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Using Students' Self Reflection to Improve Motivation and Engagement in Learning Physics

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Abstract: The traditional method of teaching advanced physics courses is modified by introducing a new item in teaching, namely students' reflection throughout the semester. Students are asked to reflect on different items in their course and in particular to reflect on their achievement, struggles, goals, and skills. Students are encouraged to be open, direct, and to give details as much as possible. Consequently, instructors felt the mentor and facilitator connection with students that strengthened the feeling of academic responsibility. On the other hand, students expressed positive experience and were less concentrated on the minute details of the course but rather on a general and global picture of learning experience. This connected students with their goals, it reminded them of their struggle, confusion, and growing up experience during the process.
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Keywords: Physics education, Students' reflection, Portfolio learning, Learning engagement

Introduction

The learning and teaching experience in higher education science programs, particularly in physics, compromises several highly challenging factors that feed into the instructor/students teaching/learning process. This includes a collection of cognitive and psychological factors that dynamically intertwine, such as content understanding, memory retrieving, communication skills, critical thinking, mathematical skills, expectations of learners and instructors, attitudes, motivation, goals, believes, and more. Challenges in learning and teaching physics in higher education have been investigated and shared by many researchers, such as, (Linder, 1992; McDermott, 1999; Osborne, 1990; Redish, 2003; Tobias, 1992), to name but a few. Many studies are focusing on students who are taking introductory physics courses (Aalst, 2000; Allen, 1996; Halloun, 1985a; 1985b; Hammer, 1994; Obaidat, 2008; May, 2002; Redish, 1998). Researchers in those studies have investigated several factors that are considered to affect students' attitudes towards understanding of physics concepts in introductory physics courses. Ineffective instruction methods, students' misconceptions about the physical world, negative attitudes toward physics, lack of critical thinking, insufficient mathematical skills, poor problem-solving skills, and ineffective testing and evaluation methods are surely some of the possible factors. Other researchers focus on teachers' beliefs and attitudes in shaping education and students experience (Abd-El-Khalick, 2000; Belo, 2013; Iqbal, 2009; Hativa, 2002; Lederman, 1992; Mulhall, 2012).

Conventional teaching method has been shown as ineffective in shaping students understanding of physics concepts leading to innovations in physics education (DeHann, 2005; Lyons, 2006; Redish, 1999; Tobias, 1992). New developments in class room physics (Thacker, 2003) include several innovations such as enhanced attention to conceptual understanding, problem-based learning, hands-on techniques, and use of technology. Despite the large body of research on physics education there is little impact on teaching physics courses in universities worldwide (Sin, 2014; Tytler, 2007) as the conventional method of teaching physics still dominant, including most parts of the middle east and in particular at United Arab Emirates University (UAEU). By conventional method we mean students learn through traditional lectures and where students act as passive receptors. Content focuses on facts, standard equations and formulas, and numerical problems that create the illusion that physics is not clearly related to real life and actual challenges in scientific research. In the conventional method, engagement of students in the learning process is not a major part of the teaching and assessment process.

One of the suggestions to change traditional method of instruction is to include students' portfolios in the course structure. Portfolios are used in education and professional development for learning, assessment, promotion and appraisal. Portfolios emphasize the collection of work which includes a reflective commentary (Arter, 1992; Baume, 2001; Jarvinen, 1995) and are used particularly for the purposes of developing teaching skills and reflective practice in all teaching levels (Hutchings, 1998; Lyons, 1998). Often in higher education the portfolio is used to demonstrate evidence of achievements for summative purposes (Baume, 2002; Nystrand, 1993). Using learning portfolios shifts the instructor's responsibility from being an expert to a guide and facilitator. The relationship between instructor and students in the portfolio approach is more equal. Feedback in this case becomes a form of a dialogue in which both instructor and students are learners (Klenowski, 2006). Reflection is an important factor in portfolio approach in education, where students can develop reflective thoughts on issues written up during, in between or at the end of the course (Schon, 1987). Portfolios can be used to record ideas, beliefs, and arguments taken on issues, this leads to development of critical thinking skills (Klenowski, 2006).

In this work we focus on using students' reflection in advanced physics courses and throughout the course semester. We do not employ the portfolio technique in teaching at this stage, rather we only direct students to express their own thoughts, expectations, struggles, and learning experience during different stages in the course semester. Students are encouraged to be open, direct, and have the freedom to add details as much as they feel needed. The reason we consider advanced courses only is because students are more mature with higher sense of responsibility. Also, the number of enrolled students in advanced courses at UAEU is low, thus we believe that instructors will be less intimated by the extra work and effort needed to monitor students' reflections and provide feedback. In the next section we report on our experience in teaching two advanced physics courses using students' reflection as part of the pedagogy and assessment.

