An investigation into the link between first-and second-year Engineering Mechanics courses.

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An investigation into the link between first- and second-year engineering mechanics courses was carried out. Engineering mechanics is one of the most important first-year courses for engineering students. Second-year mechanics instructors often experience their students not possessing adequate understanding of mechanics fundamentals. An investigation was carried out to determine what mechanics topics were not adequately transferred from first- to second-year. Areas of poor performance for the first-year were obtained by analyzing engineering mechanics exam results and by interviewing two first-year lecturers. For the second-year, areas of concern were obtained from interviewing five second-year lecturers. All in all, potential areas of poor performance were uncovered, reasons for the poor performance were discussed and also possible solutions were presented. The list of problematic topics was widespread but topics such as free body diagrams, equilibrium, moments and vectors were found for both years. A deeper analysis of the exam papers suggests that problems may lie in not being able to identify concepts when found in a different context. Furthermore, due to the immense workload in first-year, students do not have enough time to adequately absorb the material and that spreading out the first two years over three years might allow for more absorbing of the material. Students in first-year also tend to learn more skills than concepts due to the types of exams and tests administered and altering the types of questions found in tests and exams to test more conceptual understanding might provide a long term solution. It was concluded that for the exam analysis to be more reliable, perhaps three to four years' data would need to be analyzed.

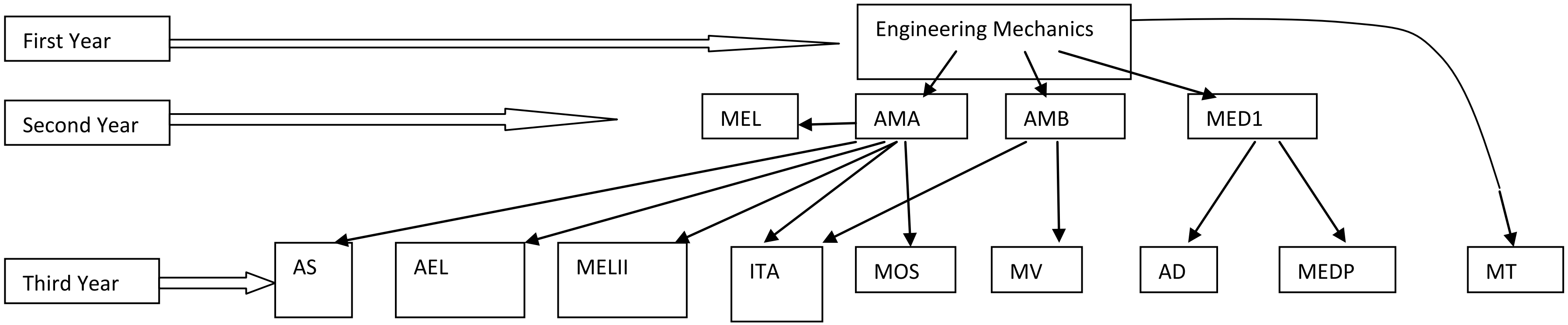
Introduction

The course engineering mechanics is one of the most important first year courses for the engineering student. It is a branch of the physical sciences which deals with the state of rest or motion of bodies under the action of forces and according to Meriam & Kraige (1987). "No one subject plays a greater role in engineering analysis than does mechanics." Danielson and Danielson (1992) say that "Success in latter courses is directly correlated to success in statics." Engineering mechanics provides the basis for nearly all branches of engineering. The importance of engineering mechanics is evident for all engineering groups, especially mechanical and civil engineering students, because it deals with the behaviour of mechanisms and structures and it builds equations based on rational models that describe physical phenomena (Papadopoulos, Rahman, & Bostwick, 2006). It is vital therefore that the necessary fundamental concepts and skills be acquired before proceeding to the upper year courses. Second-year lecturers often have to spend time to repeat work which was done in the previous year. A few questions could be asked: Did the students simply forget the work due to a long gap between first and second year courses? Or did they not understand the work in the first place? (This could imply that the students are able to pass the first year course without really understanding the concepts.)

