EXAMINING THE PRACTICE OF SCAFFOLDING DURING PROBLEM/PROJECT BASED LABORATORY

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Continuous debates on the lack of competency in solving complex engineering problems among engineering graduates in Malaysia have generated numerous researches on inquiry-based learning within the context of engineering education. However, less work had been done to investigate how the Malaysian electrical engineering undergraduates’ higher order cognitions were facilitated while undergoing project-based or problem-based learning environment. This paper presents a study that examined the practice of scaffolding during Problem/Project Based Laboratory (PBLab) at Digital Signal Processing Laboratory (DSP Lab), Faculty of Electrical Engineering, Universiti Teknologi Malaysia (UTM). A single case study design was employed in which a lecturer cum facilitator and a group of final year undergraduates served as the purposive sampling. In-lab observations that specifically focused on the interactions between the facilitator and the students, as well as a group interview were conducted to generate qualitative data. Drawing on Wood et al.’s (1976) functions of scaffolding, as well as Holton and Clarke’s (2006) agent of scaffolding, concept-driven thematic analysis was conducted on the two sets of data. The main and constituent themes were uncovered to describe the main function of the facilitator’s scaffolding and the role of the facilitator in supporting undergraduates’ cognition while attempting to solve an electronics engineering problem. The findings suggested that the main function of scaffolding during the in-lab session was meant for marking critical features, during which the facilitator accentuated the main parts of learning activity that were relevant to the given tasks. In addition, it is also revealed that the facilitator acted as the agent of expert scaffolding while interacting with the students during in-lab sessions. This study provides the insights into the importance of scaffolding as a mechanism for a facilitator who is the expert problem solver to empower the “epistemic selves” (Holton and Clarke, 2006) among the undergraduates who are the novices of complex engineering problems.

Keyword: Problem-based laboratory, scaffolding, expert scaffolding and marking

Introduction

Complex Problem Solving in Engineering Education

In the area of cognitive psychology, problem solving is defined as a process which involves individuals to “plan their attacks, often breaking a problem into its component parts and devising a strategy for solving each part” (Matlin, 2009, p. 358). In solving a problem, individuals employ certain kind of strategies and use their metacognition to monitor the effectiveness of their strategies in order to find useful solutions. Bringing this concept into the context of engineering education (EE), complex problem solving has always been one of the crucial elements of
higher order thinking skills heavily emphasized by engineering programmes and curriculum across the world. This is very much evident when Froyd et al. (2012) emphasised that problem solving is still the crucial element of teaching and learning even after “the five major shifts in hundred years of engineering education” (p. 1344). Such consistent prominence has stemmed the growing number of literature on problem solving skills among engineering students and problem-based learning (PBL) in EE across various engineering specialisations around the world (for examples, studies done by Agelidis, 2005; Adams, 2009; Hsieh & Knight, 2008; Moreno, et al., 2009; Saleh, 2009; Savin-Baden, 2008). Swart (2010) further points out that ABET for example defines engineering as:

“...(T)he profession in which a knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgement to develop ways to utilise, economically, the materials and forces of nature for the benefit of humankind. This definition places emphasis on gaining specific knowledge (theory) and experience (practice). ABET furthermore emphasises that evaluation criteria should focus on what graduates have learned and can do. Graduates must be able to apply their acquired knowledge in the field of engineering. Engineering students must therefore fuse theoretical and practical instruction into a single body of knowledge, enabling them to become skilled engineers and technologists within their own communities” (ibid., p.190).

Within the Malaysian context, similar concern has been persistently highlighted by the local industries and stakeholders. Engineering Accreditation Council (EAC), for instance, in its 2012 edition of Engineering Programme Accreditation Manual has again stressed the importance of mastering mathematics, science and engineering fundamentals among the engineering undergraduates in order for them to develop knowledge and skills in designing solutions for complex engineering problems. This is in fact an echo to the demand made by the Malaysian Qualifications Agency (MQA) (2011) which stated that “the training of future engineers, engineering technologists and technicians must focus on solving both common and complex problem” (p. 1). Such demands are in accordance with the requirement of “the authoritative organizations” (Swart, 2010, p.190) such as Accreditation Board for Engineering and Technology (ABET) and Washington Accord.

