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RESEARCH ARTICLE

PRIORITIZATION OF USER-STORIES IN AGILE ENVIRONMENT

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ABSTRACT

Agile development methodologies become popular approaches in current scenario of organizations. In agile methodologies, developers have an open communication with customers to get requirements, in form of user stories, as soon as possible. Identifying right user stories at right time is most important thing in agile development methodologies. To identify right user stories, the prioritization for user stories takes place. Customers play significant role in prioritization of user stories. The customer-oriented requirement prioritization provides more business value to customers. In this paper, a mechanism is derived to prioritize user stories in agile environment. Further, the feasibility of this mechanism has been validated using a case study.

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1. INTRODUCTION

Today several different software development lifecycle models are existing in software engineering. These models can be categorized in two categories: (i) Sequential models – such as Waterfall model, V model, and RAD model and (ii) Evolutionary model – such as Incremental model, Iterative model, and Spiral model. Now day's Agile development methodologies are become more popular. Agile development methodologies consist Scrum, Extreme Programming, Dynamic System Development Method, and Kanban models.
Traditional SDLC models use predictive approach. Predictive approach needs a complete prediction of features that are going to be deliver in the final product. Therefore, it requires detailed planning. The detailed planning can happen only at beginning of development i.e. requirement phase. Whenever any change is made that requires permission from change control management board.

Agile development methodologies use adaptive approach. Adaptive approach does not require complete prediction for features, and they do not require any detailed planning at initial phase. So any change can take place in between development of phase. In agile environment, manpower is divided into several teams. The teams should work in a close collaboration with each other. In agile, open communication with customers is most important thing. When a communication happened with customers then requirement become more clear. Requirement gathering is a continues process throughout the development. Requirement gathering is done by the product owner. Teams will select requirements based on importance. Teams select most important user stories in first sprint (i.e. release) of development. There may available a lot number of most important user stories. That requires prioritization for user stories.

In earlier work (Hudda *et al*., 2016), we have decided priority for a user story by a ratio between weight and effort. Weight was depended on rank, and rank was depended on importance. Students assigned votes to user stories based on importance. The voting process was used to assign votes, ranks decided based on votes. Weight was determined using ROC method, taking rank as an input. Relative importance was represented by weight, and duration was decided by effort. To estimate effort PERT was used.

In this current paper, we are also performing same work using some different methods. In this paper, we use an algorithm that is available in research work (Hudda *et al*., 2016). In that algorithm, we defined the priority for a user story by the ratio of weight and effort. In research work (Hudda *et al*., 2016) we used Rank Order Centroid (ROC) method to calculate weight, and PERT to estimate effort. Here, we are also using same

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proposed algorithm, and same definition of priority for a user story. Here, we are using Inverse Weight method i.e. Reciprocal Weight method to calculate weight, and PERT to estimate effort. So finally, priority is decided by the ratio between weight and effort.

The remainder of this paper is organized as follows: -Section 2 reviews related work. Section 3 presents the proposed work. Section 4validates the proposed work using case study. Section 5 concludes the paper, and mentions the future work.

2.Related work

A number of studies are available to prioritize user-stories in agile environment. To best of our knowledge there is no systematic empirical research study is present about the prioritization for user-stories in agile environment. The agile approaches are deliver the business value to clients early and periodically throughout the whole project. In study (Popli *et al*., 2014) authors described, several factors related to importance and effort, these factors affect the prioritization of user stories in a project, and the prioritization of user-stories was highly depended on these factors.

Z. Bakalova *et al*. proposed a research work (Bakalova *et al*., 2011), in which the authors analyzed" total 22 prioritization techniques employed in agile software developments and the concepts presented in the conceptual model, a model developed through interviews with total 11 practitioners belonging to 8 agile software firms drawing experience of 10 projects. The practitioners include Project Managers, Developers, Product Owners, Clients, and Scrum Master. In order to capture the gaps, the authors analyzed 22 prioritization techniques to capture the use of the concepts as presented in the model. This was termed as mapping in the paper by the authors. The results indicate that there are the huge gaps between the current practices as described in the literature and those practiced in industries. Existing requirements prioritization techniques are at coarse-grained descriptions since they only present the upper levels of the prioritization techniques without focusing on all aspects that drives the prioritization process. Very few are in fact based on client's perspectives."

An empirical study presented in (Cao and Ramesh, 2008) that showed "agile Requirements Engineering (RE) different from traditional software development RE, agile RE takes an iterative discovery approach. They stated that agile development occurs in an environment where developing unambiguous and complete requirement specifications is impossible or even inappropriate. They mentioned that strong or deep communication between the developers and customers is the most important RE practice. They presented several agile RE practices with some benefits and challenges, such as face to face communication, iterative requirement engineering, managing requirements change through constant planning, and test driven development. They mentioned that agile RE practices provide benefits such as improved understanding of customer needs, and the ability to adapt to the evolving need of today's dynamic environment".