Lecturers presenting courses in the second-year often complain that students are not adequately equipped for the second-year courses due to a lack of understanding fundamental concepts and skills (Shryock, Srinivasa, & Froyd, 2011). An interest was developed by the author of this paper regarding the connection between first- and second-year mechanics courses and the following questions were asked:

1. What are the engineering mechanics concepts and skills that are not adequately from first- to second-year mechanics courses?
2. Why are these concepts and skills not being transferred to the second-year engineering mechanics courses?
3. What are the possible solutions to this problem?

The importance of the first year engineering mechanics course is emphasized again by showing the “mechanics path” (in Figure 3) for the mechanical engineering degree at the University of the Witwatersrand. By “mechanics path” it is meant the courses in the upper years that require engineering mechanics as a pre-requisite. Figure 3 shows that engineering mechanics is a direct pre-requisite for three second year courses, and an indirect pre-requisite for one second year course. The figure further shows that there are nine courses in the third year which require the second year courses as pre-requisites. The importance of adequately grasping the first year engineering mechanics course is evident and it affects at least thirteen courses in the second and third year.



EM = Engineering Mechanics (First year)
MEL = Mechanical Engineering Lab 1
AMA = Applied Mechanics A (1^{st} semester course)
AMB = Applied Mechanics B (2^{nd} semester course)
MED1 = Mechanical Engineering Design 1
AS = Aircraft Structures
AEL = Aeronautical Engineering Lab 1
MELII = Mechanical Engineering Lab 2
ITA = Intro to Aeronautics
MOS = Mechanics of Solids
MV = Mechanical Vibrations
AD = Aircraft Design
MEDP = Mechanical Engineering Design and Production
MT = Mechatronics

Figure 3. Courses in the mechanical engineering programme that directly and indirectly require Engineering Mechanics as a pre-requisite.

Literature Review

There has been a considerable amount of research into determining concepts and skills that are lacking in students' understanding of physics. Shryock, Srinivasa and Froyd (2011) do a fine job of summarizing the various studies that have been carried out. They begin by discussing the Force Concept Inventory (FCI) which aims to detect misconceptions in Newtonian thinking, specifically focusing on Newton's Second Law, i.e. bodies in motion (Hestenes, Wells, & Swackhamer, 1992), (Danielson S., 2004). The FCI defines six areas that test various concepts related to force. It is helpful for diagnosing Newtonian misconceptions, evaluating the effectiveness of instruction and also can function as a placement exam for university students wanting to progress to more advanced courses. Shryock et al. (2011) claim however, that the main focus of the FCI has been on improving teaching of a physics course and not specifically on the preparation of students for follow on courses. The FCI authors also developed the Mechanics Baseline Test (MBT) which was designed to complement the FCI (Hestenes & Wells, 1992). It focuses mainly on Newton's First and Third Laws and is best used as a post-instruction test for students who have already completed a mechanics course as opposed to the FCI which is used on students who don't have a formal training in mechanics. The FCI assesses concepts whereas the MBT focuses on the students' problem solving ability and not only on understanding concepts. Other tests have been developed such as the Statics Concept Inventory (Steif & Dantzler, 2008) (which focuses on conceptual understanding) and the Math-Statics Baseline Test (MSB) (Mehta & Danielsons, 2002) and Static Skills Inventory (SSI) (Danielson & Hinks, 2008) which focus on evaluating skills. Although these tests are very useful and have been widely applied, the inventories were generally derived from textbooks and exams (and sometimes from interviews with instructors) and then compiled into multiple choice questions and administered again to the students. This is indeed an effective method for developing such tests. Not much research however, has gone into extracting misconceptions directly from exam results. Instead of developing a concept inventory, why not look directly at exam results to attempt to uncover topics that the students are weak in?

