Samiru Alhassan (Ghana)

National Research Tomsk Polytechnic University, Tomsk

Scientific adviser: Prof. Inga V. Slesarenko,
Candidate of Pedagogical Sciences

ESSENTIALS OF IMPLEMENTING BACKWARD DESIGN METHOD IN TEACHING PHYSICS 1.3 IN TOMSK POLYTECHNIC UNIVERSITY

The approach in teaching style has an influence on the curriculum designed. Modern styles of teaching have morphed from instructor-centered style to student-centered styles. In this article, we designed two instruments based on the traditional approach. We then applied them in the backward approach where the learning outcomes were design prior with a vision of the tasks necessary. Also, various schemes of assessments were designed to achieve our learning objectives. Forces in mechanics was the chosen topic for this evaluation. In the end, various levels of assessments were conducted which improved the contact hours with students and gave a more meaningful result without compromising the benefits of the traditional approach. This article is based on my experience as teaching assistance of the course Physics 1.3.

Keywords:

Learning Objectives (LO), results-based teaching, curriculum design, backward design, content delivery, assessment, learning outcomes (Louts).

1.0 Introduction

The curriculum design for courses or programs generally influences the style of teaching. There are three broadly grouped curriculum designs, namely: forward, central and backward designs [1, 2]. These design methods vary based on when inputs such as learning materials, content delivery and assessments are conducted [3]. In the backward design approach, there is the need to identify learning objectives, analyze these objectives and perform the task involved [4, 5]. Since Physics 1.3 is result oriented, the backward design approach is very essential in achieving result-based with focus on students.

2.0 Benefits of Backward

Backward design model provides a blueprint on the details of the curriculum linking learning objectives, assessments and content delivery between key stakeholders thus administrators, instructors and students. It also solves the problem of complete reliance on textbooks as curriculum but rather as resource. It improves communication and interaction between instructors and students hence making teaching and learning goal oriented. Lastly, the cycle of program evaluation helps in building consensus between stakeholders thereby increasing the overall learning outcomes [6].

2.1 Stages of the Backward design

In planning the backward design approach, three stages are considered. They include; (1) Identifying long-term desired results of learning objectives (LO); (2) Determining acceptable evidence; and (3) Plan learning experiences and instruction. The above stages first, seeks to articulate clearly the set-out learning objectives. This will spell out what competences students will come out of the program with. The second stage will take the form of activities such as in-class participations, individual tasks, exams, self-assessments, publications, which should be conducted as practical assessments. Finally, the approach to achieving the desired learning objectives are implemented based on which instructional activities will lead to successful outcomes. Therefore, any method or approach which is possible to facilitate student learning consistent with the stated learning objectives is used [7].

3.0 Backward design model for Nuclear Physics

Physics 1.3 is a bachelor's degree program under the division for Experimental Physics for the Autumn, 2022 to Spring, 2023 academic year. I act as the teaching assistant who performs mainly tutorial and independent studies with the students while the main lecturer performs lection, practices and laboratory works. This is a typical, traditional approach in teaching and learning even though tutorial format is added. The figure below demonstrates this approach.

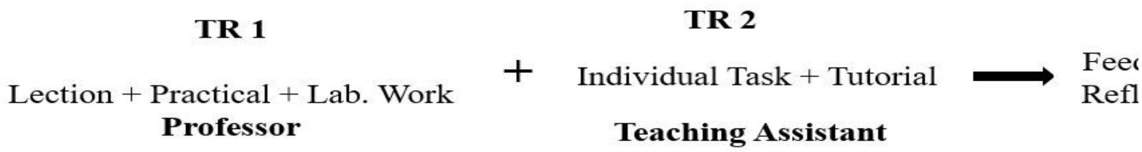

Fig. 1. Illustration of traditional approach in teaching Physics 1.3

In this article, we prepared two instruments which enabled the implementation of backward design by demonstrating with a topic under the module, the feasibility of such an idea. Table 1 is a time schedule of activities for Physics 1.3 in the academic calendar. Each activity represents a content of the courses to be executed. This is the first instrument.

Table 1

Time schedule of activities for Nuclear Physics 1.3 [8]

Weeks	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1		Activity 1			Activity 2		
2			Activity 3			Activity 4	
3	Activity 5			Activity 6			
4		Activity 7		Activity 8		Activity 9	
5	Activity 10		Activity 11		Activity 12		
6		Activity 13		Activity 14			
7			Activity 15			Activity 16	
8		Activity 17		Activity 18			
9	Activity 19				Activity 20		
10		Activity 21		Activity 22			
11			Activity 23			Activity 24	
12		Activity 25			Activity 26		
13	Activity 27			Activity 28			
14		Activity 29			Activity 30		
15			Activity 31			Activity 32	
16	Activity 33			Activity 34			
17	Final test. Defense of laboratory reports.						
18	Total formative assessment. Final exams.						

The second instrument in table 2, describes the activities to be executed in the time schedule above. It has defined learning objectives and outcomes, laboratory works, independent studies and assessments. A complete 18 weeks schedule is designed with overlapping activities. These activities numbered in each module, indicates the kind of activity to be executed.

Table 2

Description of activities for 2022 – 2023 academic year [8].