A research work proposed by Racheva *et al*. (2008) in that "authors presented various prioritization approaches as employed in agile methodologies. The authors classified these approaches into two categories i.e. those comparing requirements pair wise and those grouping requirements on the basis of importance. A conceptual model from the client's perspective is then presented followed by issues and solution strategies related to requirement re-prioritization. The paper was focused on two main research goals i.e. to highlight the main factors and identify the problems in the process of reprioritization of requirements."

One more research work is presented by Racheva *et al*. (2010) in that "authors mentioned the findings acquired after the review of requirement prioritization by considering the different information sources like journals, books etc., in the form of two conceptual models. First model (Say model A) describes the requirement prioritization process in agile from client's perspective while the second model (Say model B) is the detailed description of the above model. It describes the various factors that are considered by the clients while making prioritization decisions at an inner iteration time i.e. during requirement re-prioritization. The outcome of the analysis of the collected information was the conceptual reprioritization model (Model A & B) that was based on the perspective of the clients rather than that of developers. This had provided the future research path concerning re-prioritization."

Ina research study (Racheva *et al*., 2010) "authors presented the findings acquired by conducting the interviews with 11 practitioners belonging to 8 agile methodologies based software developing firms in the form of another conceptual model. The practitioners include Project Managers, Developers, Product Owners, Clients, and Scrum Master. The results were analyzed for total 10 projects. The conceptual model illustrates that at the time of reprioritization, client's perspective included the five main factors i.e. Business Value, Effort Estimation/Size Measurement, Learning Experience, Input from the Developers, and External Change. It was also found that the clients consider only three decision aspects during reprioritization namely business value, negative values, and risks. The project constraints like delivery time, costs etc. and requirement dependencies are given due consideration during the process of reprioritization. The authors reported the results in the form of conceptual model illustrating the reprioritization in inter iteration time for agile projects only."

In research study (Racheva *et al*., 2010), authors concluded that "while an agile software company lets clients prioritize requirements, the requirements decision-making process can take place only when the client's interest to make changes along the way is in balance with the developer's interest for a sustainable business. They also presented that the prioritization process instantiation varies across projects at different client companies and those variations seem to be linked to project characteristics such as size of project and size of client's organization".

Hudda *et al*. presented a research work (Hudda *et al*., 2016) in which authors showed prioritization of user stories in agile environment. The authors defined the definition of the priority for a user story, is a ratio between weight and effort. They considered the priority was a multiple criteria factor. The authors were used Rank Order Centroid method to calculate weight, and PERT to estimate effort.

In a book (Hwang and Yoon, 1981) authors mentioned that "Multiple Criteria Decision Making (MCDM) or Multiple Criteria Decision Analysis (MCDA) refers to screening,

prioritizing, ranking, and selecting the alternatives based on the human judgement from a finite set of decision alternatives in terms of multiple conflicting criteria. In MCDM, three separate steps are used to obtain ranking of criteria. These steps are: (i) Determine the relevant criteria, (ii) Assign weights to criteria, and (iii) Determine the rank for these criteria."

In research work (Choo *et al*., 1999), researcher presented that "In the multi-criteria models the weights of criteria play a very significant role and they have different interpretation depending on context of decision making, on multiple criteria analysis methods. Usually weights provide the information about the relative importance of the considered criteria."

In study (Roszkowska, 2013), the author presents a comparative overview for several multiple decision analysis method. In (Roszkowska, 2013) author presented "many real world decision making problems involve multiple criteria. Corporatedecision-making problems rarely involves single criteria. Several different methods are developed to take criteria priorities into account. The judgements of the decision makers are frequently vague and their preferences as well weights can't be evaluated exactly or truly. The true weights of criteria remain unknown in practice. Even if the elicitation of true weights is possible, it would be more time consuming and difficult. When rank ordering information available in advance, the rank ordering weighting method provide approximation of true weights for considered criteria. Assigning ranks to elicit weights using some formulas is more reliable than just directly assigning weights to criteria, since experts or non-experts are more confident about the ranks of some criteria than their weights, and they can agree on ranks more easily. The great advantage of these methods is that they depend only on the ordinal information about the criteria importance."

In study (Roszkowska, 2013) researcher also highlighted that "Decision makers can rank criteria in situation of time pressure, lack of knowledge, partial information, incomplete information, and quality nature of criteria. This follows that decision makers may not able to provide true or exact estimations of criteria or they may not reach agreement on a set of exact weights, so in such situation agreement on ranking may become realistic. Hence, the ranking methods are easy to use and simple to understand for decision maker."

Usually, two steps are involve to determine weights. These steps are: (i) Ranking the criteria according to their importance, and (ii) Using mathematical formula to attach the weights to these criteria based on their ranks.

