sciendo PAN COMMITTEE ON EDUCATION STUDIES OF THE POLISH ACADEMY OF SCIENCES FACULTY OF EDUCATION UNIVERSITY OF BIALYSTOK

POLISH JOURNAL of EDUCATIONAL STUDIES

ISSN 2657-3528 2022, Vol. IV (LXXIV) DOI: 10.2478/poljes-2022-0003

Bridging Academic Gaps: How to Assist Under-prepared Students whose Academic Background was Highly Suppressed by Covid-19?

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ABSTRACT

The objectives of this study were to investigate the degree to which first-year students are underprepared for university physics due Covid-19 pandemic, and get insight on what could be the intervention strategies with which their conceptual gaps can be bridged by higher education institutions. This was achieved by conducting a qualitative study on a sample of 72 students who are enrolled in extended engineering programmes in a South African university. The collected categorical data was analyzed using descriptive statistics. The results of this study show that more than half of the respondents did not complete the matric physics syllabus and were extremely underprepared for their university physics lectures. In particular, they lack conceptual understanding of Newtonian mechanics. These students welcome the idea of being given lecture videos and/or in-person lectures/workshops, by the university, with which they could revise the matric syllabus before they start attending university physics classes. Moreover, the results reveal that the majority of students appreciate the coupling of the foundation physics and mainstream physics modules. The results further show that it could be more effective to have students simulating half of their physics experiments in a computer before they conduct them in a laboratory.

KEYWORDS:

physics curriculum, underprepared students, post-Covid-19 era, first-year students

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Introduction

Over the past many years in the pre-Covid-19 era, our basic education system has been struggling to make a significant positive impact on the future of the learners it produces, due to various challenges some of which are beyond its control (Maree, 2022). As a result, in disadvantaged communities learners, educators and parents have even lost hope and feel traumatized and demotivated. In particular, learners in underprivileged communities have been unable to achieve academic excellence due to severe poverty, under-resourced schools, and disjoined households. Such youth becomes unemployable due to the lack of skills (Maree, 2022; Fugate et al., 2004; Karue & Amukowa, 2013).

Recently, the world faced Covid-19 pandemic breakout from year 2019. This pandemic exacerbated the challenges of the already stressed academic system in South Africa (Maree, 2022). In particular, during the peak of Covid-19 schools had to maintain a social distancing measure of 1.5-meters and transition to online teaching and learning. Although, private schools and schools in affluent areas adapted well to this change. Many schools in disadvantaged and under-resourced areas were unable to make this transition. Teaching and learning time of at least 9 months was lost between the beginning of the pandemic and July 2021. Catching up on the lost time has been a challenge and some schools had to trim the syllabus (Maree, 2022).

Numerous studies have been done to investigate the impact of Covid-19 pandemic on grade 12 learners´ performance on science subjects. In particular, the study of Ukobizaba and Nizeyimana (2021) conducted in Rwanda revealed that the performance of students in science and mathematics declined due to Covid-19 pandemic. This is because the pandemic negatively affected students in various ways socially, economically, academically and psychologically. On the same vein, Sitema (2020) conducted a similar study in Zambia and found the pandemic will have a negative impact on the science, mathematics and technology results in secondary schools. Other studies were done in Nigeria and Pakistan and also showed that senior secondary school students are likely to perform badly on science subjects due to the factors arising from the Covid-19 pandemic (Oyinloye, 2020; Iqbal et al., 2021). In the South African context, Gustafsson and Deliwe (2020) predicted that grade 12 results will be lower up to the year 2022 and probably up to the year 2031. This is also supported by work of Soudien et al. (2022) who predicted that the progress of the already fragile South African education system is likely to be set-back by five years, by the pandemic. The above predictions have been confirmed to be true by the South African matric results obtained in the year 2020 and year 2022. In particular, physical science pass rate declined, compared to year 2019, by 10% and 5% in 2020 and 2021, respectively (Basic Education, 2022). This reduced performance is also a sign that Covid-19 left grade 12 graduate under-prepared for university education.