Students' Reflection in Advanced Physics Courses

Teaching advanced courses in the physics department at UAEU mainly follows the traditional method of delivering lectures where students act as passive receptors. Recently some changes have been implemented to few advanced courses such as creating new PowerPoint lectures and showing few videos and animations. However, nothing substantial has been changed in pedagogy, assessment, or attitudes of instructors or students. There is a clear hesitance in the department to adopt new pedagogy in teaching advanced physics courses. Instructors are always worried about the amount of effort and time needed to adapt to new methods, as well as the effectiveness of such methods is always in question. Therefore, we believe that a gradual change in method of teaching accompanied by a change in mind setting of instructors and students is the best practice. Due to low enrollment in physics students at the undergraduate level at UAEU, we do not expect time and effort to be major obstacles.

Recently, we have introduced a new factor in the process of teaching and assessment to engage students in their learning experience through continuous reflection on their progress during the course semester. Students' reflection usually is part of implementing the portfolio technique in teaching, however, at this stage we only concentrate on the reflection part. Students' reflection is performed electronically on the Blackboard platform that is provided by the university. Given the low enrollment of physics students in advanced courses the process will not take much of the instructor's time but on the contrary it is found to stimulate the interest of instructors in the process. To encourage students in participating in this new experience, a percentage of the final grade of the course was dedicated to this contribution. Also, specific deadlines were set for receiving the students' reflection throughout the semester.

What we are interested in this article is to provide insight into the impact of students' reflection in advanced physics courses on their attitudes, achievement, and assessment. Students reflection has been implemented in two physics courses at the senior level. The first course is Quantum mechanics and the second is Mathematical Physics. Throughout the semester students were asked to reflect on different parts of the course and at different times during the semester. At the beginning of the semester students were asked to comment on three major points; their expectations from the course, their strengths, and their weakness as learners. The question on students' expectations of the course is important as instructor gains insight onto students thinking and expectations of the learning outcomes of the course. Rather than directing the students into reading the existing learning outcomes, we prefer to explore the students' expectations of what they think and hope to achieve in the course. It also reflects the level of students' appreciation of the importance and relevance of the course.

Examples of excerpts from students' expectation in Quantum Mechanics are shown below as posted by students and without editing as English is a second language for students. One student writes: "My expectations from this course: I will have knowledge in quantum mechanics as a physics student should have, I will be able to explain general quantum phenomenon, and solve quantum math problems." Another student writes

> My expectation in this course is to learn the fundamental concepts of Quantum mechanics by using Schrodinger's equation which can solve quantum mechanics problems and, as result of it I will be able to add to my learning the mathematical skills needed to solve quantum problems which hopefully will lead me finally to discuss or understand the microscopic world.

Another student writes:

> I expect to learn a lot of things in this course. Firstly, I would like to understand the fundamental concepts of quantum mechanics and its application n life and why classical mechanics is not the right theory of nature in certain situations. In addition of applying the recommended techniques that can be used while solving quantum mechanics questions such as Schrodinger equation, operators and Eigen functions. Beside using the tools, methodologies, language and conventions of physics to test and communicate ideas of quantum mechanics.

An interesting contribution from another student is:

> Quantum mechanics has been an intimidating experience for past students, I expect it to be slightly harder than the previous courses, however I believe I will be able to understand the basics of the course throughout the semester. I expect this course to discuss particles and their movement and positions using mathematical methods, and it will include the uncertainty (particle in a box) concept in those calculations.

Another example is from the Mathematical Physics course:

> I believe that once I've successfully completed this course that I'd be much more familiar and comfortable with reading mathematical notations in complicated fields. I would expect that I'd be very fluent using them as well. Furthermore, I reckon that there will be a link between those learned skills and physical applications.

Students have their own view of the course learning outcomes and what they expect to learn. In general, we find that students views are compatible to large extent with the actual course learning outcomes. Also we notice that some students have a labeling scheme to some courses, such as the Quantum Mechanics course is hard which could affect their commitment and attitudes toward the course. This course labeling is transferred through students' interactions and communication.

