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AN INVESTIGATION OF THE DECISION-MAKING PROCESS IN AGILE TEAMS

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This paper firstly explores the decision-making process in agile teams using scrum practices and secondly identifies factors that influence the decision-making process during the Sprint Planning and Daily Scrum Meetings. We conducted 34 semi-structuredinterviews and 18 observations across four agile teams. Our findings show that a rational decision-making process is sometimes followed in the Sprint Planning and Daily Scrum Meetings and that three factors can influence the rational decision-making process: sprint duration, experience and resource availability. Additionally, decisions are not always made in a collaborative manner by team members. This research contributes to the decision-making literature and project management literature by highlighting difficulties pertinent to decision-making in agile teams.

Keywords: Decision-making, agile teams, sprint planning, daily scrum, rational decision-making, decision process.

1. Introduction

Scrum[1] is an agile project management (APM) methodology commonly used in industry[2]. APM methodologies such as Scrum develop software in short time periods (sprints), emphasizing the agile team and the role of the individuals within the team. Agile teams are typically small (less than ten members)[3], collaborative, and empowered to make decisions[4]. The structure of an agile team is flexible and adaptable with team members

interchanging roles to gain new experiences[5]. In an agile team the project manager is not the accountable decision-maker but more a facilitator or coordinator for the agile team[6, 7], with the customer continuously involved in the process[8]. The project manager facilitates decision-making between all team members rather than just making the final decision him/herself as in traditional systems development life cycle (SDLC) teams[9]. As agile teams self-organize, all team members contribute, with decisions made collaboratively[1, 5]. These include decisions for changing requirements, identifying problems that require resolution, and generating new ideas that need to be explored[10].

Agile teams are less structured than teams following the traditional SDLC. The end product of SDLC projects is typically unavailable to end-users until the very end of the project, which could take months or years to complete[11]. This contrasts with agile methods, which are considered at the opposite end of the spectrum to the SDLC as they are based on iterative and incremental development. They enable teams to adapt and respond quickly to changing requirements, delivering working software frequently, sometimes as often as two weeks[12]. Thus, software development is no longer a sequential development process akin to a linear relay race where the product is passed from one group to the next but is a more interactive group process with a multidisciplinary team working together from start to finish akin to a rugby team[13], i.e. APM.

The decision process that SDLC teams follow is similar to their development process as prior research concludes that SDLC teams use a rational decision-making (RDM) model for requirements engineering decision-making[14] and for software evolution projects[15]. RDM models assume decision-makers are fully informed[16, 17] and define decision-making as an optimal way of choosing between a number of alternatives [18], often in a linear, sequential manner[19]. Research on software evolution projects[15] adapted Mintzberg's seminal RDM model[20] to show how it applies to SDLC teams. Mintzberg's decision-making model seems appropriate for traditional SDLC teams that have rigid team structures and roles compared to agile teams that are more adaptable with flexible and changing team structures. Other research has recently begun to examine whether a rational decision process is appropriate in agile team decision-making and has determined that it has been used when APM teams compare options to make design decisions [21].

As agile teams develop software in a flexible manner, it calls to question whether agile teams use a RDM process when their software development process has become less rational and linear and more flexible. The decision-making process in agile teams can be impacted by the team's cohesiveness and empowerment to deliver working functionality as the agile team members are the core of APM [22], participate in decision-making, and have autonomy to make decisions about their tasks and processes[4]. Further research explored obstacles to agile decision-making[23] and identified decisions made at various points in an agile process[24]. For example, this research found that agile team members may be involved in decisions outside of their traditional skill areas due to their self-organizing, flexible team structure, although theoretically the customer, who is responsible for requirements decisions, drives the agile team who is responsible for all technical decisions[25]. Agile teams may also make quick decisions to maintain task

momentum, even though these decisions are sometimes reversed at a later date once further information is available[1].

Therefore, our first objective is to explore the decision-making process in agile teams because a more flexible approach to decision-making may be required. Research on the decision-making process in agile teams is limited, even though the importance of decision-making is recognized[26]. Also, there is limited research on specific aspects of some agile practices with recent calls for further empirical research on agile methodologies[27], specifically research that is more practice-focused[28].