In order to accommodate the perpetual demands and requirements from both the international and local stakeholders, a number of Malaysian academics have begun their efforts in seeking the best teaching and learning approaches in EE. Since the early 2000s Malaysian academics and researchers such as Khairiyah et al. (2004) and Mohd Ariffin et al. (2004) had been exploring Problem Based Learning “as an alternative to traditional lectures in moulding engineering graduates to acquire the desired attributes” (Khairiyah et al., 2004, p. 1). Others soon ventured in this particular research trend and researchers such as Bakar and Ab. Rahman (2005), Said et al. (2005), Syed Hassan et al., (2005), as well as Ahmad and Jabar
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(2007) had been examining PBL across different engineering programmes and specialisations. Until today, research on PBL is still relevant as this particular scope of study is in line with the recent requirements made by MQA (2011) which suggests that PBL is to be included as one of the “delivery methods” (p. 37) in the teaching and learning process of EE. The current research on PBL continues to explore PBL as a means to enhance engineering students learning experience (for example Khairiyah et al., 2012a; 2012b).

While many studies on PBL had been conducted with the aims of making evidence that this particular learning environment is one of the effective teaching and learning approaches for EE, overshadowing these efforts are the issues of the lacking of higher order thinking skills among the Malaysian graduates. Bernama (2012) reported a statement made by a chairman of a prominent company in Malaysia who, based on his experience interviewing potential new staff, claimed that “most of today’s university graduates are lacking in skills, especially problem solving skills needed in the workplace”. This problem has constantly been the main concern to most of the researchers, who attributed it to the schooling system which promoted surface learning that have been reinforced by “exam oriented” and “spoon-feed” culture (Khairiyah et al., 2005a, 2005b). To explore this issue, many researchers has not only confined their research to examine the applicability of PBL and its effectiveness in enhancing students’ learning and higher order thinking like problem solving (for example Khairiyah et al., 2011) but also to investigate the affect of PBL on the other soft skills like team working and motivation (see Nor Farida et al., 2012; Syed Ahmad Helmi et al., 2012;).

Nevertheless, despite extensive studies on the applicability and effectiveness of problem based learning in enhancing engineering undergraduates’ learning skills and soft skills (for examples Khairiyah et al., 2005a, 2005b; Nor Farida et al., 2012; Syed Ahmad Helmi et al., 2012) less work has been done on how the Malaysian electrical engineering undergraduates’ higher order cognitions were facilitated while undergoing project-based or problem-based learning environment. Hence, the main focus of this study is to examine the function of scaffolding and the role of the facilitator as a scaffolding agent during Problem/Project Based Laboratory (PBLab) at Digital Signal Processing Laboratory (DSP Lab), Faculty of Electrical Engineering, Universiti Teknologi Malaysia (UTM).

**Scaffolding as Means of Facilitating Higher Order Thinking**

The term scaffolding was coined by Wood et al. (1976) when they described the role of tutoring in developing problem solving skills among children. According to the authors, in a task-oriented situation, a tutorial process took place during which “an adult or “expert” helps somebody who is less adult or less expert” (p. 89). They argued that although children are naturally problem solvers, but in most cases, they learn more when their efforts are being assisted and fostered by those
who are more skilled than them. Thus, tutorial interactions between adults (i.e. the experts) and children (i.e. the young learners) are the crucial element in the process of learning. This concept is especially applicable in problem solving situations that require learners to acquire skills that can be accumulated into “higher skills” (ibid.), used to solve complex problems. When confronted with challenges, learners need to have the ability to determine necessary actions to reach the end, i.e. solving the problem. As emphasised by Wood et al. (1976), the heart of problem solving is “to match means to end” (ibid., p.90).