Another question that students were asked at the beginning of the semester is to reflect on their weaknesses and strengths as learners. Students were asked to be honest in reflecting on this point and were told that their reflection will be set to private on the electronic platform where only instructors were allowed to read students response. Here we provide some excerpts from students' answers. One student writes passionately:

> My strengths: I'm able to learn fast. My weaknesses: I thought I was good in math, but when I took electromagnetic theory last semester, I realized I'm so far behind, and the reason is I didn't take the needed math concepts in university, Calculus 1 and 2 were easy to me but when I took linear algebra, unfortunately, I did really bad, and got D, we took ordinary differential equations course and I got B+, in mathematical physics we just had 2 chapters on coordinates double and triple integrations and vectors. So my math knowledge is really weak; I don't know complex numbers, partial differential eq. I was motivated at the beginning to continue in physics after graduation, but unfortunately after I realized that I'm not taking real physics, and maybe my sister in school knows physics more than me. and the math knowledge Is also weak, I really lost motivation and I am looking for another field to continue my Master in.

Another student writes:

> I enter this course after learning advanced mathematics, high level of physics courses, basic Philosophy and I think I can be fine with quantum mechanics course if I work hard for it. So I can say that my strength points are critical thinking and problem solving and dealing with high level of mathematical physics problems and the ability to find and prepare the needed notes of the course from different sources such as library and online learning. However, I have some weakness in some areas such as computational physics, statistical physics, electromagnetic theory because I didn't learn these subjects yet and I am afraid that quantum mechanics is related to them in the same math or same concepts so I hope from you doctor to make a small revision for us at the beginning if quantum is related to these subjects.

It was a surprising experience for the instructor to read students input and how students were explicit in pointing out the struggle and frustration they were experiencing as students. Students were passionate in describing their struggle in their physics courses and experience as students. This part was influential on the instructors' attitude and feeling of responsibility toward students. Instructors expressed support, guidance, and encouragement to students throughout the semester, pointing out that struggle is an indispensable part of learning.

Next step was to ask students to reflect whenever they submit a homework or perform a test. Students were asked to evaluate their understanding of the material and wither practicing solving the homework has played a role in enhancing performance and understanding. It was always interesting for the instructors to read students comments and connect with their struggle. In the middle of the semester students were asked to reflect on their achievements and efforts. Also, they were asked to compare their initial expectations with their experience in the course so far. This gave students a time to pause and rethink about what has been accomplished and what has been missed. They reflected on the adequacy of their efforts and some students expressed their intention to modify their study plans for the course. We find this self-evaluation is critical to keep students on track during the semester as they easily get distracted by other factors beyond the course. We find students' self-reflection to be helpful for both the student and instructor. The instructor can use the students' reflection to rethink about the objectives of the course and how to handle issues that students find particularly important or confusing. We give only one response of a student from the Mathematical Physics course as the student writes:

> I believe that I have focused my entire attention on the material instructed in class and that I'm not lacking in that area. Although I work and practice a lot when it's time for the assignments and quizzes, I don't usually go over what I took in class when I go home. The constant tasks I keep getting throughout the past 3 weeks gave been overwhelming to the extent that I started sleeping almost 2 ~ 3 hours a day. And this hindered my ability to perceive the information in class in comparison to the beginning of the semester. I put up very high standards for myself before commencing any course, so anything other than a full mark is usually a disappointment. The thing I do appreciate about myself is that when this happens, I get more motivated and work even harder than I previously did, to achieve the grade that I want. Apart from the grades, I'm quite satisfied with the grasp of the new concepts I learned, especially the dissection of uniform circular motion. To know how that equation came to be was very interesting. So far I'd say that my expectations were spot on. Personally, I find that the examples which correlate the math to the actual physical application help quite a lot in delivering the information.

At the end of the semester students were asked to reflect on the whole course and reflect on the following items as explicitly and thoroughly as they find appropriate:

1) Did you work enough on achieving your expectations? explain
2) Did you accomplish your expectations? explain
3) What are your comments about the course and what have you learnt, and how the course could be improved?
4) Write general comments on your personal goals and whether the course has made any change.