Moreover, as a large number of agile practices exist, it is difficult to examine the decision-making process in each agile practice in a single study. Consequently, we chose to focus on two agile practices: the Sprint Planning Meeting (SPM) and the Daily Scrum Meeting (DSM) (see Table 1), which are forums where decisions are made collectively by the agile team. In addition, these two agile practices were selected because they are two commonly implemented practices where we could easily observe and examine the decision-making process. We recognize that decisions are also made outside of these meetings, but these two meetings provide a regular touch-point for all stakeholders, both business (customer) and technical (developers, quality assurance), where all team members are expected to actively participate and contribute to decisions made.

Table 1. Agile Practices where Agile Project Management Teams Make Decisions.

Meeting	Description
Sprint Planning Meeting	Meeting taking place at the start of each sprint where the team collectively defines and plans tasks to be completed during the next sprint[1].
Daily Scrum Meeting	Short daily status meeting lasting a maximum of 10-15 minutes typically conducted at the same time each day with team members standing up. Team members explain briefly what they accomplished since the previous meeting, what will be completed by the next meeting and any impediments that may prevent them from completing their current tasks[1].

The second objective of this study is to identify the factors that influence the decision-making process during the SPM and the DSM. Many different decisions are made during the SPM, which include decisions on sprint scope, setting goals and priorities; identifying task owners, their capacity and estimates; devising the approach for delivering a story; determining whether discovery work is needed; and whether a user story should be split or combined[24]. Decisions made during the DSM include how to remove impediments to completing tasks[23] and how to coordinate work especially where there are dependencies[26]. As the literature identifies a range of decisions for these two meetings, we focused solely on the decision process for the following types of decisions for the purposes of this paper: decisions related to task definition, task estimation and resource allocation in the SPM and

decisions on how to remove impediments in the DSM. This research therefore addresses the following research objectives:

(1) Explore the decision-making process in the Sprint Planning and Daily Scrum Meetings.
(2) Identify the factors that influence the decision-making process during the Sprint Planning and Daily Scrum Meetings.

The remainder of the paper is structured as follows. Section 2 reviews the decision-making literature, followed by the research approach in section 3. Section 4 presents the results of a multiple case study. The findings are discussed in section 5, and we conclude with limitations of the study in section 6 where we also provide recommendations for future research.

2. Decision-Making Process

This paper defines a decision as "the point in time when a team or an individual commits themselves to a course of action where multiple reasonable alternatives exist even if they are not identified or compared"[18] and a decision process as "the set of actions beginning with the identification of a stimulus for action and ending with the specific commitment to action"[20]. Traditionally, decision-making research examined normative decisions, or the act of making sensible decisions consistent with rational behavior where decision-makers make the decisions they *should* make in particular scenarios[19]. Normative decision theory views decision-makers as idealized, rational, extremely intelligent beings who make optimum choices[29]. Within this theory, RDM models look at optimal ways of making decisions between choices of alternatives in well-structured settings[18]. These RDM models describe the rational, subjective utility model which asserts that decision-makers maximize the expected utility of different possible choices as decisions can be predicted and prescribed through constructed utility functions that are representations of the decision-maker's assessment of relative weightings of each possible choice[19].

Such RDM models contain the following sequential steps: (1) define the problem, (2) identify the criteria or objectives of the decision, (3) weight or prioritize the criteria or objectives of the decision, (4) generate alternative courses of action to solve the problem, (5) evaluate alternatives against each criterion or objective, and (6) compute the optimal decision and select it[30]. This linear process assumes decision-makers are fully informed and rational, and problems are well-defined with a variety of informed, alternative solutions[16, 17].

