Student Engagement in a One Day One Problem PBL Class

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ABSTRACT

Problem-based learning (PBL) is adopted in a unique One-Day One-Problem approach at Republic Polytechnic (RP), Singapore. The basis is that students learn best through engagement. This engagement at RP starts in response to a question or a problem, and continues with reasoning and understanding by students throughout the day. This paper presents the RP's PBL practises in the School of Engineering in student engagement and daily reflection by citing one of the daily problem "Heart Rate Filters" in the module "Linear Circuits and Control" to show how students are engaged through problem trigger, simulation and class discussion throughout the learning process. This new form of engagement broadens the educational experience of engineering students and increases students' interest in engineering education.

KEYWORDS

Problem Based Learning, Student Engagement, Reflective Learning, Holistic Assessment.

1. INTRODUCTION

Student engagement plays an important role in students' learning process in any form of education. Students learn best through engagement and active learning, and by using self-monitoring and reflection to guide their learning (Blank 1997; Dev 1997; Kushman 2000; McCormick 2003; Woods 1995). Research has shown that educators who are most successful in engaging students is to develop activities that best suit students' basic psychological and intellectual needs in mind (Ames 1992; Anderman & Midgley 1998; Strong et al. 1995). Thus, the challenge for every institute is to constantly review their course content to improve on student engagement.

The One-Day-One-Problem PBL in Republic Polytechnic (RP) emphasizes on students' engagement during their learning journey. Students are assigned into small teams and worked together to solve a problem daily. All learning engagements of regular modules at RP are initiated by a statement demanding a response from the students. Collaborative self-directed learning during each engagement culminating with a presentation, defence and reflection is expected of students. This is RP's strategy to apply PBL to meet its specific mission of training professionals out of secondary school graduate and to prepare them for real world challenges (Glen & Alwis 2002).

In the School of Engineering, Republic Polytechnic, the design of the daily learning activities for students is based on the Kolb's descriptive model of learning process. Kolb's learning cycle consists of four stages: Concrete Experience is followed by Reflective Observation that generates the Abstract Conceptualisation. This leads to Active Experimentation that will generate a new Concrete Experience, as shown in Fig.1.

Many use Kolb's descriptive model of learning process as a model of experiential learning. However, problem based learning is different from experiential learning. In our PBL context, concrete experience in the model includes the past experience of students in their daily life, their experience gained through simulation in classroom (Wang, Fong 2006), and their hands-on experience gathered in laboratories and during field trips. With a properly designed problem statement, these experiences will trigger students' curiosity to explore further. In the second stage, students try to figure out the reasons why a topic is important and what they need to learn in order to understand the topic. In the third stage, information about the topic is collected through online resources, textbooks, and discussions. Abstract conceptualization happens at this stage to bring students to a higher level of understanding to the topic, with the support of scaffoldings and helps from facilitator. Finally, in the fourth stage, students apply the topic in problem solving and experiment actively based on their understanding to the topic. In this way, students are engaged throughout the day.

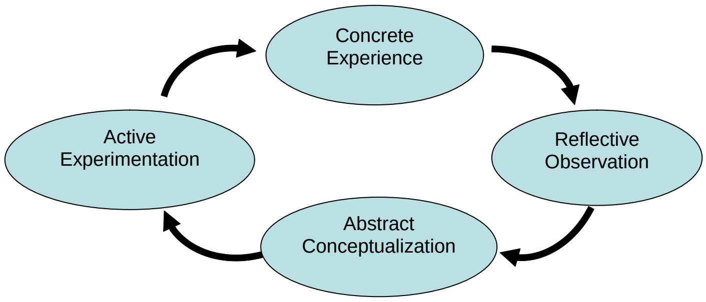

Fig. 1. Kolb's descriptive model of learning process

In the section 2, the student engagement and reflective learning will be discussed further, followed by a case study based on a problem designed for a module called "Linear Circuits and Control", then student learning will be reviewed briefly through their reflection journal. Final will be a brief discussion on incorporating CDIO into our curriculum and the conclusion.

2. STUDENT ENGAGEMENT AND REFLECTIVE LEARNING

Student engagement refers to "student's willingness, need, desire and compulsion to participate in, and be successful in, the learning process promoting higher level thinking for enduring understanding" (Bomia, et al. 1997). In the Republic Polytechnic, we have identified three key elements in our One-Day-One-Problem problem solving process for student engagement that are learning environment, problem statement and daily activities, and reflection, as shown in the Fig. 2.