Danielson (2004) discusses the need for instruments that can assess student learning after completing the engineering mechanics course. It is highly beneficial for faculties to possess such instruments for use in assessing a course. In essence, the methodology they used to determine important concepts and skills was to initially ask a group of instructors to describe topics in statics that their students had difficulties in. They state that in some cases, ***the instructors even used the experience of grading exam papers*** to help in their response. It is not clear whether they only looked at the exam questions or also at the exam results. Ultimately they ended up with 48 concepts and 43 skilled items. Thereafter, it was required that each participant rank the concepts and skills in order of importance. What was of interest, (and generally expected) was that two of the first three concepts involved aspects of the free body diagram. They also briefly discuss research carried out by Phye and Andre (1986) regarding distinguishing between concepts and skills. Distinction was made between concepts and skills based on "*knowing that*" and "*knowing how*" types of understanding where the first type refers to conceptual understanding and the second refers to skills needed for problem solving. An important point was raised that although there is the aspiration that students be grounded in both concepts and skills, engineering instruction often focuses on the "knowing how" types of knowledge which does not ensure that concepts are adequately absorbed. This previous statement provides some insight into possibly why concepts are not transferred through to second-year. It may be due to the focus generally being on skills and not enough on concepts. On the one hand, engineers are being trained to carry out designs which involve calculations for which the skill aspect plays a huge role. On the other hand, if the conceptual level is not being similarly developed then the student will suffer later in their course and as a practicing engineer.

Shryock, Srinivasa and Froyd (2011) were the only group found to be researching what was envisioned in the current research, namely the connection between first- and second-year mechanics courses. They investigated what knowledge is needed from the first-year mechanics and calculus courses in order to successfully complete the second-year statics and dynamics course. Second-year instructors were asked to provide problems that they felt would test all the necessary topics that were needed in their course. The authors then extracted learning outcomes from these questions and developed a test based on these outcomes. The learning outcomes included:

- Free Body Diagrams
- Newton's Second and Third Laws
- Linear Momentum
- Friction
- Conservation of Energy

They acknowledge that the perception of the second year instructors (who provided the initial questions) may not be fully accurate and they therefore analyzed homework and exam problems to further determine what knowledge and skills were needed. The initial test was revised based on the new findings and it was administered to 362 students at the beginning of the semester. From the results of the revised test, it was found that the topics free body diagram and Newton's Second Law scored very poorly, 2 % and 6 % respectively. They claim that ***their test identified three problem areas: Free body diagrams where the body is stationary, free body diagrams where the body is in free-fall and forces and acceleration specifically related to circular motion***. The authors don't discuss why the students scored so poorly and state that it was outside the scope of their paper. This presents again the need to determine why the students struggle in certain topics, specifically free body diagrams in this case.

The same research group also investigated the alignment between the first-year calculus and mechanics courses and the second-year statics/dynamics courses (Shryock, Srinivasa, & Froyd, 2011). In this case, it appears they were not directly testing the students' knowledge, but rather analyzing the course content. They investigated to what extent the mathematics and mechanics preparation in first year aligned with what was expected in second-year. To carry this out, the authors analyzed 151 homework and exam problems from the second-year course to determine what knowledge and skills were needed and compiled the topics. This collection was then compared with the syllabi and table of contents for the first-year mathematics and physics mechanics course. They calculated the *percentage of homework and exam problems* covering the specific topics in the second-year statics/dynamics course and compared it to the *percentage of time spent* in first year calculus and mechanics courses. They found significant misalignments with the topics free body diagrams and friction. These topics were extensively used in second-year but appear to not have been covered at all during first year.