However, in the literature there is no work that has investigated the extent to which grade 12 graduates, in South Africa, are underprepared for university physics as a result of the Covid-19 pandemic. This is the main area of focus for this research paper. In particular, we are answering the following research questions:

i) By what extent are South African grade 12 graduates under-prepared for university physics because of the Covid-19 pandemic?
ii) What are the effective measures that universities must implement to assist students who do not have strong physics background due to the Covid-19 pandemic?

In this work, we addressed the above questions by conducting a quantitative survey on first-year students who are enrolled in extended engineering programmes at a South African university. It is anticipated that findings and recommendations from this work will be useful for at least two more years, especially in the South African context. This is because many learners who are still in the high school system may reach universities while they still lack fundamentals due to trimming the syllabus in grades preceding the 12^{th} grade. Our recommendations may be useful in many other countries because the under-preparedness of students for higher education is a global issue (Mulvey, 2008).

Data collection and analysis methods

The main focus of this work is the investigation of the degree to which the first-year students' readiness for first-year physics has been affected by Covid-19 in South Africa, and how universities can assist such students. To achieve this, we adopted a qualitative case study approach. Categorical data was collected using a purposive sampling method, through a self-administered online questionnaire which was compiled using a Google form. Our sample consisted of 72 engineering students who were enrolled for extended engineering programmes, in the comprehensive South African university in Gauteng province, and had just completed term 3 of their first-year. This sample of students completed their matric during the Covid-19 era, and their matric results were affected by the pandemic. The questionnaire was open for one week for participants to voluntarily complete it, and was completed by the 72 students of our sample. The collected categorical data was analyzed using descriptive statistics. In particular, using the frequency distributions, which are summarized in bar graphs, and pie charts that were generated in the Google form. The questionnaire consisted of ten questions. The first five questions were designed to investigate research question i), while research

question ii) is investigated using the last five question. The copy of the questionnaire is shown in the appendix.

Summary of Responses

This section comprises the responses of the 72 students who answered the questionnaire used in this study. These are summarized in pie charts and bar graphs, as shown in figures 1 to 10.