Learning environment:

To engage students effectively, learning environment is crucial. In RP, the typical number of students in each class is 25. Students are randomly grouped in teams of 5 with the help of a facilitator and they will need to work within their team for the day itself. The classroom layout is designed in such a way that 5 students are sit face to face around a table. There are 5 tables in total in one classroom. Students are expected to share their own ideas, do research and develop possible solutions together with their team mates. Social bonding among students is developed due to a collaborative classroom environment.

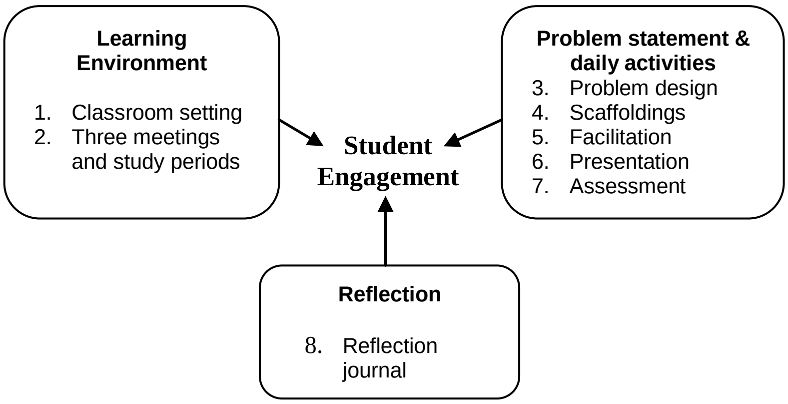

Fig. 2. Three key elements for student engagement in RP

There are three meetings every day for students to interact with the facilitator of the class. While the first meeting is for students to understand the problem and figure out the knowledge they need to learn in order to attack the problem, the second meeting is giving a chance for students to move in the right direction. Normally this is done through the inquiries and questions from facilitator. There are two study periods between three meetings which are for students to do self-directed learning. Students continue to learn through presentations during the third meeting. Challenging questions from facilitator and classmates force presenter and listener think more critically.

Problem statements and daily activities

Problem statement is the key to trigger students to start to learn, and problem must be suitable for students to complete it within a day. The problem design and problem statement crafting become the most critical component for one day one problem approach, especially in engineering.

Recently there are plenty of discussions on engineering education reform. Many reports indicated that traditional engineering education focuses on and encourages largely the study of engineering science. Students in engineering schools get boxed into one-dimensional careers consisting mainly of technical work, eventually get bored and then stagnate in their career (Prados 2004, Duderstadt 2008).

For engineering education in the Republic Polytechnic, holism is a necessity. We believe in an education strategy that will make students regularly evaluate a given scenario, identify, search and gather relevant information, work in teams, reason and justify to form opinions, apply various known tools, convince others and reflect regularly on whatever they do (Wang, Fong and Alwis,2005). To achieve these, the engineering fundamentals covered in traditional curriculum are re-engineered to form a selection of key ideas that define the subject. For each key idea, a context is crafted that motivates a response dealing with the idea strongly. The subject content is secondary and shall get expressed along with the response. Each problem sets an achievable, meaningful & relevant target for the day to the students, thus engage them to complete the daily learning activities.

The students in RP are mainly secondary school graduates who have been so used to traditional lecture system invariably find themselves unfamiliar with the PBL environment. To help the students, well designed scaffolding is provided to nudge them towards developing a comprehensive response. Scaffolding is in the form of worksheet accompanying the problem statement.

In the third meeting, students are required to present and defend their solution in front of their classmates and facilitator, to enhance their communication and critical thinking skills.

We understand that assessment tends to drive students' learning. To engage students beyond contents and knowledge, the assessment in RP includes two main components, daily grade and understanding test grade. Daily grades capture the different facets of the broad perspective of problem solving in a team. Understanding tests are conducted three times per semester for each module to assess the level of understanding of students to the problems they solved.

Reflection:

Problem based learning (PBL) is learning by reflective thinking. As a teaching and learning methodology the problem from a real world context becomes the catalyst for students to achieve both knowledge and process outcomes but only in as much as students engage with the processes of reflective thinking. Reflective learning is an essential attribute for lifelong learners. This learning process allows an Individual to make sense of their experience and provides them with an opportunity to challenge thoughts and feelings about events and change future behaviour. To further enhance reflective learning, the facilitator of a class posts a reflection journal (RJ) question after the third meeting so that student can reflect on their learning of the day. It helps the students to reflect on their learning process as well as engagement for the day.