Goldfinch , Carew and McCarthy (2008) adequately summarized research carried out into possible causes of poor performance. One of the most common causes of failure cited is the time input from the students. But interestingly, Balascio, Benson, Hotchkiss and Balascio (2007) found that study hours were a poor predictor of performance. The issue of student motivation was also discussed and shown that it is difficult to relate motivation to performance, even though it may have a huge effect. Under this topic of motivation, what was brought out was that some students follow the practice of studying just to pass, because "P's get the degrees" where P indicates a pass). This also may highlight why second-year students struggle; they may do just enough to get by and not allow the knowledge to really sink in. The lack of prior learning in mathematics and physics was also mentioned as a cause for poor performance, but research showed that students who took a high level of mathematics and physics in high school only enjoyed a slight advantage in first-year and by second-year the advantage had disappeared. Cognitive psychology was also discussed, specifically in terms of two types of thinkers, field dependent and field independent. Field dependent thinkers struggle to separate the information from the surroundings whereas field independent thinkers do not have this problem. They found no statistically significant difference between these two types of thinkers when testing their conceptual understanding of mechanics. There was a significant advantage however, for the field independent thinkers in terms of problem solving skills. In terms of trying to find solutions for all these problems, Flores Camacho et al. (as sited in Goldfinch, Carew & McCarthy, (2008)) suggest that educators often only address a few misconceptions and sometimes in isolation which is not always beneficial since concepts are generally linked. What can be gathered here is that the notion of ***context*** is vital; ask a student to solve a problem in a real life context and they may not realize what needs to be done even though they possess the necessary understanding to solve the problem. Instructors are also cited as possible contributors to poor performance by not emphasizing important topics. They conclude by saying that of all the possible causes of poor performance that have been discussed, few are substantiated by statistical results. Goldfinch et al. conclude that because of the vastness of the information regarding the causes of poor performance and because various research methods exist for improving mechanics education, numerous approaches need to be made simultaneously.

To briefly summarize the findings from the literature in relation to the goal of this paper, this research set out to determine mechanics concepts and skills that were not transferred from first- to second-year and. The literature shows that various inventories have been created to test student understanding of mechanics concepts and skills. However, no inventory was found to be developed by directly assessing exam results. A gap therefore existed for determining the concepts and skills that are lacking by directly analyzing exam results. It also seems that the question of why students struggle with fundamental mechanics has not been resolved and this research also aimed to investigate this matter.

Research Methodology

Exam scripts from the first-year engineering mechanics course were obtained and analyzed (the details of which will be mentioned below). This was possible due to the author's familiarity with the course material. The aim was to extract topics that the students struggled with by analyzing the exam questions that the students scored poorly in. Once these topics were extracted, the aim was to perform a similar exercise on second-year mechanics exam papers and compare the results. However due to the author not being directly involved with the second-year mechanics courses and thereby not being adequately familiar with them, it was felt to not analyze exam scripts from the second-year course. Instead, five second-year lecturers were interviewed to give their impressions of which topics the students struggle with in second-year and why. To add to the first-year data, two first-year mechanics lecturers were also interviewed to provide their impressions. The simple reason for five second-year lecturers and two first-year lecturers being interviewed is because they were willing and available to participate in this research. In both the exam analyses and interviews, possible solutions to the problems were also explored.

First-year exam paper analysis

Four hundred and five (405) exam scripts from the first-year engineering mechanics course were obtained, 188 for the June 2012 exam and 217 for the November 2012 exam. The aim was to obtain a sample that would reflect on the total population and it is shown later that the sample was statistically representative of the total population. The June exam mainly covered statics and the November exam, dynamics. The goal was to calculate an overall average for each question and determine which questions the students performed poorly in. If a question scored on average below 50 %, it was identified and further analyzed. The topics that comprise these exam questions were extracted and the required concepts and skills were established. Note that in total seven questions from both papers were analyzed but the analysis of only four questions is presented to show the methodology that was used.

Table 1 shows the results from a sample of 188 students who wrote the ***engineering mechanics June 2012 exam***. The total number of students who wrote the exam was 1150. The exam average and pass rate for the entire population was calculated as 63 % and 83 % respectively and the average and pass rate for this sample was calculated as 65 % and 86 % respectively. It is felt that this sample is an accurate representation of the population.

Table 1. Average mark for each question from Phys 1015 June 2012 exam.

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Average	3.1	6.9	6.6	5.5	8.6	5.3	4.5	5.3	5.1
Total	5	9	10	6	12	11	11	10	6
Percent	62.1	76.5	66.3	92.0	71.6	48.2	40.7	53.4	85.5

It can be seen that Questions 6 & 7 averaged below 50 % and are worth analyzing further. The textbook used for this course is Engineering Mechanics by Hibbeler (2010).