3.Proposed work

We are using definition for priority that we have discussed in our earlier work (Hudda *et al*., 2016). In that work, we have defined the priority for a user story by the ratio of weight and effort. In (Hudda *et al*., 2016) we used ROC method to calculate weight, and PERT to estimate effort. In this paper, we are also using same PERT method and Voting method to estimate effort and to assign rank respectively, but we are using Reciprocal weight method to calculate weights.

3.1 Ranking User-Stories with Voting Method

To assign rank to a user story, we are using voting method (Hudda *et al*., 2016). The voting method includes following steps (Hudda *et al*., 2016):

- Select all the user-stories, and enables them to receive votes from clients (here clients are students).
- Ask the clients to place their votes to user-stories. Clients should place votes to show their own preference.
- Take sum of votes for each user story received from every client.
- Order the product backlog from the user-stories that receive lesssum of votes to the user-stories that receive high sum of votes.

3.2 Reciprocal Weight or Inverse Weight MCDA Method

To calculate weight, we are using reciprocal weight method. This method converts the rank into respective weight using mathematical formula. The inverse or reciprocal weight method uses the reciprocal of the ranks, which are normalized by dividing each term, by the sum of the reciprocals. This method has following steps:

- Select the list of ranked requirements (i.e. user-stories).
- Take the inverse of the rank for a user story (for that weight to be calculated), which is $\frac{1}{r}$.
- Now take the sum of the reciprocals (i.e. inverse) of the ranks for all ranked user stories.
- Then divide the inverse of rank by sum of the reciprocals of ranks.

This method can be expressed in mathematical formula as follows:

$$W_j = \frac{1/r_j}{\sum_{k=1}^{n} \frac{1}{r_k}} \quad (1)$$

Where n is the total number of ranked user stories, W_j is the weight for j^{th} user story, and r_j is rank of user story.

3.3 Estimating Effort with PERT

When effort (i.e. estimation of duration) is estimated by PERT method then it takes uncertainty into the account. It provides little extra time to do a task. For example, if a task might take five days but there is a small chance that it might need four or six days, and a smaller chance of three and seven days, and so on. We are using PERT to estimate effort (i.e. development time) for each user story. The PERT requires following estimations (Hudda *et al*., 2016):

- Most Likely Time (t_{ml}) – the best possible time required to accomplish a task under normal circumstances.
- Optimistic Time (t_{opt}) – the minimal possible time required to accomplish a task under better than normal circumstances.
- Pessimistic Time (t_{pess}) – the maximum possible time required to accomplish a task, assuming everything proceeds as wrong.
- Expected Time (t_e) – combines these three estimates to form a single expected duration.

$$\textit{Expected time } (t_e) = \frac{1}{6} * (t_{opt} + t_{pess} + 4 * t_{ml}) \quad (2)$$

Therefore, we have calculated weight based on rank, and effort is estimated using PERT method. The priority for user story is given by following mathematical formula (Hudda *et al*., 2016):

$$Priority = \frac{Weight}{Effort} \quad (3)$$

4. Result and evaluation

Now we want to show the feasibility of our algorithm using a case study. Using this case study, we have created total 21 user stories from the online account of faculty members – University Management System, Lovely Professional University. Using this online account, faculty members can perform several activities such mark daily attendance, allocate assignments to students, assign term paper to students, give practical marks to students, and they are able to see their time table. These 21 user stories are shown in Table 1 with their serial number from 'A' to 'U'. Here, we are using following format to create all 21 user stories:

As a <user type> I <goal> so that <benefit>

Where <user type> - Role of user (who), <goal> - Action (what), and <benefit> - Reason (why)

Table 1. User Stories

S. No.	User Story
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.
J.	As a teacher I want to apply for leave so that I can do my urgent work.
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.
M.	As a teacher I want to know daily activities so that I can keep record of them.
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.

A. Phase 1

In this phase of our research work, we determine ranks for each user story using voting method. We have created list of user stories at a white paper (on both side) as shown in Figure1 (front side) and Figure 2 (back side). This list of user stories distributed among several students to assign vote. Total 63 students are take participation in voting process. They belong from different departments such as Mathematics, Physics, Computer Science & Engineering, Electrical Engineering, Mechanical Engineering, Information Technology, and Electronics & Communication Engineering. They are also from different course program such as M.B.A., M.Sc., B.Sc. (Hons.), B.B.A., B. Tech., M. Tech., L.L.B.