The idea of social interactions that occurred during tutorial process as suggested by Wood et al. (1976) is very much influenced by Vygotsky’s Zone of Proximal Development (Holton and Clarke, 2006). This is evident by the emphasis on the vital role a tutor played through the concept of scaffolding, when they stated that:

“The intervention of a tutor….involves a kind of “scaffolding” process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts. This scaffolding consists essentially of the adult “controlling” those elements of the task that are initially beyond the learner’s capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence. The task thus proceeds to a successful conclusion. We assume, however, that the process can potentially achieve much more for the learner than the assisted completion of the task. It may result, eventually, in development of task competence by the learner at a pace that would far outstrip his unassisted effort”. (Wood et al., 1976, p. 90).

Based on their research Wood et al. (1976) outlined the process of scaffolding that involved the functions of the tutors. Holton and Clarke (2006) referred this process as the six key functions of scaffolding (p. 129). They are:

- Recruitment: engaging the student in an interesting and meaningful task;
- Reduction in degrees of freedom: developing the task around manageable components;
- Direction maintenance: ensuring that the student is on task and finding a solution;
- Marking critical features: accentuating the main parts of the task;
- Frustration control: reducing the frustration level of the task;
- Demonstration: providing a model of the solution method for the student.

The first function of scaffolding is recruitment that can be described as a situation wherein the tutor (or facilitator) engages the learner’s interest towards the task. On the other hand, reduction in degrees of freedom means that the facilitator simplifies the tasks by reducing the number of fundamental acts required to reach the possible solution. This involves reducing the size of the task to the level where the learner can recognize whether or not the act or approach can be used in solving the problems. The third function, direction maintenance is where the facilitator
motivates the learner by providing clues or hints to ensure that the learner is on the right track in arriving the solution. The next function is marking critical features, during which the facilitator accentuates the features that are vital and relevant to the given task. The fifth function is frustration control where the tutor manages the learner’s emotion in facing challenges while attempting to solve the given task. Finally, demonstration is the stage where the facilitator demonstrates or models the solutions for the given task.

Holton and Clarke (2006) further advanced the basic concepts of scaffolding as proposed by Wood et al. (1976). One of the expanded conceptions of scaffolding worth explored by this study is the idea of a facilitator, or a “scaffolder” (ibid. p. 133), as a scaffolding agent. In a learning environment, this is an individual who is an expert, usually an adult or a more competent peer, responsible for empowering the learners, i.e. the “scaffoldee” (ibid. p. 134). Holton and Clarke (2006) classified scaffolding into three types, namely self-scaffolding, reciprocal scaffolding, and expert scaffolding. These types of scaffolding operate within two main domains: conceptual domain and heuristic domain. Conceptual scaffolding is meant to promote conceptual development, while heuristic scaffolding aims at “the development of heuristics for learning or problem solving, that transcend specific content” (ibid., p. 134).

Self-scaffolding is a situation in which the learner is able to provide scaffold for himself or herself when learning new concepts or materials while attempting to solve a given task. Hence, both conceptual and heuristic domains are involved during self-scaffolding. Whereas reciprocal scaffolding is a situation when two or more individuals work collaboratively in solving a shared task. Such situation is common during active learning activities in a classroom where learners are grouped together in working on group assignments. Diverse knowledge and skills each learner possesses provide the advantage for such learning situation allows them to become scaffolders to one another. Similar to self-scaffolding, both conceptual and heuristic domains take place during reciprocal scaffolding. On the other hand, expert scaffolding involved a situation in which the scaffold is “an expert in the subject or problem under investigation and…most likely a teacher in the widest sense of the world” (ibid., p. 134). By having such expertise that is based on a specialised knowledge or skills allow the scaffold to provide the guidance in exploring approaches to solve the given problem. In most cases, especially in problem based learning environment, expert scaffolding involves heuristic domain.