In the next two sections, a real problem package in the module “Linear Circuits and Control” will be used to illustrate the student engagement ad reflective learning in RP.

3. PROBLEM DESIGN: HEART RATE FILTER

The heart rate filter was one of the sixteen problem presented to students in the module “Linear Circuits and Control”. The learning objectives for this problem were filter designs and filter application. It should be noted that students had acquired knowledge of basic filters and common types of filters such as low and high pass filters, higher order filters in previous weeks.

The problem designed begins with the forming of a problem trigger. Considerations for good problem trigger include motivational issues and authenticity. Whenever possible, it must also be kept relevant to the industry to better prepare students for future challenges. These characteristics of problem crafting increase the student's willingness and desire to participate in the learning process. In this case, the problem described the need for filters for the biomedical industry where heart rate signals obtained from electrodes are noisy in nature. Fig. 3 shows the basic formulation and layout of the problem statement. (see Appendix A)

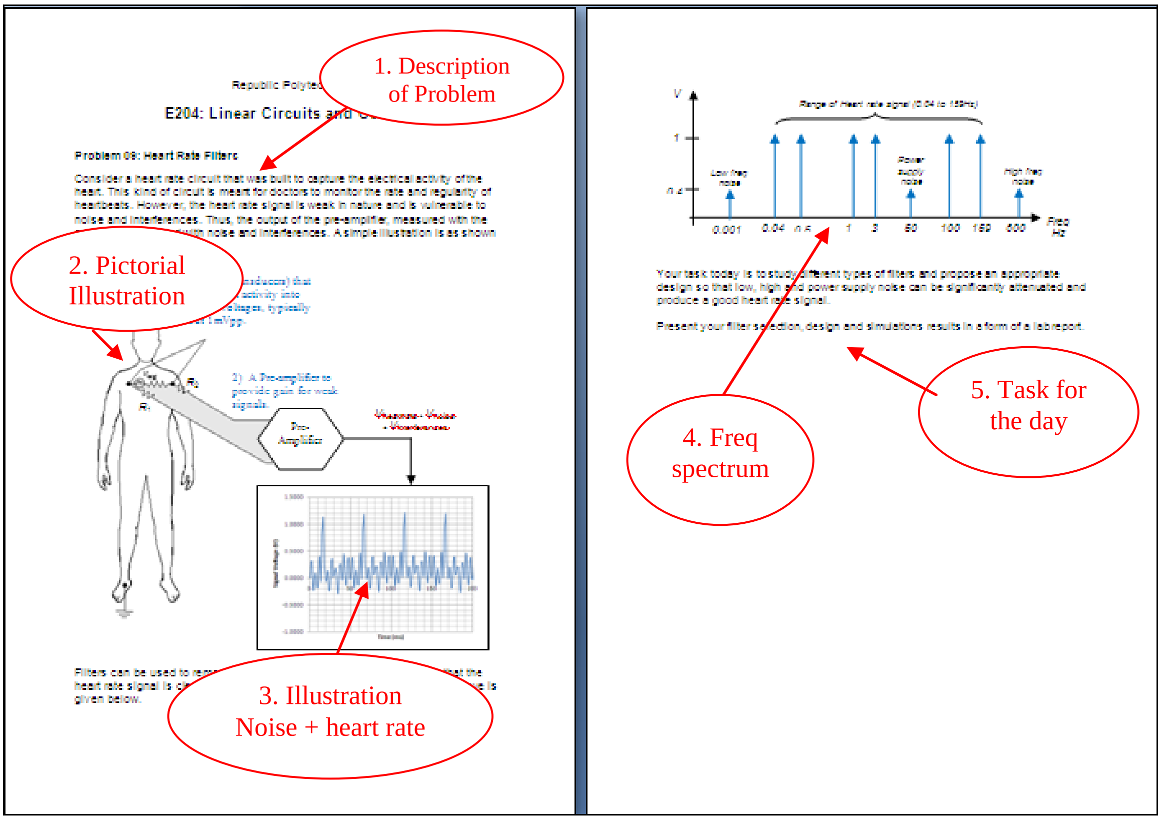

Fig. 3. The Problem Statement of Heart Rate Filter

As discussed earlier, scaffoldings are distributed to students together with the problem statement to assist student in their learning. There is no restriction to the form of scaffold other than its relevance. The following describe some of key scaffolds provide for students in the heart rate filter problem.