After assign the votes to these 21 user stories by 63 students, we calculate sum of votes for each user story. The sum of votes for each user story is shown in Table 2. We are also drawing the sum of votes by a graph in Figure 3. Due to the lack of space, we are representing these user stories by the serial numbers instead of their name in the graph. The sum of votes for a user story with serial number "A" is 370, sum of votes for a user story with serial number "O" is 982. So we can say user story "A" is more important, and user story "O" is less important, compare to others, for students. Now we assign rank 1 to "A", and 21 to "O". Here, we are only discussing user story "G", and "L" in detail. Since all 21 user stories need a lot of space. We are mentioning votes with their frequencies for user story "G", and "L" in Table 3 and Table 4 respectively. The votes for user story "G", and "L" are also drawing by the graphs in Figure 4 and Figure 5 respectively. In the graphs, X-axis represents vote that is assigned by the students, and Y-axis represents frequency i.e. how many number of students assigned that vote.

For user story "G", 1st vote is assigned by 12 students, 2nd vote is assigned by 8, and 3rdis assigned by 6. Some votes are not assigned by any student, like vote 10th, 11th, 13th, 16th, 18th, 20th, 21th; and some votes are assigned by single student. For user story "L", 1st vote is assigned by 0 (zero) i.e. none students, 2nd vote by 0, 3rd vote by 1. Seven students are assigned vote 19th, single student assign vote 20th, and vote 21st is assigned by 5 students.

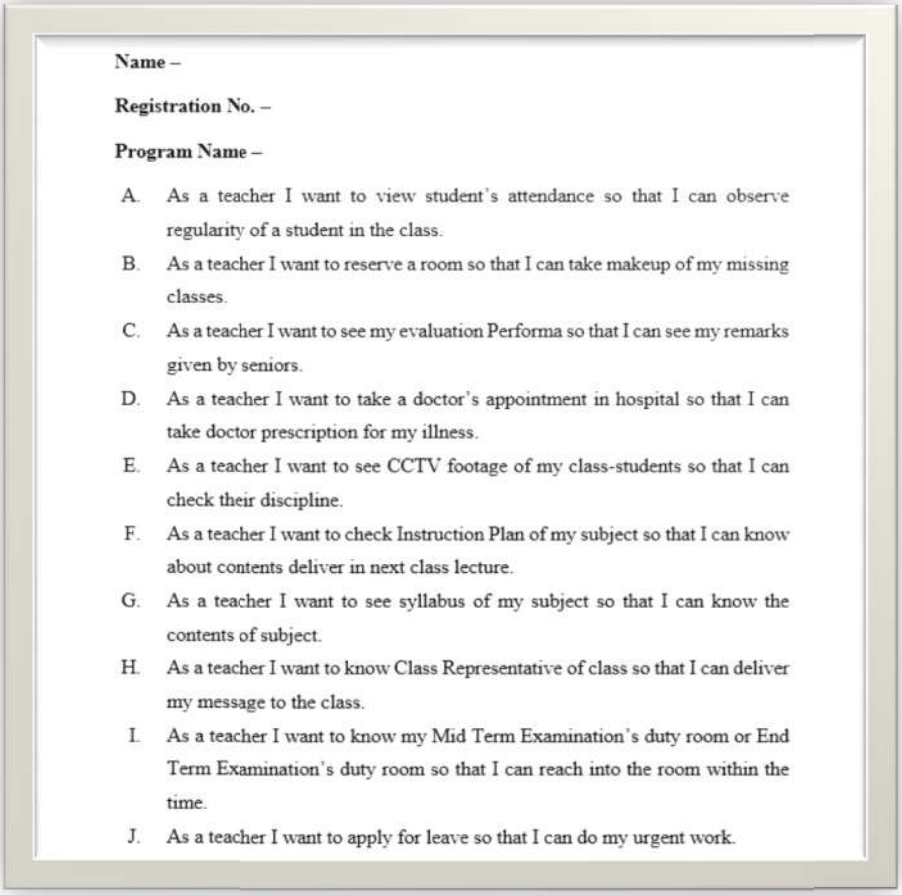
Now on the basis of sum of votes, the rank is assigned to each user story. The sum of votes for user stories "A", "B", and "C" are 370, 574, and 536 respectively. Therefore, user story "A"gets rank 1, B gets rank 6, C gets rank 5, and so on. The ranks for each user story is mentioned in Table 5.

B. Phase 2

In this phase of our research work, the weights for each user story have been calculated using mathematical formula of Inverse Weight method. To calculate weight for a user story, divide the inverse of rank by sum of reciprocal of all user stories. So weights are calculated using a mathematical formula that is available in Equation 1. The user stories with weights are presented in Table 6.

C. Phase 3

In this phase of research work, we are estimating effort for each user story using PERT. To estimate effort every user story requires three estimations. These three estimations are:(i) Optimistic Time (t_{opt}), (ii) Most Likely Time (t_{ml}), and (iii) Pessimistic Time (t_{pess}). The final estimation (i.e. Expected Time) is a combination of all these three estimations, and it is estimated by a formula that is mentioned in Equation 2.Table 7 contains these three estimationas well as final estimation. In the Table 7, we are using only notations to represent all these estimations.