In this study both Wood et al.’s (1976) functions of the facilitators, as well as Holton and Clarke’s (2006) idea of a facilitator as a scaffolding agent served as the provisional framework. This framework was vital especially as the guidance for conducting concept-driven thematic analysis on the qualitative data generated from the research fieldwork.
Research Objective and Research Questions

An earlier study by Samah et al. (2014) on the implementation of Problem/Project Based Laboratory (PBLab) Model at Digital Signal Processing Laboratory (DSP Lab), Faculty of Electrical Engineering, Universiti Teknologi Malaysia (UTM) found that the strategy succeeded in facilitating electrical engineering undergraduates’ higher order thinking skills. This included enhancing students’ metacognition strategies and transfer of knowledge abilities, as well as generic skills such as intrapersonal/interpersonal communications and team-working. The aim of this research is to further explore the similar scope, but by focusing on the practice of scaffolding during PBLab. Specifically it attempts to answer the following questions:

1. What is the main function of scaffolding during PBLab?
2. What role does a facilitator play during PBLab?

Methodology

Research Design

A qualitative single case study design (Yin, 2009) was employed to explore the practice of scaffolding during problem-based in-lab sessions. Problem/Project Based Laboratory (PBLab) at Digital Signal Processing Laboratory (DSP Lab), Faculty of Electrical Engineering, Universiti Teknologi Malaysia (UTM) served as “the single instance of a bounded system” (Cohen et al., 2001, p.181). During the PBLab students engage in experimental tasks to find solutions to problems that are similar with the real-world or industry related electrical engineering problems (Naziha et al., 2012). Three to four students were grouped together to work as a team in solving three problems based on the three laboratories they are assigned according to their programmes. The groups of students were given four weeks to solve a given problem or project at each laboratory therefore PBLab usually takes 12 weeks to complete in a semester. To complete the given tasks, students were expected to optimise their interactions with their group members and with their facilitators during the three hours laboratory session per week. In addition they had to allocate at least two hours outside the laboratories per week for group discussions and consultations with their respective facilitators. Each group were to document their learning activities in a group log book. Table I describes the activities during the four-week PBLab sessions.

Participants

A group of three SEL (Bachelor in Electrical Engineering) undergraduates and a lecturer cum facilitator at the Faculty of Electrical Engineering served as the purposive sampling in this study. In the first week of their PBLab, this group received a student pack entitled “Error Detection Using Cyclic Redundancy Check”.
TABLE 1: PBLAB ACTIVITIES

<table>
<thead>
<tr>
<th>Week</th>
<th>In-lab Session (3 hours)</th>
<th>Out-lab Session (2 hours)</th>
</tr>
</thead>
</table>
| 1    | 1. Understanding of problem with guide from facilitator.  
      2. Brainstorming and sharing ideas in solving problem.  
      3. Identifying available resources and tools.  
      4. Identifying prior knowledge and what knowledge needs to be acquired in solving the problem.  
      5. Facilitator conducts assessment on individual in-lab activities. | 1. Obtaining more resources to help understand the problem.  
2. Dividing work among group members.  
3. Reporting findings to group members.  
4. Agreeing on a solution |
| 2    | 1. Presenting solution to facilitator.  
      2. Facilitator providing comments on proposed solution; monitoring the group’s progress is on-track.  
      3. Designing experiment.  
      5. Facilitator monitors and conducts assessment on individual in-lab activities and group log book. | 1. Conducting simulation work to reconfirm design.  
2. Verifying the availability of equipment/tools to conduct experiment.  
3. Preparing schematic or diagrams for experiment. |
| 3    | 1. Conducting the actual experiment.  
      2. Facilitator monitoring and assessing individual in-lab activities and group log book.  
      3. Obtaining results from experiment. | 1. Preparing presentation of completed work.  
2. Preparing written report. |
| 4    | 1. Group presentation and demo  
      2. Report writing  
      3. Facilitator monitors and conducts assessment on presentations, individual in-lab activities and group log book. | 1. Continuation of report writing.  
Submission of report is within a week after group presentation. |

In order to accomplish the task they were specifically required to: (1) Explain how CRC error detection scheme is used to generate parity at the transmitter and detect error at receiver; (2) Implement the CRC error detection in software and verify its functionality; (3) (For a given CRC polynomial), perform Monte Carlo simulation to verify the performance of the CRC error detection in the presence of noise.