Question 6 tested work out of Section 4.8 which covered Force and Couple Systems. The question was broken up into five sub questions and the following was tested:

- Calculating the total force and expressing the force in Cartesian vector notation
- Calculating the position vectors and expressing in Cartesian vector notation
- Calculating the resultant moment produced by the forces about the origin
- Replacing the four forces by an equivalent force and determining the position of the resultant force

It should also be noted that this was a three-dimensional problem which may introduce a higher degree of difficulty. The following topics therefore were tested in this question:

- Resultant force
- Position vector
- Cartesian vector notation
- Moment of a force
- Equivalent force
- Three dimensional visualization

The above question scored 48% which may be considered to not be a major problem. But because the topics listed are very important building blocks for later work, the average should be considerably higher. Comparing it to the 63 % total population average, the result for this question can be considered quite insufficient.

Question 7 tested work from Section 5.3 which covered Equations of Equilibrium of a Rigid Body. The question presented a system of links with various supports, forces and couple moments being applied. The following topics were tested:

- Being able to construct a ***free body diagram*** which included identifying correct supports reactions together with the correct direction of its force.
- Understanding the meaning of ***equilibrium*** and applying equations of equilibrium.

At face value, this question looked quite complicated in that it had a three links, an applied force and moment, and constraints. The difficulty for the student may lie in their inability to ***break a complicated problem into parts*** to simplify it and analyze each part. Also, they may simply not have developed the basic skill of learning to accurately construct a free body diagram.

Moving on to the ***engineering mechanics November 2012 exam***, the total number of students who wrote the November exam was 850 and the average and pass rate was 49 % and 49 % respectively. The average and pass rate from the random sample of 217 exams was 50.3 % and 55.3 % respectively. It is felt that this is an accurate representation of the total population although slightly higher. Table 2 shows that Questions 1,4,5,7 & 8 averaged below 50 % and Questions 4 & 8 were exceptionally poor with averages of approximately 26 % and 25 % respectively. Only Questions 1 & 4 are presented below.

Table 2. Average mark for each question from Phys 1015 November exam

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Average	3.8	6.9	4.2	4.2	3.8	5.5	4.9	2.7	5.5
Total	9	10	8	16	9	10	10	11	10
Percent	42.4	69.4	52.1	26.2	42.2	54.5	48.9	24.8	55.

Question 1 tested the understanding of Kinematics with the focus being on Curvilinear Motion: Normal and Tangential Components (found in Section 12.7 (Hibbeler, 2010)). It was required to calculate the normal acceleration of a person standing at a point on the Earth and also to calculate the speed of a satellite travelling at constant speed around the Earth.

Specific topics were tested:

- Identify that the question is testing Normal and Tangential Components
- Realize that the earth is travelling at constant speed and based on this there is only a normal component of acceleration and no tangential component
- Being able to calculate the normal acceleration of a particle using the correct equation for Normal acceleration
- Conversion of units
- For the satellite problem, once again, being able to see that there is only a Normal acceleration due to its constant speed. Also, that the Normal acceleration is equal to the acceleration due to gravity.
- Free body diagram.

Concerning the question above, it was interesting to see that in the research carried out by Shryock et al. (2011) one of the three main topics that were listed was *acceleration specifically related to circular motion* (discussed under the Literature Review) and this is in agreement with one of the main areas of poor performance found in the exam analysis.

Question 4 tested the concepts of Conservation of Momentum, Impact and the Conservation of Energy. The question was based on a block being dropped onto a spring-supported plate.

Specific topics were tested:

- Ability to see that the first part of the question was on Conservation of Momentum which includes the Momentum equation
- Ability to see that in the first part of the question, the spring forces do not come into play. It required ***the ability to separate the question into parts*** and see which concept applies where.
- The concept of Coefficient of Restitution and combining this concept with Momentum to obtain the solution.
- In the second part of the question, the spring supporting the plate is compressed and the concepts tested here are the Conservation of Energy.
- Understanding how springs work and the energy stored in springs due to compression.
- Applying the Conservation of Energy equations.
- In general, simultaneous equations are also tested in both parts of the question.