Name –

Registration No. –

Program Name –

A. As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.

B. As a teacher I want to reserve a room so that I can take makeup of my missing classes.

C. As a teacher I want to see my evaluation Performa so that I can see my remarks given by seniors.

D. As a teacher I want to take a doctor's appointment in hospital so that I can take doctor prescription for my illness.

E. As a teacher I want to see CCTV footage of my class-students so that I can check their discipline.

F. As a teacher I want to check Instruction Plan of my subject so that I can know about contents deliver in next class lecture.

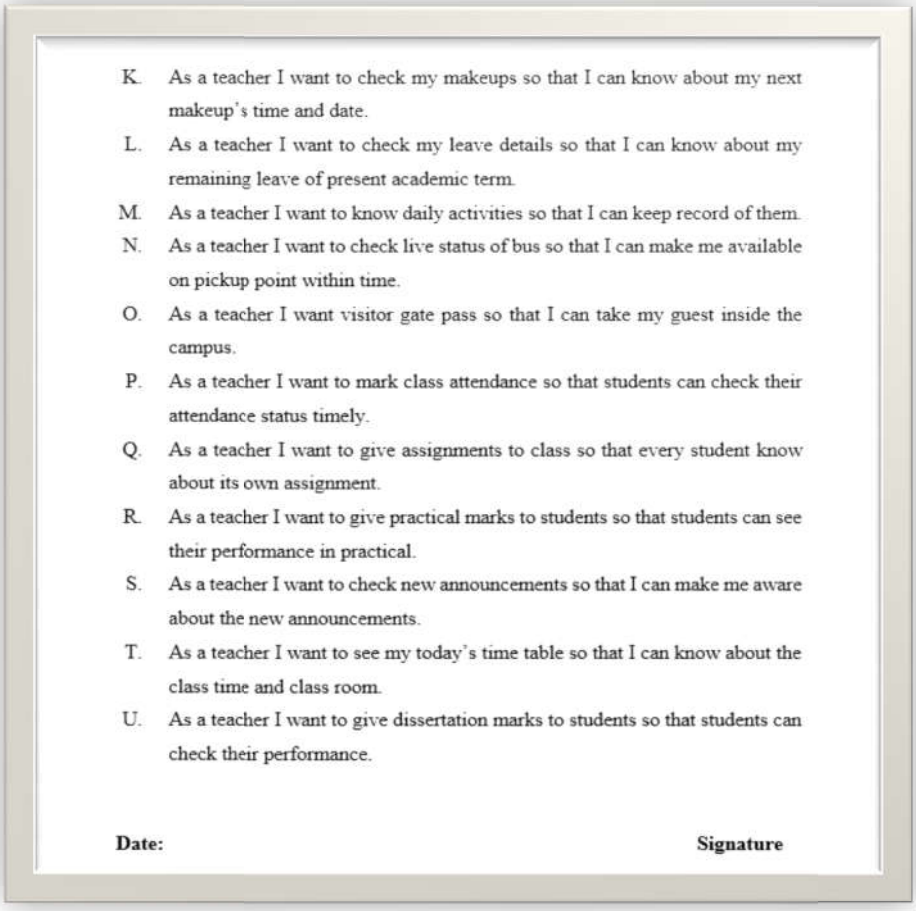
G. As a teacher I want to see syllabus of my subject so that I can know the contents of subject.

H. As a teacher I want to know Class Representative of class so that I can deliver my message to the class.

I. As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.

J. As a teacher I want to apply for leave so that I can do my urgent work.

Figure 1. User Stories on White Paper (Front Side)



K. As a teacher I want to check my makeups so that I can know about my next makeup's time and date.

L. As a teacher I want to check my leave details so that I can know about my remaining leave of present academic term.

M. As a teacher I want to know daily activities so that I can keep record of them.

N. As a teacher I want to check live status of bus so that I can make me available on pickup point within time.

O. As a teacher I want visitor gate pass so that I can take my guest inside the campus.

P. As a teacher I want to mark class attendance so that students can check their attendance status timely.

Q. As a teacher I want to give assignments to class so that every student know about its own assignment.

R. As a teacher I want to give practical marks to students so that students can see their performance in practical.

S. As a teacher I want to check new announcements so that I can make me aware about the new announcements.

T. As a teacher I want to see my today's time table so that I can know about the class time and class room.

U. As a teacher I want to give dissertation marks to students so that students can check their performance.

Date: **Signature**

Figure 2. User Stories on White Paper (Back Side)

Table 2. User Stories with sum of votes

User stories with sum of votes		
S. No.	User Story	Sum of Votes
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	370
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	574
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	536
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	804
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	608
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	442
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	385
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	457
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	704
J.	As a teacher I want to apply for leave so that I can do my urgent work.	739
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	770
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	921
M.	As a teacher I want to know daily activities so that I can keep record of them.	724
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	906
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	982
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	677
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	701
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	750
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	821
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	671
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	775