Data Collection and Data Analysis

Two sets of qualitative data were generated from an observation and a group interview. The researchers observed in-lab sessions for weeks during which the lecturer facilitates the group of students while they were working on the given tasks. One of the recordings from the four observations was chosen as the first data set as it optimally captured the interactions between the “scaffolder” and the “scaffoldees”. An interview was conducted on the group of students after the fourth week of PBLab. Students were asked about the experience of working together in completing the given task and how their facilitator facilitated them throughout the process of problem solving. Recording of the interview served as the second set of data. Drawing on both Wood et al.’s (1976) functions of the facilitators, as well as
Holton and Clarke’s (2006) idea of a facilitator as a scaffolding agent, concept-driven thematic analysis (Brown & Clarke, 2006) was conducted on these two sets of data.

**Findings**

Figure 1 summarises the practice of scaffolding during PBLab. The main and constituent themes were uncovered to describe the main function of the facilitator’s scaffolding and the role of the facilitator in supporting undergraduates’ cognition while attempting to solve an electronic engineering problem.

![Diagram](image)

**Figure 1: The practice of scaffolding during PBLab**

The findings suggested that the main function of scaffolding during in-lab session was meant for marking critical features, during which the facilitator accentuated the main parts of learning activity that were relevant to the given tasks. Table 2 describes the excerpts from the conversations between the facilitator and the students during one of their discussions.

From the descriptions shown in Table 2, it is evident that the facilitator had implemented the function of marking throughout the stages of scaffolding process. During the discussion, he persistently emphasised the correct way to approach the task as to make sure that the students had clearer ideas on how would further work
on the given problem, and hence would not repeat the same mistake. The facilitator also showed students the steps, one by one, on how to develop the code and then asked them to follow the steps. Other than that, the facilitator kept repeating the same questions as a way to monitor whether the students were confident enough with their proposed solutions to the given problem. The facilitator also purposely repeated the right answer but as the same time conveyed the message that the

<table>
<thead>
<tr>
<th>Main Theme</th>
<th>Constituent Themes</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marking critical features</td>
<td>Emphasis on the</td>
<td>“Have you done with the submission in Matlab?” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>right answer</td>
<td>“No, one function can make all.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Instructions to</td>
<td>“From the table, when N=0, its input is one, then the output is A.” “You need to follow the step.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Emphasis on the</td>
<td>“Follow the step, no need to plus, just straightly add, no need make the function.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>right answer</td>
<td>“You can do this example for IIR” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“You calculate, by hand first then try to implement it.” “This thing becomes zero, calculate manual first. It cannot become zero.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Repetitions of the</td>
<td>“You need to do one function only. This function can make the FIR input is X then coefficient. If need to use loop, just use it.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Emphasis on the</td>
<td>“Encode? Haah?... This is encode? No, I tell (you) about this encode. This is ours, programmed, it takes the message to (the) generator then get the parity, right?” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>right answer</td>
<td>“I want the message, it is located before the parity.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Repetitions of the</td>
<td>“Have you completed the decoding?” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Emphasis on the</td>
<td>“Is it true?”</td>
</tr>
<tr>
<td></td>
<td>right answer</td>
<td>“This is parity, what we need to do is add it behind the message so that the transmitted data becomes 1010011100.” “This is the output of the function. What you make is right.” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>“In one function, encode can do all. It is like this and your data is like this, from here to here. Your parity is here. So you take this, take this value and put it at the behind” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“There is no addition. We take this and put at the back” (Facilitator)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“The message is unchanged, it is still (the) same?” “If we understand the concept, we can re-modify it, then it will become a universal solution.” (Facilitator)</td>
</tr>
</tbody>
</table>
students’ answers were not totally wrong. At the same part, the facilitator pointed out to the students that they needed to understand the output of their task. This would help them understand the actual concept, which allowed them to modify the output in order to get better results.

