talvio, M., Berg, M., Litmanen, T., & Lonka, K. (2016). The Benefits of 'Teachers' Workshops on Their Social and Emotional Intelligence in Four Countries. *Creative Education*, *07*(18), 2803–2819. https://doi.org/10.4236/ce.2016.718260

Uganda National Examination Board. (2017). *Uganda National Examinations Board Report on Work of Candidates UCE 2016*.

Ugandan Ministry of Education and Sport. (2014). *Teacher Issues in Uganda: A shared vision for an effective teachers policy*. UNESCO - IIEP Pôle de Dakar. https://doi.org/ISBN:978-92-803-1378-9

Uwamahoro, J., Ndihokubwayo, K., Ralph, M., & Ndayambaje, I. (2021). Physics 'Students' Conceptual Understanding of Geometric Optics: Revisited Analysis. *Journal of Science Education and Technology*, *30*, 706–718. https://doi.org/10.1007/s10956-021-09913-4

Weizman, A., Covitt, B. A., Koehler, M. J., Lundeberg, M. A., Oslund, J. A., Low, M. R., Eberhardt, J., & Urban-Lurain, M. (2008). Measuring 'Teachers' Learning from a Problem-Based Learning Approach to Professional Development in Science Education. *Interdisciplinary Journal of Problem-Based Learning*, *2*(2). https://doi.org/10.7771/1541-5015.1081

Weizman, A., Covitt, B., Koehler, M. J., & Lundeberg, M. (2008). Measuring Teachers' Learning from a Problem-Based Learning Approach to Professional Development in Science Education. *The Interdisciplinary Journal of Problem-Based Learning*, *2*(2), 29. https://doi.org/10.7771/1541-5015.1081

Zaidi, Z., Zaidi, S. M., Razzaq, Z., Luqman, M., & Moin, S. (2010). Training workshops in problem-based learning: changing faculty attitudes and perceptions in a Pakistani medical college. *Education for Health*, *23*(3), 440.

Appendix A. Teachers' survey on their motivation to Use PBL

Section A: Background information (Tick appropriate response)

School ownership: Government ☐ Private ☐

School category: Single-girls ☐ Single boys ☐ Both girls and boys ☐

School type: Day only ☐ Boarding only ☐ Both day and oarding ☐

School location: Rural-based ☐ Urban-based ☐

Gender: Female ☐ Male ☐

Age (years): 20 – 24 ☐ 25 – 29 ☐ 30 – 34 35 – 39 ☐ 40 and above ☐

Teaching experience (years): < 2 ☐ 2 – 5 ☐ 6 – 10 ☐ 11 – 15 ☐ Above 15 ☐

Qualification: Certificate ☐ Diploma ☐ Bachelors ☐ Postgraduate ☐

Section B: Concepts on motivation to use PBL

The scale interpretation: 1 = Strongly Disagree, 2 = Disagree, 3 = Somehow disagree, 4 = Somehow Agree, 5 = Agree, 6 = Strongly Agree

Item	Response (Tick ✓)					
	1	2	3	4	5	6
I have previously had PBL.						
I have been teaching using PBL.						
In a PBL classroom, the teacher functions as a facilitator, and therefore, no content teaching is necessary.						
PBL gives too much responsibility to students.						
PBL is especially effective for students with low ability.						
I will be able to implement PBL successfully.						
I do not feel competent to teach with a PBL approach.						
I may not persist with PBL if my students struggle.						
I feel confident that I can successfully assess students' learning progress in a PBL setting.						
I am not sure that I can teach with PBL in ways that meet state and district standards.						
I am not interested in implementing PBL.						
Teaching with PBL could be enjoyable.						
Teaching well with PBL is important for my career.						
Teaching with PBL is not important for my professional growth						
The skills that I gain by implementing PBL may be useful beyond the classroom.						
PBL does not help students to obtain a deeper understanding of the content knowledge than they do in a traditional classroom.						
Using PBL causes students to have negative attitudes toward learning						

In PBL, students engage in issues relevant to their lives/communities						
PBL stimulates students' creativity						
PBL enhances students' collaboration and communication skills						
PBL promotes students' critical thinking						
I am concerned that PBL can lead to students missing out on learning important basic concepts						
Preparing to implement PBL would require too much of my time						
Implementing PBL will make classroom management more difficult						
It will be too stressful for me to cover the mandated curriculum if I implement PBL						
I worry that PBL might have a negative impact on how my students score on the end-of-course tests						
I am concerned that implementing PBL might have a negative impact on my teaching evaluation						
I believe that the overall benefits of implementing PBL would outweigh the costs						
There are not many people at work who are willing to help me with implementing PBL						

Appendix B. The two-day schedule for the professional training in PBL

Time (Hours)	Activity	Facilitator	Supporting materials
Day 1			
8:00-8:30	Arrival and registration	Research assistant	Registration Forms
8:30-9:00	Individual introduction	All members	Attendance sheets
9:00-9:30	Opening remarks (sharing training objectives)	Training leader	Powerpoint slides
9:30-10:00	Pretest	All Participants	Survey forms
10:00-10:30	Commercial Break	All members	
10:30-11:30	Origin of PBL	Training Leader	Powerpoint slides
11:30-12:30	Importance of PBL in Teaching and Learning	Training Leader	Powerpoint slides
12:30-13:00	Open discussion	All members	Flip charts
13:00-14:00	Lunch Break	All members	
14:00-15:00	Formulating a PBL question	Training Leader	Powerpoint slides
15:00-16:00	Class-activity - on Formulating PBL questions	Facilitated groups and SESEMAT trainer	Flip charts
16:00-16:30	Summary of the day' 's activities and closure	Training leader	Powerpoint slides

Day 2			
8:00-8:30	Arrival and registration	Research assistant	Registration forms
8:300-9:30	Steps followed in the presenting a PBL lesson	Training Leader	Powerpoint slides
9:30-10:00	Class activity- drafting PBL lessons	Participants and SESEMAT trainer	Flip charts
10:00-10:30	Commercial break	All members	
10:30-13:00	Group presentations on PBL lessons	Group secretaries	Flip charts
13:00-14:00	Lunch break	All members	
14:30-15:00	Assessing a PBL lesson	Training Leader	Powerpoint slides
15:00-15:30	Open discussion	Participants	Flip charts
15:30-16:00	Summary of the day's activities	Training leader	Powerpoint slides
16:00-16:30	Post-test and closure	Participants and Training leader	Survey forms