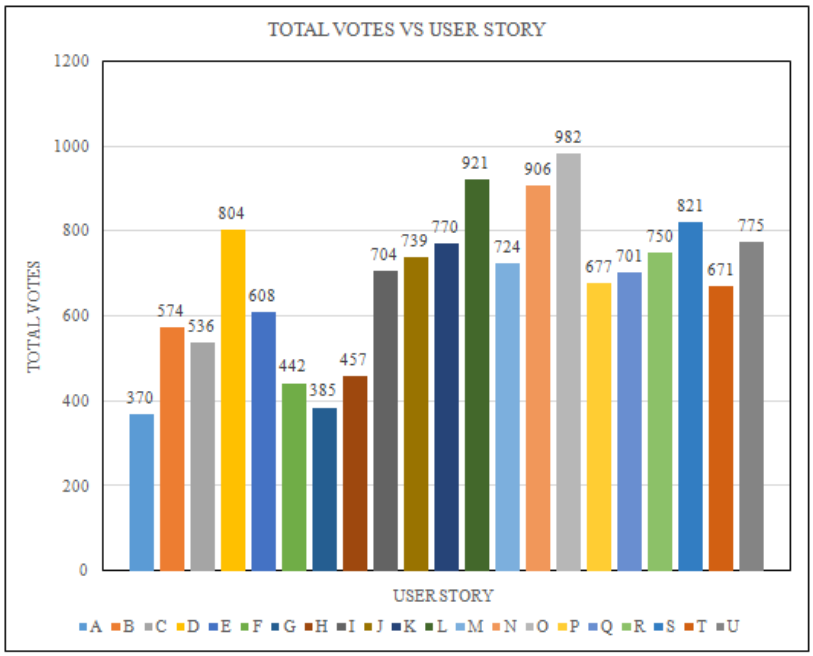


Figure 3. Total Votes for each User Story (Hudda *et al*., 2016)

Table 3. Total Votes for User Story G

Vote	Frequency
1st	12
2nd	8
3rd	6
4th	5
5th	8
6th	1
7th	6
8th	4
9th	2
10th	0
11th	0
12th	1
13th	0
14th	3
15th	1
16th	0
17th	1
18th	0
19th	5
20th	0
21th	0

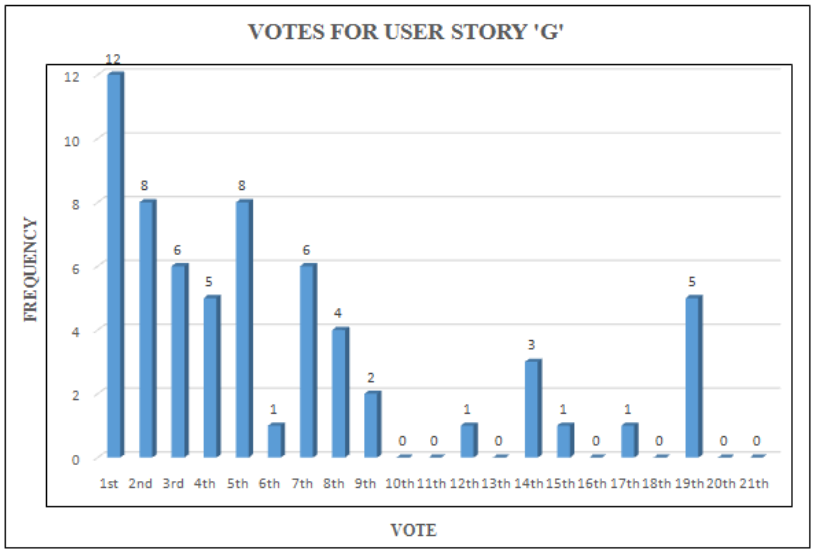


Figure 4. Votes for User Story G

Table 4. Total Votes for User Story L

Vote	Frequency
1st	0
2nd	0
3rd	1
4th	0
5th	1
6th	1
7th	2
8th	3
9th	1
10th	1
11th	3
12th	1
13th	7
14th	6
15th	8
16th	6
17th	6
18th	3
19th	7
20th	1
21th	5