Software or hardware scaffoldings are often created to aid student where certain areas of understanding are beyond the learning proximity for the class. Most of students may have rough ideas how heart rate signal is captured and displayed in medical devices in hospitals, but lack of experience of capturing, processing and displaying the signal. Thus in the case of the heart rate filter problem, a scaffold was created in Excel to better illustrate the effect of unwanted signals (noise) which distort a desirable heart signal (Fig.4). The scaffold brought in experience in a simulated environment to facilitate students' reflective observation.

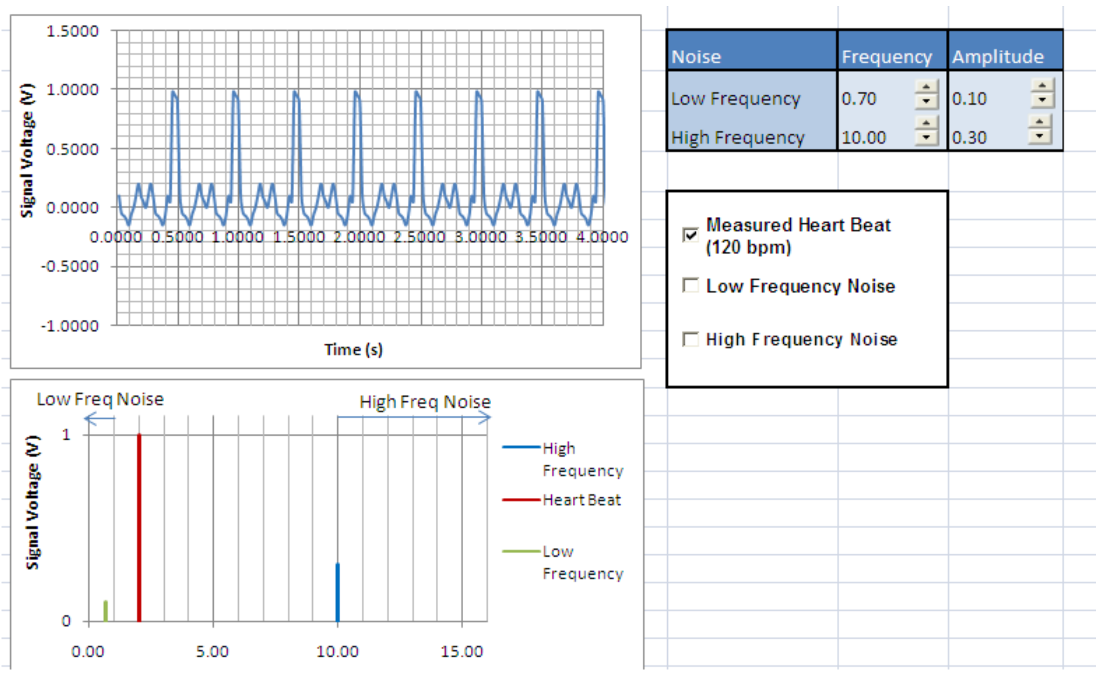

Fig.4. Scaffold created using Excel

The worksheet is another key scaffold provided to students. The questions raised in the worksheet are carefully designed to help student to build understanding of concepts requiring a high level of abstraction. For this problem, students normally are able to figure out the formation of a band pass filter or a band stop filter by a high-pass filter, a low-pass filter and a summing filter, but have difficulties dealing with notch filter. Questions in the worksheet help students to jump from what they can comprehend to more abstract concepts such as central frequency, quality factor and the design of a notch filter. These questions are normally reviewed by a team of facilitators to adjust the level of guidance so as to complement the level of difficulties faced by the students.

Finally, facilitator is also an important scaffold in class. In this problem, facilitators help students learn to use PSpice software to simulate their filter designs whenever necessary. Facilitator monitors the team dynamics in each group, facilitate self-directed learning of each individual student and make sure students are engaged throughout the three meetings.

With the context of filtering noises from heart rate signal, students are more motivated to explore the new concepts brought up by the problem. This can be seen from their reflection journals after the class.

Table below shows some of responses from students who have gone through the “Heart Rate Filter” problem.