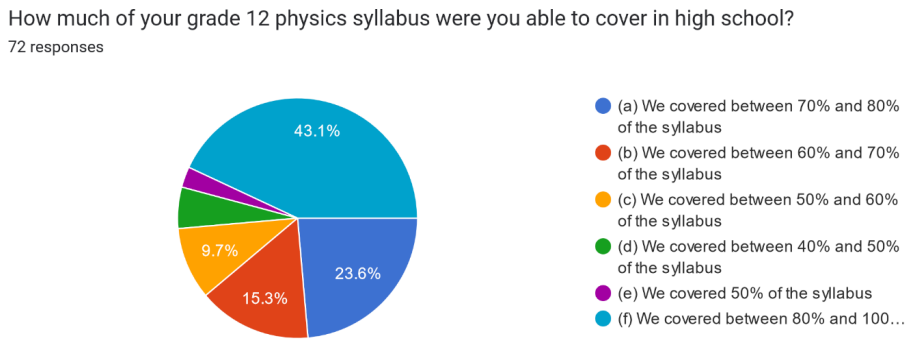


Figure 1. Summary of responses to question 1

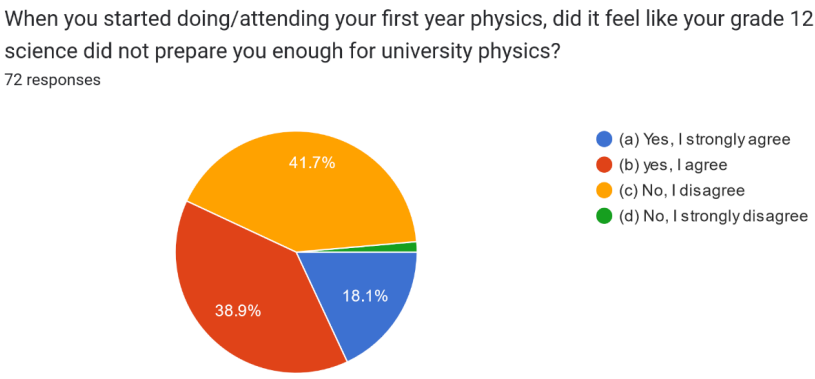


Figure 2. Summary of responses to question 2

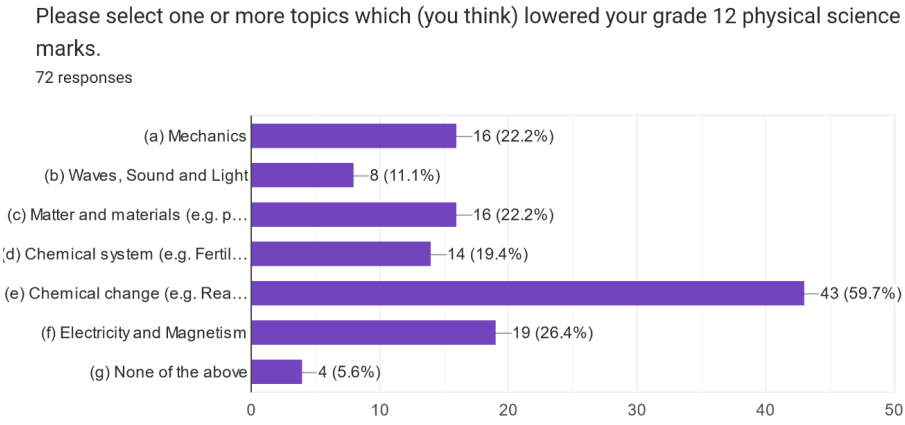


Figure 3. Summary of responses to question 3

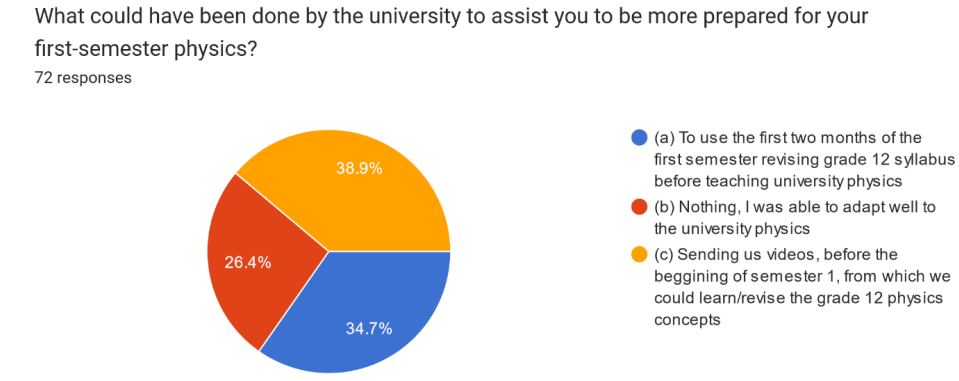


Figure 4. Summary of responses to question 4

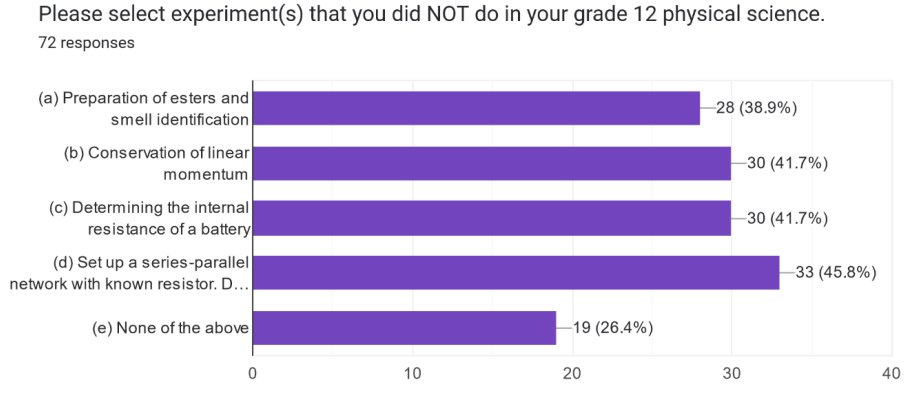


Figure 5. Summary of responses to question 5

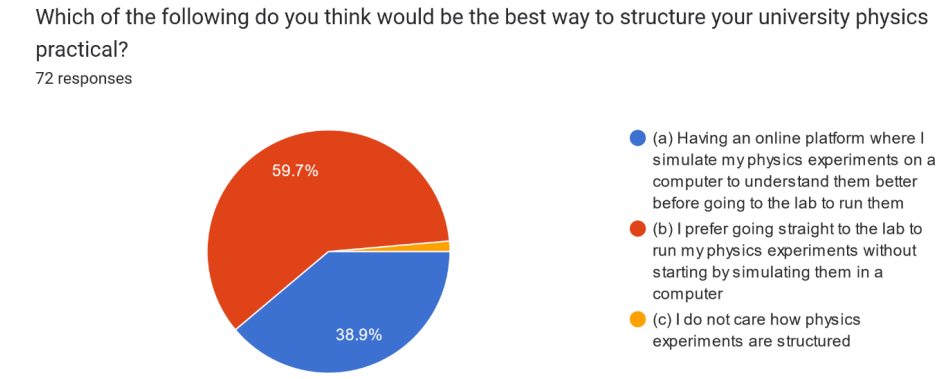


Figure 6. Summary of responses to question 6

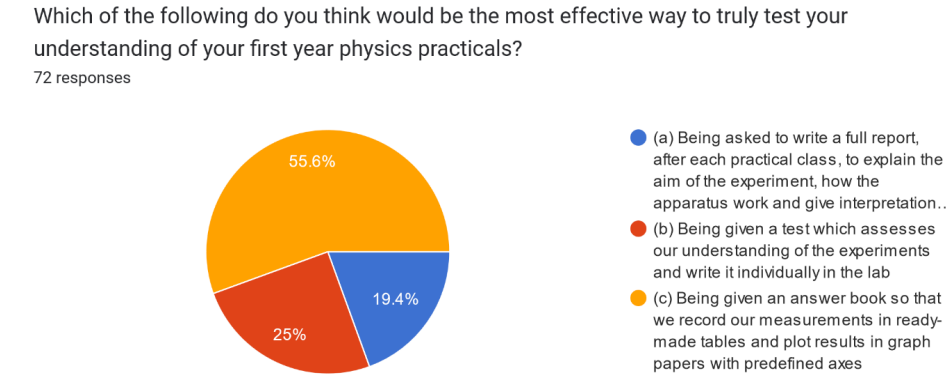


Figure 7. Summary of responses to question 7

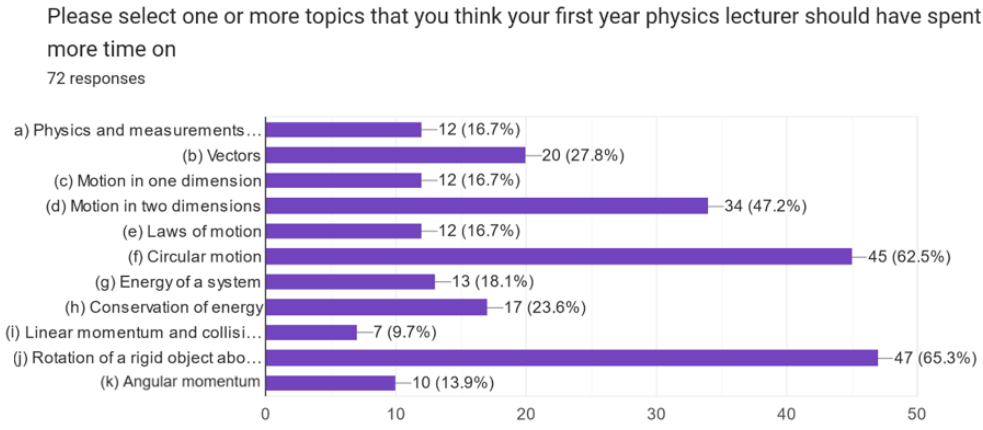


Figure 8. Summary of responses to question 8

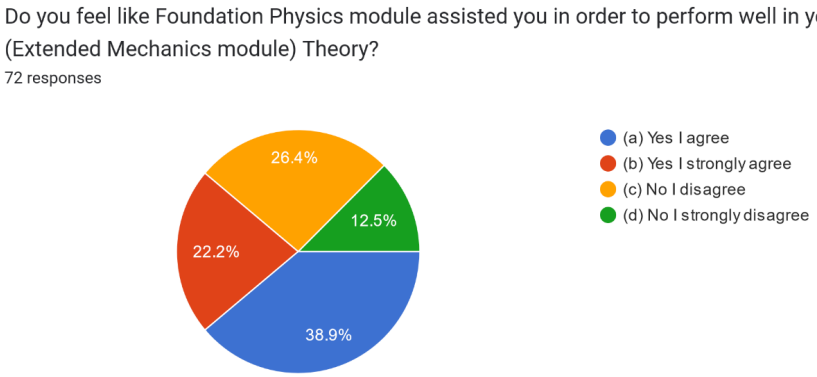


Figure 9. Summary of responses to question 9

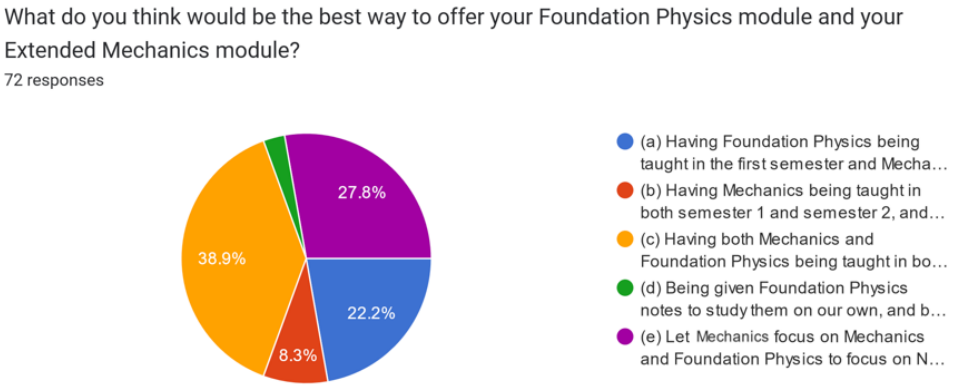


Figure 10. Summary of responses to question 10. See question 10 in the previous section for a complete text

Results and Discussions

The first five questions are meant to investigate research questions i), while the last five questions are addressing research question ii). The outcomes of these are discussed below.

How much of your grade 12 physics syllabus were you able to cover in high school?