No.	*Activity*
1-34	The students will by the end of the semester be able to accomplish these *activities*: ***Module 1 – Mechanics (Planned Activities 5, 6, 7, 8 10, 11, 12, 13, 14, 15, 17, 18 & 19)*** - Understand and solve problems on dynamics of a material points. - Understand forces in mechanics on material points and rigid bodies for Translational and Rotational motions. - Understand and apply the law of Conservation on work and energy. - Understand and apply the special theory of relativity. Part I & II. - Explain the phenomena of mechanical oscillation and solve problems. - Use statistical distribution methods (Maxwell and Boltzmann distribution). ***Module 2 – Molecular physics and Thermodynamics (Planned Activities 21, 22, 23, 25, 26, 27, 28, 29, 30, 31 & 33)*** - Equation of Gas State. Processes. Laws of ideal gases. - Statistical distribution. Maxwell and Boltzmann distribution. Barometric formula. - Understand the fundamental laws of thermodynamics. - Apply thermodynamic processes. Heat capacity, Internal energy. - The second law of thermodynamics. Entropy. - Cycle processes and heat engines. Efficiency - Elements of physical kinetics. Transfer phenomena - Phase equilibria and phase transformations. ***Lab. Works (Planned Activities 4, 9, 16 & 24)*** - Measurement and evaluation of errors. - Study of uniformly accelerated motion. - Determination of the Young modulus of steel wire from extension. - Determination of the moment of the inertia of a bar from elastic eccentric impact. - Determination of mean free length and effective diameter of air molecules. - Determination of the adiabatic index of gases using the Flammer Feld oscillator. - Determination of the heat capacity of an ideal gas. ***Defense/ Conferences*** - Defense of report on dynamics of material points (Translational & Rotational motion). - Defense of report on work and energy & Laws of Conservation. - Defense of individual homework *N*o.1 covering *Module 1.* - Defense of the report on fundamental laws of thermodynamics & Cycle processes, Efficiency. - Defense of individual homework *N*o.2 covering *Module 2.*
1, 2	- Library search of electronic resources provided. - Provision of lecture notes and reading materials. - Familiarize themselves with laboratory instructions and instruments.
3	- Open discussion on new and modern discoveries on the subject matter.

No.	***Activity***
	- Exhibition of research opportunities and publications.
4	- Visit to the mechanical laboratory to apply laboratory instructions and use instruments.
5-19	- Presentation of lectures. - Group the class into small units to solve common problems. - Identify scenarios in everyday life where the lecture is applicable to.
21-33	- Presentation of lectures (Understand work and Energy & law of conservation). - Group the class into small units to solve common problems. - Identify scenarios in everyday life where the lecture is applicable to.
4, 9, 16 & 24	- Use the laboratory equipments to perform group experiments based on the previous lectures. - Compare the experimental outcomes to the calculations performed previously. - Prepare a report on the experiments performed.
20,34	- A tutorial discussion on all the learning objectives set in the beginning. - Put students in group to sol problems and explain the results. - Assign individual task to be solved independently by students.
35	- Assessment is carried-out based on all learning objectives.

4.0 Module 1 – Forces in Mechanics

The topic (forces in mechanics) is selected to demonstrate the implementation of the backward approach. A set of learning objectives are designed based-off of a preconceived learning outcome and assessments. This then aids in the design of request task to achieve such learning outcome. The learning objectives and outcomes are defined in table 1 above.

Table 3

Backward design approaching on teaching forces in mechanics [9]

LO	Topic and Learning Formats (Forces in mechanics)	Louts	Assessments		
			Task	Presentation	Report
LO5.	Dynamics of the system of materials (I, II)	Louts7	Group	Group presentation	Report 1
LO6.	Translational dynamics - Practical	Louts9	Individual	Individual presentation	Individual Report 1
LO9.	Study of uniform acceleration motion -Lab.	Louts10	Individual	Group presentation	Report 3
LO9.	Independent studies /Tutorials	Louts12	–	–	Report 3

5.0 Conclusion

In conclusion, the traditional approach in teaching Physics 1.3 at the National Research Tomsk Polytechnic University is good even though the backward approach we used in teaching forces in mechanics provided the opportunity to assess students in various ways including individual and group task, presentations and report. Tutorials remained impactful as is the case in the traditional approach.

6.0 Acknowledgement

The paper has been prepared within the framework of National Research Tomsk Polytechnic University Priority Programme 2023. The research is supervised by Prof. Inga Slesarenko and Prof. Ekaterina Stepanova, Associate Professors at National Research Tomsk Polytechnic University.

REFERENCE

1. Richards JC Curriculum approaches in language teaching: Forward, central, and backward design //Relc Journal. - 2013. - T. 44. - No. 1. - S. 5-33.
2. McTighe J., Thomas RS Backward design for forward action //Educational leadership. - 2003. - T. 60. - No. 5. - S. 52-55.
3. Reynolds HL, Kearns KD A planning tool for incorporating backward design, active learning, and authentic assessment in the college classroom //College Teaching. - 2017. - T. 65. - No. 1. - S. 17-27.
4. Whitehouse M. Using a backward design approach to embed assessment in teaching //School Science Review. - 2014. - T. 95. - No. 352. - S. 99-104.
5. Isecke H. Backwards Planning-Building Enduring Understanding Through Instructional Design. – Shell Education, 2011.
6. Paesani K. Redesigning an introductory language curriculum: A backward design approach //L2 Journal. - 2017. - T. 9. - No. 1.
7. Wiggins G., Wiggins G. P., McTighe J. Understanding by design. – Ascd, 2005.
8. Teaching and Learning in Higher Education [Электронный ресурс]: электронный курс / И. В. Слесаренко. – Электрон. дан. – Томск: ТПУ Moodle, 2022. – URL: https://stud.lms.tpu.ru/course/view.php?id=2943 (date accessed: 08.10.2022).
9. E.N. Stepanova. Physics 1.3. Tomsk Polytechnic University, Tomsk, 2022.