Table 1. Reflection Journal response quoted from students

Reflection Journal questions posted by facilitators:	**Student’s response**
Class A: How do you find today’s problem on the application of filters? Do you think it will be beneficial to you?	Today I have tried my best to understand well and perform for this problem. I found that today's problem is not very tough and class discussion enhanced my understanding.
	I find that, by learning the day's problem about filters, give a better view and a larger scope on what are we trying to focus on about handling medical equipments.
	To me it is very beneficial and important as it is regarding and how to handle the equipments stuffs. Not only that, it is also link to what we will do after we graduate. Therefore, having to learn and understanding the scope of how the filtering works, it benefits me for now and also during the working industry.
	As usual, the basic knowledge is very important. Actually we have learnt about filters in the Problem 7. From then on, each day’s problem is going to feed the knowledge of filter step by step to us. So I link today’s problem to the previous two problems. I think they are very helpful for me to understand the new knowledge.

The RJ question probed into student motivation for the day. Most students were able to relate the heart rate filter circuit design to the medical equipment used in industry. The problem scenario helps to trigger students’ interest in their learning, even for those students who may find it tough.

4. RP’s PBL and CDIO

With the main aim of educating students who are able to “*Conceive-Design-Implement-Operate engineering products, processes, and systems in a team-based environment*”, the CDIO Initiative has codified the expected learning outcomes of an engineering education into the CDIO syllabus. This syllabus is organized into four main sections:

1) Technical knowledge and reasoning
2) Personal and professional skills and attributes
3) Interpersonal skills: Teamwork and Communication
4) Conceiving, designing, implementing and operating systems in enterprise and societal context.

As described above, RP’s adaptation of PBL emphasizes learning engineering fundamentals through a well designed context and a series of engaging activities which center on students working in small teams to deal with issues brought up through the daily problems. As the students work through the problems, students identify the learning issues, gather the relevant information, communicate their ideas and develop a possible solution to the problem. They would then need to present and justify their solution to the class. Through this approach, students are able to improve their capability to understand by learning how to learn.

RP’s School of Engineering has been exploring how elements of the CDIO syllabus, especially section 4, can be incorporated to enhance RP’s existing curriculum structure. One recent change that has been implemented is the introduction of a core module, Engineering Design, in the first year curriculum for all engineering students. In addition, the school is considering getting second year students to be engaged in a design challenge so that they can integrate their learning during their first two years. For third year students, engineering curriculum requires students to complete two project modules, that each is a semester long, to engage students to conceive, design and implement a workable prototype or a system in different areas. Many of the projects are industry initiated.

5. CONCLUSION

With contextualization of abstract engineering concepts, engineering students can be more effectively engaged in their learning process. Properly designed problem trigger, scaffolding like simulation and worksheet, class discussion and self-directed learning make sure students in the Republic Polytechnic to solve a problem a day. The experience prepares student for real world challenges when student graduate from their studies.