Figure 1 shows that only 43.1% of the respondents were able to cover at least 80% of their physics syllabus in grade 12. The other 56.9% covered less than 80% of their physics syllabus. This means that more than half of the participants did not complete their

matric physics syllabus, which is supposed to form a solid foundation for their university modules, especially physics. This is consistent with the study of Maree (2022) who also pointed out that schools has to trim the syllabus due to the impossibility of having all students attending everyday, during the Covid-19 lockdown period.

When you started doing/attending your first-year physics, did it feel like your grade 12 physical science did not prepare you enough for your university physics?
As illustrated in figure 2, the results show that more than 57% of the survey participants felt that their grade 12 physical science did not prepare them enough for their university physics. This makes sense because our results reveal that 57% of the students did not complete their matric physics syllabus, and literature has also shown that taking high school physics has a positive impact on students´ performance in introductory college physics (Saddler & Tai, 2001).

Please select one or more topics that you think lowered your grade 12 physical science final marks.
According to Horner et al. (2015), there are specific topics that students must have done and be competent on by the time they complete matric. These are: i) mechanics; ii) waves, sound, and light; iii) matter and materials; iv) chemical systems; v) chemical changes, and vi) electricity and magnetism. Figure 3 shows that most students struggled with the chemistry part of their grade 12 physical science. In particular, topic v) was reported to have lowered students' marks by 59.7% of participants. While each physics topic was reported to have lowered final marks by at most 26.4%. It is very interesting that more than 70% of students don´t feel that physics topics are the ones that they struggled with in their matric physical science exams, but 57% did not complete their matric physical science syllabus and felt that their grade 12 physical science did not prepare them enough for university physics. This is in contrary with what is expected because the matric exam paper was not trimmed; It covered all topics the same way it used to in the pre-Covid-19 era (Basic Education, 2023). It is also in contrary with the work of Saddler and Tai (2001). These results suggest that during Covid-19 era students were only trained to pass and not to understand concepts in details.