It is assumed that marking is a function of scaffolding practiced by the facilitator to highlight the critical features of the activity in order to make sure that the students were on the right track of solving the given problem. All these examples reflect what Wood et al. (1976) had suggested, that facilitator’s marking “provides information about the discrepancy between what the (learner) has produced and what he would recognise as a correct production…. His task is to interpret discrepancies (p.98). Hence, such strategy would motivate the students to stay focus in finding the solutions to the given problem. This indirectly enhanced their confidence level throughout the learning process.

The findings also revealed that the facilitator acted as the agent of expert scaffolding while interacting with the students during in-lab sessions. Table 3 presents the role of the facilitator as perceived by the students.

<table>
<thead>
<tr>
<th>Main Theme</th>
<th>Constituent Themes</th>
<th>Excerpts From Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert Scaffolding</td>
<td>Expert reference</td>
<td>“I also refer to my supervisor.” (Student 3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“In the second week, we asked Dr.” (Student 3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“We get the correct answer from Dr.” (Student 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“We need to refer to the function correctly. I also met my supervisor and asked him to help me on how to combine the B code and C code.” (Student 1)</td>
</tr>
<tr>
<td>Good supervision</td>
<td></td>
<td>“Actually it is not about the title. If supervisor can supervise us better, it can be more easier.” (Student 1)</td>
</tr>
<tr>
<td>skill</td>
<td></td>
<td>“He (the facilitator) guides us.” (Student 1)</td>
</tr>
<tr>
<td>Indirect coaching</td>
<td></td>
<td>“Just give a simple hint. Not all but just an idea indirectly. So we have the motivation.” (Student 1)</td>
</tr>
</tbody>
</table>

Based on the excerpts presented in Table 3, the students indicated that they had a meeting with the facilitator during the second week of PBLab. During the meeting, they presented their initial ideas and obtained feedback from the facilitator. They strongly felt that the input and suggestions given by the facilitator had given them the impression that they were on the right track. In addition, the students also used other alternatives such as referring and asking the assistance of their final year project supervisor on how to go about with the task. The students also felt that the topic of their problem pack was the reason that made their task too difficult. Nonetheless a good supervision from the facilitator was one of the contributing factors that made their task became easier. From this finding, it is assumed that expert scaffolding was more likely to occur because the students were still dependant
on the guidance from their facilitator who was considered to be more knowledgeable and expert in the field of electronic engineering could be due to the learning culture of the educational context that perceived teachers or lecturers to be the authority figures and thus are more knowledgeable in a particular field.

Discussion
This study provides the insights into the importance of scaffolding as a mechanism for a facilitator who is the expert problem solver to empower the “epistemic selves” (Holton and Clarke, 2006, p. 127) among the undergraduates who are considered to be the novices of complex engineering problems. One of the implications of this study is for the lecturers to acknowledge that the interpersonal communication or interactions between them and their students are crucial in enhancing their students’ problem solving skills during an inquiry based learning like PBLab. From this study, it was evident that some parts of the facilitator’s scaffolding was aimed at both conceptual development (i.e. “conceptual scaffolding”) (ibid., p.134), as well as the development of heuristics for solving problems (i.e. “heuristic scaffolding”) (ibid., p. 134) among the students. By realizing this, lecturers then need to optimize problem-based learning process as a platform where learners can construct new engineering knowledge and can refine their problem solving skills. Acquiring such new knowledge and skill will help students to anticipate the ways that they would apply what they have learned throughout their studies when practicing in the industrial world and to become competitive graduates upon graduation.

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References
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1567584&isnumber=33240
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6185632&isnumber=6259910


URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5413196&isnumber=5413192