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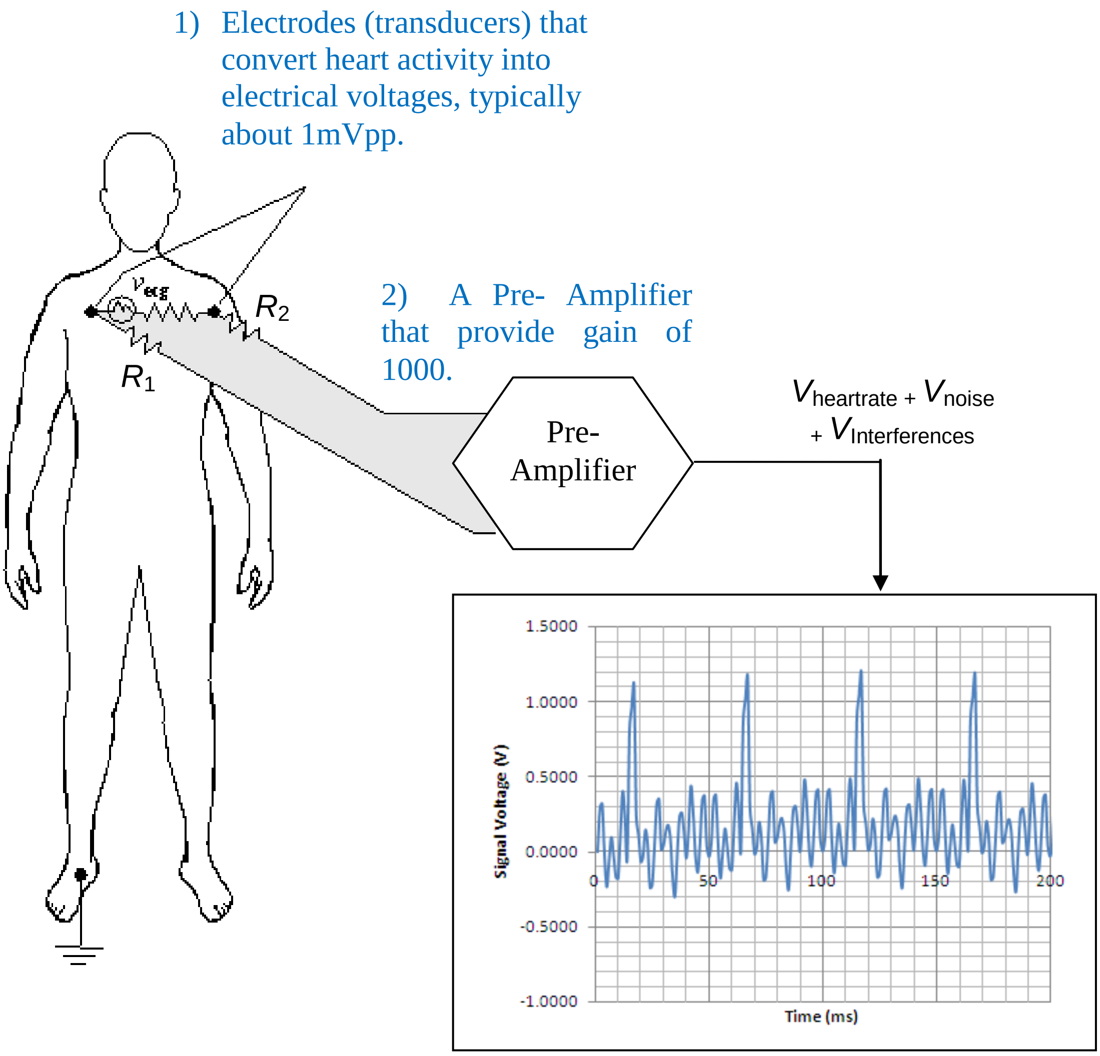
Appendix A

Republic Polytechnic

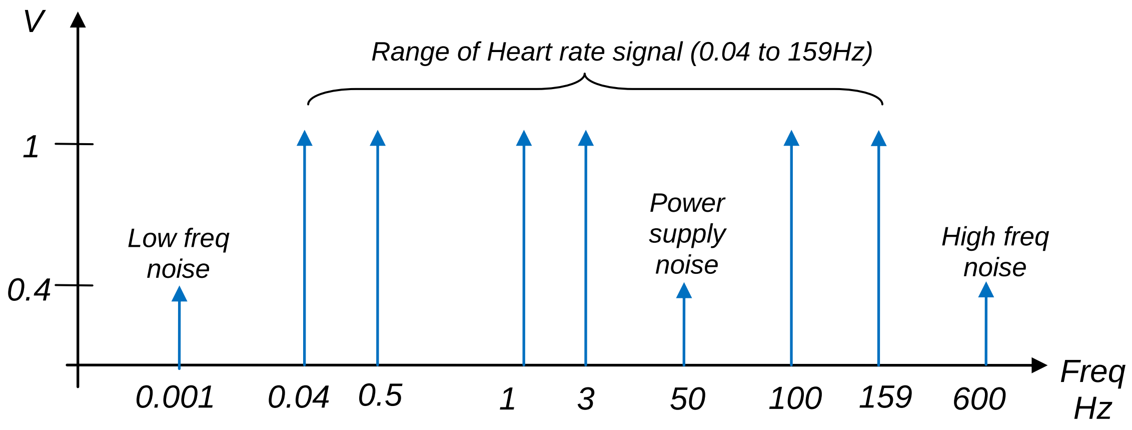
E204: Linear Circuits and Control

Problem XX:Heart Rate Filters

Consider a heart rate circuit that was built to capture the electrical activity of the heart. This kind of circuit is meant for doctors to monitor the rate and regularity of heartbeats. However, the heart rate signal is weak in nature and is vulnerable to noise and interferences. Thus, the output of the pre-amplifier, measured with the oscilloscope is filled with noise and interferences. A simple illustration is as shown below.



Filters can be used to remove the unwanted noise and interferences so that the heart rate signal is clear. Supposing the frequency spectrum of the signal above is given below.



Your task today is to study different types of filters and propose an appropriate design so that low, high and power supply noise can be significantly attenuated and produce a good heart rate signal.

Present your filter selection, design and simulations results in the third meeting.