What could have been done by the university to assist you to be more prepared for your first-semester physics?
According to the results in figure 4, 38.9% of respondents indicated that the university could have assisted by spending the first two months of the first semester revising the grade 12 syllabus. While 34.7% indicated that they could have been assisted by being given videos, which have grade 12 physics lectures, for them to watch and revise the grade 12 physics syllabus before the beginning of their first semester. These findings

imply that 73.6% of respondents (almost the entire class) felt that they needed the university to assist them to prepare for their first-year first semester physics by revising the matric physics syllabus, before teaching them university physics. These results are in contrary with the findings of Monnapula-Mapesela (2015) who investigated students´perception of own preparedness for higher education, in South Africa, in the pre-Covid-19 era. Hence, the preparedness of students for higher education has been significantly reduced by the pandemic.

Please select experiment(s) that you did not do in your grade 12 physical science.
There are 4 main experiments that must be demonstrated in a matric physical science class, namely: i) preparation of esters and smell identification; ii) conservation of linear momentum; iii) determining the internal resistance of a battery; iv) setting up a series-parallel network with a known resistor (Horner et al., 2015). Determining the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value. Figure 5 reveals that there are 38.9%, 41.7%, 41.7%, and 45.8% of the survey participants who did not do experiments i), ii), iii) and iv), respectively. This means we may expect at least 42% of students in the class to lack experimental skills and hands-on experience in the physics topics ii, iii) and iv). In literature there is no exact percentage, for comparison, of students who did grade 12 physics experiments in South Africa before the pandemic. However, 42% is a significant percentage and is very concerning because, as shown in the work of Shana and Abulibdeh (2020), experiments have a positive impact on the students´ understanding of science subjects.

In summary, the responses to the first five question clearly show that almost the entire class (73.6%) needed the university to assist them revise grade 12 physics in order to prepare for their first-year university physics, but 70% of them did not struggle with physics questions during their grade 12 exams. This means that students´ physics scores obtained in grade 12 during Covid-19 are not necessarily a true reflection of their understanding of physics concepts. Although this is new and strange, it brings us to the suggestion that universities should give students conceptual physics assessments during their selection process to get a better understanding of the quality of students they are enrolling. This will help identify specific gaps and topics that students need to be assisted with in order to thoroughly prepare for university level physics.

Which of the following do you think would be the best way to structure your university physics practical?
The traditional method of facilitating physics practical classes is to take students straight to a laboratory, in which experiments are demonstrated and students are asked to reproduce those or do experiments that are similar to the ones that have

been demonstrated. Another way is to start by giving students a chance to simulate experiments on a computer to gain a deeper understanding before they run an actual experiment. Figure 6 shows that 59.7% of respondents prefer the traditional approach, while 38.9% prefer simulating their experiments before conducting them in a laboratory. On the other hand, the study of Smith and Holmes (2021) revealed that students who study through computer simulations may be as good as or better than learning through hands-on experiments.

Which of the following do you think would be the most effective way to truly test your understanding of your first-year physics practicals?

The results in figure 7 show that 55.6% of the participants indicated that the best way to test their understanding of physics experiments is to give them answer books to record measurements in ready-made tables and ask them to plot results on graph papers with predefined axes. On the other hand, 25% of them indicated that it's best to give them a test that they write individually in the lab. While 19.4% of them reported that it is best to ask them to write a full report in which they explain the aim of the experiment, how the apparatus works, and give the interpretation of the results. Hence the majority of students feel that its is enough to test their understanding of experiments in less thought-provoking manner. This students´ perception is in contrary with the study of Zezekwa and Nkopodi (2020) which revealed that the best way to assess practicals is test all skills such as their understanding of how the apparatus works.

Please select at least one topic that you think your first-year physics lecturer should have spent more time on.

Figure 8 shows that: i) motion in two dimensions; ii) circular motion; and iii) rotation of a rigid object about a fixed axis are the topics, on which many respondents felt that a lecturer should spend more time. In particular, 47.2%, 62.5%, and 65.3% of the survey participants reported that their lecturer should spend more time teaching topics i), ii) and iii) respectively. Hence, we can expect about half of the students in the class to struggle with these three topics. As pointed out by Searle (1985), topics ii) and iii) require thorough understanding of Newtonian mechanics, which students should have already learnt in details in grade 12. Since schools trimmed the syllabus and did not complete it in the Covid-19 era, it is expected that students would not have in-depth conceptual understanding of this topic.