This question was relatively complicated in that it had a few parts to it. If the students were able to ***break up the problem***, and consider what was happening in each instant, the average mark could possibly have been nearer to 50 %.

Interviews with first-year lecturers

Moving to the interviews with the first-year lecturers, one presented a list of topics that he felt the students performed poorly in together with a couple of general areas of concern. The topics covered the following:

- Decomposing vectors along non-orthogonal axes which might be due to using geometry which is a weakness for many students
- Using the Dot Product which is vector multiplication.
- Problems involving minimisation or maximisation of forces.
- Converting units

It was also mentioned students have difficulty in ***solving long problems***. If a question is asked and it is not broken into steps for the students then they get lost. They don't seem to be able to break things down for themselves. This corresponds to some of the observations from the exam analysis.

For the second lecturer, there was a reluctance to mention any specific topics but more general problems were discussed. A possible reason that students do not succeed later on is because they lack the ability or the aspiration to connect the various topics that are learned in first year. They ***learn topics and courses in an isolated way***. When the students finish a course, there is the feeling that the course has been passed and they do not have to be concerned with that material any longer. There seems to be a lack on the students' part of realizing that future courses are built on the first year courses. It was also mentioned that it is possible to pass the first year course without fully understanding the concepts because questions are often structured in a way that allows the student to obtain enough marks from writing down equations and doing calculations. Once again, the matter of focusing more on ***testing skills*** is revealed here. If the lecturers only focused on conceptual understanding, then it's possible the students would fail because the exams and tests require problem skills-based solving. Also, the students ***do not spend time to read the questions thoroughly and develop an understanding of what is being asked***. They look at the problem briefly and head for the calculator to try to get an answer. From high school, the learners can master the algorithms and get good results without really understanding concepts and this way of learning is brought with them to university.

The author of the paper also teaches the engineering mechanics course, albeit in the setting of additional classes for students who feel they need extra help. What was found during interacting with the students for the past couple of years is that there is ***minimal studying of the theory and examples in the textbook***. The students would come to the sessions and attempt to start doing problems without thoroughly studying the background theory and the examples. The students are commended for giving up their free time and coming to the extra mechanics sessions, but it is felt that not much effort is put into ***figuring things out for themselves***. In a number of instances, students have asked for assistance with certain problems, but when asked if they have studied examples that look very similar to the problem they are doing, many say they have not attempted them. It is felt very strongly that students need the assistance. That is not disputed. But what does it mean to help the students? It is felt that it is better to lay emphasis on their developing the ability to figure things out.

Interviews with second-year lecturers

The following presents a list of topics extracted from the interviews with the second-year lecturers:

- Accurately constructing free body diagrams
- Calculating moment arms and moments
- Vectors and vector addition
- Mathematics topics, specifically algebra, trigonometry and calculus.
- Bending moment diagram
- Equilibrium and application of equilibrium equations
- Proper use of units

In addition to the topics mentioned above, general concerns were raised in the interviews: Students can at times successfully complete a problem without really understanding what they are doing. This ties into what was discussed in the literature review that the engineering courses may be ***more focused on the skill level*** in problem solving and not that much on the conceptual level. Another lecturer said that the trouble was not really with specific topics that could be pinpointed, but with the ***inability to visualize*** what is asked in the questions. The students read a question and are not able to understand what is actually being asked or to visualize what might be happening in the problem. Moreover, there is a lack of being able to ***critically evaluate*** the problem and the answer that is obtained. By this it is meant, when answers are obtained, there is a lack of questioning their validity or significance.

Comparison between first- and second-year findings

From the information gathered above, attempts were made to compare the first- and second-year topics extracted and the general remarks obtained from the interviews. Table 3 indicates that the ***free body diagram, moment of a force, vector related topics, equilibrium and the proper use of units*** are topics that are highlighted for both years. It is felt that in order for this type of analysis to bear more weight, perhaps three to four years' exam papers should be analyzed to see if a pattern emerges with similar topics. However from this first run, it may be of benefit to spend more time focusing on these overlapping topics more during the first-year.