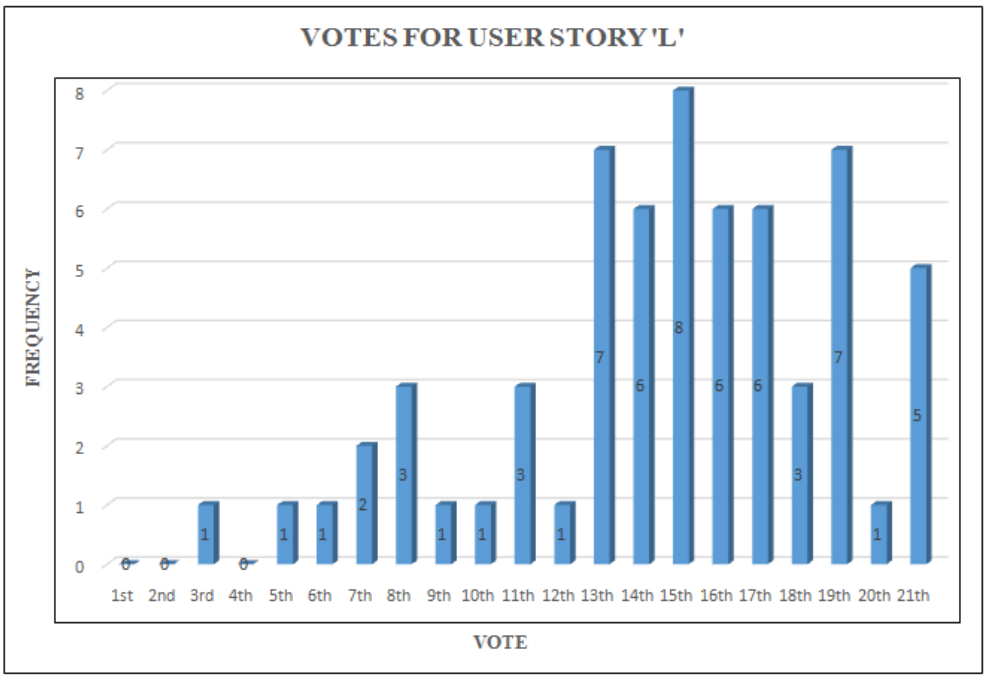


Figure 5. Votes for User Story L

Table 5. User Stories with ranks (r)

User stories with ranks			
S.No.	User Story	Sum of Votes	Rank
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	370	1
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	574	6
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	536	5
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	804	17
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	608	7
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	442	3
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	385	2
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	457	4
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	704	11
J.	As a teacher I want to apply for leave so that I can do my urgent work.	739	13
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	770	15
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	921	20
M.	As a teacher I want to know daily activities so that I can keep record of them.	724	12
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	906	19
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	982	21
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	677	9
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	701	10
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	750	14
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	821	18
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	671	8
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	775	16

Table 6. User Stories with weights (w)

User stories with weights			
S. No.	User Story	Rank	Weight
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	1	0.274321426
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	2	0.137160713
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	3	0.091440475
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	4	0.068580356
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	5	0.054864285
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	6	0.045720237
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	7	0.039188775
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	8	0.034290178
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	9	0.030480158
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	10	0.027432142
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	11	0.024938311
M.	As a teacher I want to know daily activities so that I can keep record of them.	12	0.022860118
J.	As a teacher I want to apply for leave so that I can do my urgent work.	13	0.021101648
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	14	0.019594387
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	15	0.018288095
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	16	0.017145089
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	17	0.016136554
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	18	0.015240079
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	19	0.014437969
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	20	0.013716071
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	21	0.013062925

Table 7. User Stories with effort (E)

User stories with effort					
S. No.	User Story	Effort t_{opt}	t_{ml}	t_{pess}	t_e
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	182	196	205	195.16
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	153	165	165	163
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	150	161	168	160.33
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	152	160	169	160.16
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	150	150	158	151.33
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	173	185	185	183
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	210	213	228	215
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	225	229	240	230.16
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	173	173	180	174.16
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	180	188	200	188.66
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	172	182	205	184.16
M.	As a teacher I want to know daily activities so that I can keep record of them.	202	215	226	214.66
J.	As a teacher I want to apply for leave so that I can do my urgent work.	180	180	184	180.66
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	200	209	221	209.5
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	187	190	203	191.66
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	191	201	201	199.33
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	237	245	250	244.5
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	191	191	203	193
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	180	180	195	182.5
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	240	241	247	241.83
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	220	223	233	224.16

Table 8. User Stories with weight by effort ratio

S. No.	User Story	Weight	Effort	Weight/Effort
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	0.274321426	195.16	1.405623214E-03
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	0.137160713	163	8.414767684E-04
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	0.091440475	160.33	5.703266731E-04
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	0.068580356	160.16	4.281990299E-04
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	0.054864285	151.33	3.625473158E-04
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	0.045720237	183	2.498373647E-04
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	0.039188775	215	1.822733731E-04
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	0.034290178	230.16	1.489840907E-04
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	0.030480158	174.16	1.750123938E-04
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	0.027432142	188.66	1.454051874E-04
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	0.024938311	184.16	1.354165481E-04
M.	As a teacher I want to know daily activities so that I can keep record of them.	0.022860118	214.66	1.064945443E-04
J.	As a teacher I want to apply for leave so that I can do my urgent work.	0.021101648	180.66	1.168031008E-04
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	0.019594387	209.5	9.352929645E-05
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	0.018288095	191.66	9.541946728E-05
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	0.017145089	199.33	8.601359131E-05
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	0.016136554	244.5	6.599817791E-05
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	0.015240079	193	7.896414119E-05
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	0.014437969	182.5	7.911216337E-05
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	0.013716071	241.83	5.671782378E-05
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	0.013062925	224.16	5.827500478E-05