Do you feel like Foundation Physics module assisted you in order to perform well in the extended mechanics module?

All students who took part in the survey attended both the foundation physics module and the extended mechanics module. These have many topics in common. The latter

has the same content as the mainstream physics module, but it is offered over 2 semesters instead of 1 semester. The outcomes in figure 9 reveal that the majority (61%) of the participants felt that doing the foundation physics, in addition to the mainstream physics content, assisted them to perform well in the latter. This is consistent with the study of Mundalamo (2006) that showed that the students´ conceptual understanding of physics is greatly improved by taking a foundation physics module.

What do you think is the best way to offer your Foundation Physics module and your extended mechanics module?
As illustrated in figure 10, 38.9% of the participants prefer having both extended mechanics and foundation physics being taught in both semester 1 and semester 2. There is 27.8% of them who felt that it's best to have the foundation physics focusing on non-mechanics topics only, and the extended mechanics being the only one that comprises mechanics topics. Furthermore, 22.2% of the respondents indicated that they would rather have foundation physics in the first semester and extended mechanics in the second semester. Only 8% of them prefer being taught only the extended mechanics module. These results imply that the majority, 61%, of the participants would like to be taught both modules either concurrently or one of them per semester, without altering the curriculum. The other 27.8% of the respondents do not find it necessary to have foundation physics repeating the same content that is presented in the mechanics module, but they would still like to have non-mechanics topics.

Based on our findings on the last five question, we make the following suggestion: i) universities must give physics students an opportunity to do a computer simulation of 50% of their physics practicals before doing them with physical equipment in a lab; ii) Students must be taught about the role of experiments in their physics curriculum and be assessed in a manner that tests all necessary practical skills; iii) universities must compile lecture videos that assist prospective students revise grade 12 Newtonian mechanics and appoint tutors who can help them in case they don´t understand something on those videos; iv) universities must offer all first-year engineering students an opportunity to enroll for foundation physics in addition mainstream physics.

Conclusions and Recommendations

The results show that the majority of students felt underprepared for their university physics curriculum during the first semester. They also did not complete their matric physics theory and practical syllabus, and this correlates well with their under-prepar-

edness. It is interesting to note that most students indicated that they did not struggle with their physics topics when they were writing their grade 12 exams. This shows that trimming matric syllabus during Covid-19 only helped students pass matric exams, and left most of them highly underprepared for university physics. This also supported by the fact that they indicated in their university physics they struggled with topics that they are supposed to easily understand if they had good conceptual understanding of basic grade 12 concepts such as Newton's laws of motion. Therefore, their under-preparedness is extreme.

Furthermore, they indicated that there was a need for the university to revise the matric physics syllabus before teaching university physics. Hence, the ideas of being offered lecture videos and in-person lectures as the revision of the matric physics curriculum, especially Newtonian mechanics, before the beginning of the first semester, are equally welcome by students. We, therefore, recommend that academic development units, at universities, start offering revision videos and/or in-person lectures to students who have been accepted for tertiary education. Different students may lack background on different topics. Hence, Higher education institutions are encouraged to start by running baseline online assessments to identify major conceptual gaps that each student has, and recommend relevant revision videos and/or in-person lectures accordingly. Appointing tutors that can assist such students is also highly recommended.

Although the majority of the respondents thought that the most effective way to facilitate physics practical sessions is to have students conduct experiments without starting by simulating them first. There is a significant proportion, 40%, of students who prefer simulating their physics experiments on a computer before conducting them in a laboratory. Most students prefer recording their findings on ready-made report templates, but there is also a significant percentage, 44%, of them who think that the most effective ways to test their understanding of experiments are requiring them to write detailed reports, and give them tests that are written individually at the end of each practical session. Thus, we recommend that higher institutions consider blending the above-mentioned methods of facilitating physics practical classes, as well as methods of testing students' understanding after each physics practical class.

Moreover, most students find coupling the foundation physics and extended mechanics modules necessary for them to perform well in the extended mechanics modules. The idea of offering both of these modules is welcome by 61% of students, even though they have many topics in common. Therefore, we recommend that these modules are offered in both semesters, but students are given an option to not attend foundation physics classes for topics with which they feel comfortable.