Here we list few excerpts from students' responses in Quantum Mechanics. One student writes:

> The course was really challenging for me, but I'm very happy and satisfied that I took quantum mechanics as one of the most important courses in physics with you doctor, it was a very great experience, you have no idea how much I learned in this course. I might not get a high grade, but I know myself that I understood the basics of quantum mechanics pretty well! and I'm very confident about it. I did my best in this course, and I really enjoyed the

> material. It was a pleasant experience to me, taking a course with you, because it brought back my confidence in physics again. Please doctor keep doing the reflection idea for the next generations, it is an excellent idea to make your students improve, it makes them know where they are and know how to solve their problems. Your way of explaining is the best in our department with the agreement of all students and other professors. I'm very happy that I took my last physics course in my undergraduate with you. As for my personal goals, I'm a person who is passionate about learning, I have taken business, science, engineering and IT courses, inside and outside university, but the thing I loved the most since I was 10 years old is everything about computer... I just feel happy whenever I do or develop anything in computer. So I want to continue my masters in Software engineering, most likely in our university, and then do my PhD as well. the field that I want to specialize in IT the field of Big Data and Data Mining. This field has so many applications in science especially in physics. So my plans are to find a nice application that connects both physics and data mining together and do my master degree in it. Thank you doctor for everything you have done. Have a happy and relaxing summer with your family.

Another student writes:

> Going into this course, I honestly was more scared of the difficulty of Quantum Mechanics, than I had any expectations or inspirations. Of course, I expected it to be hard and I was willing to study hard for most of the time. I wanted to get a high mark in this course, to challenge myself and prove that if I had worked hard at the beginning, I would have been a much better student with better grades. However, I felt that I did not live up to my expectations and was lazy to study most of the time. It had nothing to do with the course or the instructor. Actually, I find Quantum Mechanics to be the most exciting subject I took so far. From the Schrodinger equations to the angular momentum. But again, I have the habit of procrastination that hindered my progress in the course. But if there is one thing that I am proud of, it would be that I did everything I could that I dedicated 3 continuous days for the final exam. Therefore, I think I did well in the final compared to my overall performance during the course. On a side note, I would suggest to have a small bonus pop quiz just to make the student motivated for the course. Moreover, a more frequent homework and project would have had motivated me to study more. Other than that, I think the course structure was well-organized. In the end, I would like to say that this course had made me see how hard physics could be. And a course like Quantum Mechanics needs a consistent student with the motivation to learn and challenge himself. Although I was not that kind of a student, I think at least, my motivation in the final week made me do the impossible, and cover most of the subject in a relatively short time. Quantum Mechanics is captivating, but it needs a consistent hard work!

Another student writes:

> I think quantum mechanics was fairly difficult, even though I knew that, I still struggle in the course. I believe I have worked hard, but not hard enough. I study the notes and homework, but I don't refer to the text book for detailed explanation and more examples I was expecting to know the basics of quantum mechanics, and I think I managed to achieve that. (Such as the infinite potential well). This course helped me improve my skills in mathematics. It helped me create better bonds with my classmates, and that's duo to the study groups we used to do to solve homework and project. For my personal goals, I aim to graduate and start the next phase of my life, this course was a step in the right direction.

Students reflections during the courses semester were influential on the instructors. They provided a personal link between the instructor and students. Instructors feeling of academic responsibility were strengthened and the awareness of students' struggle and frustration created a connection between instructors and students. The experience of reflection was enjoyed by both students and instructors as well. Students expressed satisfaction with this method of writing about their struggles and experience throughout the semester. Instructors are more determined to repeat the experience in future courses.

Conclusion

Our experience with students' reflections throughout the course semester was positive. As instructors we felt a personal connection with our students that strengthened our feeling of academic responsibility. Reflections expressed by students exposed some of the struggles and frustrations that students feel toward their courses, instructors, learning experience, and personal life. One cannot disassociate students learning experience in class from the overall issues and experience they having as students and young adults. We think that instructors' involvement and connection with students directly promote the case were instructors act as mentors and facilitators. On the other hand, we find that students find reflection a useful act throughout the semester. It opens students' eyes into their learning experience and progress. It takes them away from the minute details of the course into the general and global picture of learning experience. It connects them with their goals and attitudes, it reminds them of their struggle, confusion, and growing up during the process. Any course taken by students should not be looked at as a disconnected piece from their overall learning experience. Rather it should be looked at as an integrated piece into their overall learning process. We do not claim this method will boost the achievement of students in the course as few students finished the course with low grades. However, both the student and instructor were aware of the struggle and effort made by the student throughout the whole semester. We think that this self-reported awareness of the students may have some positive effect on their learning and working experience in the future.

Recommendations

We plan to repeat this method in the next coming semesters to collect more data to be analyzed systematically. We encourage other instructors to adapt this technique in their teaching and observe enhancement in students' engagment.

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