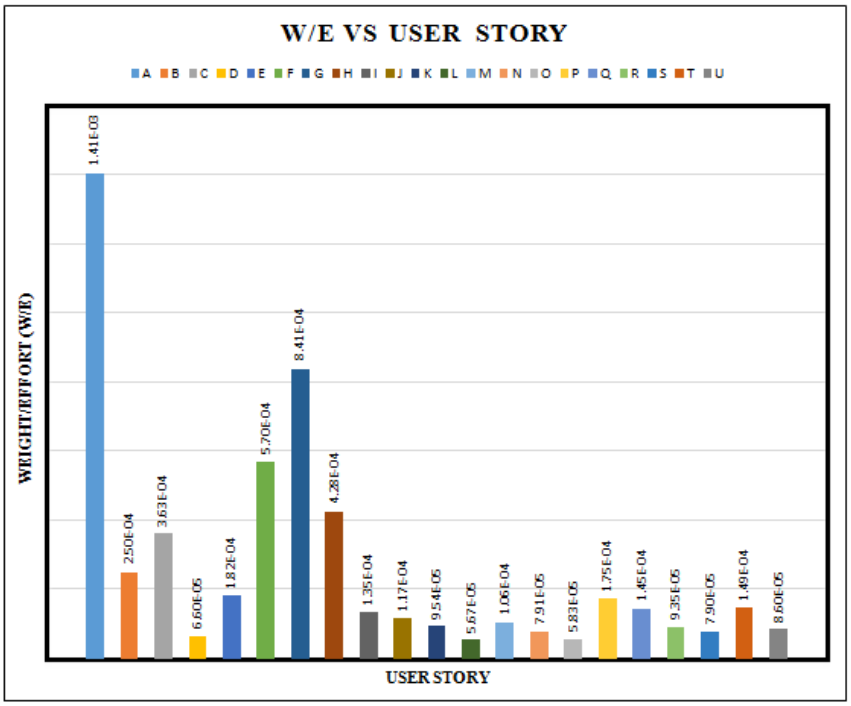


Figure 6. Prioritization of User Story by calculating ratio between Weight and Effort

The optimistic time is represented by t_{opt}, most likely time is represented by t_{ml}, pessimistic time is represented by t_{pess}, and final expected time is represented by t_e.

Finally, we are determining weight by effort ratio to decide priority. This weight by effort ratio is determined by a formula that is available in Equation 3. The weight by effort ratio is shown in Table 8.

Now we are assigning priority to each user story. To the user story with largest value of weight by effort ratio, we assign highest priority, and user story with smallest value of weight by effort ratio, we assign lowest priority. So user story "A" receives highest priority, and user story "L" receives smallest priority. The priority for each user stories is shown in Table 9. We are also drawing graph for weight by effort ratio versus each user story in Figure 6. In the Figure 6, the user story with

Table 9. User Stories with Priority

S. No.	User Story	Weight/Effort	Priority
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	1.405623214E-03	1
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	2.498373647E-04	6
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	3.625473158E-04	5
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	6.599817791E-05	19
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	1.822733731E-04	7
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	5.703266731E-04	3
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	8.414767684E-04	2
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	4.281990299E-04	4
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	1.354165481E-04	11
J.	As a teacher I want to apply for leave so that I can do my urgent work.	1.168031008E-04	12
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	9.541946728E-05	14
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	5.671782378E-05	21
M.	As a teacher I want to know daily activities so that I can keep record of them.	1.064945443E-04	13
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	7.911216337E-05	17
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	5.827500478E-05	20
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	1.750123938E-04	8
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	1.454051874E-04	10
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	9.352929645E-05	15
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	7.896414119E-05	18
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	1.489840907E-04	9
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	8.601359131E-05	16

longest bar represents highest priority, and user story with smallest bar represents lowest priority.

5.Conclusion

In this work, we have proposed an algorithm to decide priority for a user story in agile environment, and we are showing the feasibility of this algorithm using a case study. That algorithm considered criteria from client side as well as developer side. The importance is considered from client side, and effort is considered from developer side. In further work, to show the feasibility of our proposed algorithm, we will take some other criteria into the account, will take some other methods to decide priority. Therefore, in future we will extend this work to decide priority for a user story.

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