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Appendix A

In this section we show all questions that were in the questionnaire used in this study. All questions were mandatory to be answered, as depicted by the red stars on each question.

Question 1	**How much of your grade 12 phisics syllabus were you able to cover in high school?**
○	(a) We covered between 70% and 80% of the syllabus
○	(b) We covered between 60% and 70% of the syllabus
○	(c) We covered between 50% and 60% of the syllabus
○	(d) We covered between 40% and 50% of the syllabus
○	(e) We covered 50% of the syllabus
○	(f) We covered between 80% and 100% of the syllabus
Question 2	**When you started doing/attending you first year phisics, did it feel like your grade 12 physical science did not prepare you enough for university phisics?**
○	(a) Yes, I strongly agree
○	(b) Yes, I agree
○	(c) No, I disagree
○	(d) No, I strongly disagree
Question 3	**Please select one or more topics which (you think) lowered your grade 12 pysical science final marks.**
○	(a) Mechanics
○	(b) Waves, Sound and Light
○	(c) Matter and materials (e.g. properties of matter, organic chemistry)
○	(d) Chemical system (e.g. Fertylizer industry)
○	(e) Chemical change (e.g. Reaction rate, Acids and bases)
○	(f) Electrity and Magnetism
○	(g) None of the above

Question 4	**What could have been done by the university to assist you to be more prepared for your first-semester physics?**
○	(a) To use the first two months of the first semester revising grade 12 syllabus before teaching university phisics
○	(b) Nothing, I was able to adept well to the university phisics
○	(c) Sending us videos, before the beggining of semester 1, from which we could learn/revise the grade 12 physics concepts
Question 5	**Please select experiment(s) that you did NOT do in your grade 12 physicla science.**
○	(a) Preparation of esters and smell identification
○	(b) Conservation of linear momentum
○	(c) Determining the internal resistance of a battery
○	(d) Set up a series-parallel network with known resistor. Determining the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value
○	(e) None of the above
Question 6	**Which of the following do you think would be the best way to structure your university phisics practical?**
○	(a) Having an online platform where I simulate my physics experiments on a computere to understand them better before going to the lab to run them
○	(b) I prefer going straight to the lab to run my physics experiments without starting by simulating them in a computer
○	(c) I do not care how physics experiments are structured
Question 7	**Which of the following do you think would be the most effective way to truly test your understanding of your first phisics practicals?**
○	(a) Being asked to write a full report, after each practical class, to explain the aim of the experiment, how the apparatus work and give interpretation of results
○	(b) Being given a test which assesses our understanding of the experiments and write it individually in the lab
○	(c) Being given an answer book so that we record our mesurements in ready-made tables and plot results in graph papers with predefined axes
Question 8	**Please select one or more topics that you think your first year physics lecturer should have spent more time on**
○	(a) Physics and measurements (e.g. significant figures)
○	(b) Vectors
○	(c) Motion in one dimensions
○	(d) Motion in two dimensions
○	(e) Laws of motion
○	(f) Circular motion
○	(g) Energy system
○	(h) Conservation of energy

- ○ (i) Linear momentum and collisions
- ○ (j) Rotation of a rigid object about a fixed axis
- ○ (k) Momentum

Question 9	**Do you feel like Foudation Physics module assisted you in order to perform well in your Physics (Extended Mechanics module) Theory?**

- ○ (a) Yes, I agree
- ○ (b) Yes, I strongly agree
- ○ (c) No, I disagree
- ○ (d) No, I strongly disagree

Question 10	**What do you think would be the best way to offer your Foundation Physics module and your Extended Mechanics module?**

- ○ (a) Having Foundation Physics being taught in the first semester and Mechanics being taught in the second semester
- ○ (b) Having Mechanics being taught in both semester 1 and semester 2, and NO Foundation Physics at all
- ○ (c) Having both Mechnics and Foundation Phisics being taught in both semester 1 and semester 2

(d) Being given Foundation Physics notes to study them on our own, and being taught only Mechanics

(e) Let Mechanics focus on Mechnics and Foundation Physics to focus on Non-Mechanics part to prepare us for 2nd year physics