Other possible problem areas are listed under the first-year column but do not have corresponding problem areas in the second-year. Once again, these would need to be validated by assessing more than one year's exam results. However, Shryock et al. (2011) found *free body diagrams* and *acceleration related to circular motion* to be problem areas and in three cases free body diagrams were found to comprise the questions students performed poorly in and in two cases normal and tangential components related questions (which corresponds to acceleration in circular motion) were found. Although not conclusive, there may be merit based on this finding and consideration should be made to spend more time on curvilinear motion: normal and tangential components.

Table 3. Comparison of first-and second-year topics

First-year	**Second-year**
Free body diagrams (3 cases)	Free body diagrams
Moment of a force	Moments
Resultant force; vectors, vector notation; equivalent force; dot product	Vectors
Equilibrium	Equilibrium
Converting to units (2 cases)	Units
	Calculus
3d visualisation	
Curvilinear motion:Normal &Tangential Components (2 cases)	
Conservation of Momentum	
Coefficient of Restitution	
Springs	
Conservation of Energy	

In Table 4 an attempt was made to match the underlying or supporting observations from the results and interviews. Emphasizing skills rather than concepts may be a problem in both years. It is not sure whether this is due to the students' background in high school or whether the university structure requires the student to develop more on the skills side. However, this seems to be an issue and ***the testing of concepts should be addressed***.

The remaining observations are more difficult to link directly but it seems very plausible that the inability in second-year to visualize and critically evaluate problems may lie in what is listed under first-year, namely students not understanding the theory because of ***minimal study of the textbook***, learning ***topics in isolation*** and not adequately ***reading questions*** to develop proper understanding of what is being asked. If somehow these matters can be addressed in first-year, perhaps higher success will be noticed in the upper years.

Table 4. **Comparison between observations concerning first- and second-year.**

First-year	Second-year
Testing of skills emphasized	More focused on skills than on concepts
Not read questions thoroughly;	Visualization of problems
Not develop understanding of what is being asked;	Critically evaluate questions and answers
Minimal studying of theory and examples in textbook	
Learn topics/courses in isolation	

Potential reasons and solutions

Potential reasons for the poor performance and possible solutions to reduce the poor performance were also obtained from the information. A point that came out was that the students simply ***don't have enough time*** to absorb and understand the various concepts. A possible solution mentioned was to spread out the work covered in the ***first two years over three years*** and during this time allow the students to develop deeper conceptual understanding and allow them to do more problem solving.

Another point is that students learn based on exams and tests that are administered to them. As was mentioned earlier, students develop more of a skill-based type of learning (procedural) because that is ***the way the tests and exams are set up***. There may be a problem in the second-year because of the way tests and exams (in general) in the first-year are prepared. If first-year students are trained, through class examples, homework problems, class tests and exams, to develop their understanding of what the question is asking, to expand their ability to visualize problems and identify the concepts in a real life context, and to learn to break problems up, then perhaps when they get to second-year, they will be better prepared to successfully complete the courses. Skills in engineering are very important but perhaps a greater emphasis should be placed on conceptual understanding in the first-year.

Another possible solution for better preparing the students for the second-year mechanics courses is to have a pre-semester school of perhaps a week or two to revise many of the topics. This solution though, is seen rather as a makeshift solution than one that goes to the root of the problem.

Conclusion

An investigation into the link between the first- and second-year engineering mechanics courses was carried out. Questions were asked regarding ***what*** topics were not adequately being carried through to second year, ***why*** this was the case, and possible ***solutions*** were explored. Topics such as free body diagrams, moments, equilibrium and vectors were found to be potential problem areas in both years. Reasons for the topics not being carried through might be due to the students not having sufficient time to absorb the material. An additional reason might be that they do not develop deeper conceptual understanding of the material because of the way that the exams and tests are constructed. Potential solutions include spreading the first two years over three years and placing a larger emphasis on conceptual type questions in the first-year. Also, by spending more time on the topics that were found to be problematic may improve the student preparedness. It is felt that to have more confidence in this method, results from three to four years' exams should be analyzed.

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