Prior research has taken one such RDM model, Mintzberg's model[20] (see Fig. 1), and adapted it to SDLC teams. This current research seeks to apply Mintzberg's model to agile teams to assess whether a RDM model is used in flexible agile team structures. The model contains three phases: Problem Identification, Solution Development, and Selection of Best Alternative. While Mintzberg[20] saw value in identifying these three distinct phases of the decision-making process, he differed from other rational decision theorists by

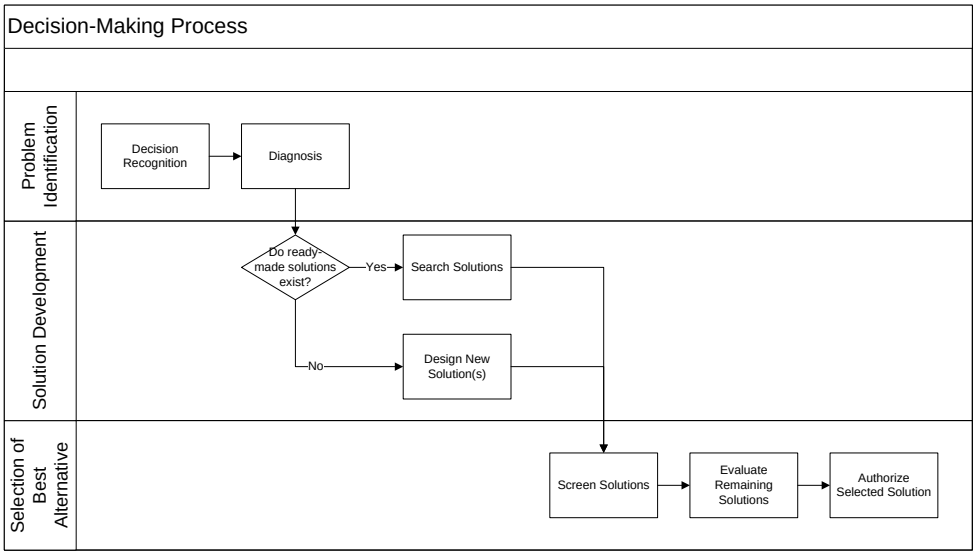

Fig. 1. Rational Decision-making Process (adapted from Mintzberg et al. (1976) and Saarelainen et al. (2007).

claiming there was no simple, sequential process between these three phases. Rather, decision-makers cycle both within and between the phases.

Similar to the rational decision process[30] outlined above, Mintzberg's[20] first phase, the *Problem Identification* phase, identifies the problem via two steps: decision recognition, which identifies opportunities and problems evoking decision activity; and diagnosis, where decision-makers try to make sense of the opportunities and problems to understand the decision situation and its cause-effect relationships[20, 31].

The second decision phase, *Solution Development*, identifies solutions to the problem via two steps: the search step searches ready-made solutions and the design step creates new solutions to the problem. This phase is the core of the decision-making process and requires the greatest amount of resources[20, 31].

The third phase, *Selection of Best Alternative*, selects the best solution. It includes three steps: the screening step removes infeasible solutions quickly without intense evaluation, the evaluation step evaluates the remaining solutions to determine which is appropriate, and the authorization step authorizes the accountable decision-maker to implement the solution. The overall decision process may include many selection phases because the development phase often involves breaking one decision into multiple sub-decisions each requiring their own selection phase[20, 31]. This seminal RDM process was initially developed to examine unstructured strategic decisions[20] and has been adapted for SDLC research teams focusing on software modernization and evolution[15] and requirements engineering decisions[14].

Although the rational decision process works well for project teams using the SDLC, we cannot assume that the rational decision phases are either appropriate or inappropriate

for flexible, self-organizing agile teams. Rational decision models often prescribe decision-making as a linear process but can fail to adequately capture team-based decisions and often unstable contextual variables such as experience inherent in group decision-making processes[19]. When making decisions in real-life situations, decision-makers do not always generate multiple options and compare them on a set of evaluative criteria; they may not generate probability estimates for different options; and if they do compare options, it may not be in a systematic way[32]. While traditional decision models focus more on generating and choosing between options[33] rather than sizing up situations to understand the problem using feedback and experience[34], agile teams may still use traditional, rational decision models at some point in their teams. Yet, it seems likely that with a more flexible team structure and development method, they may use rational decision models less so than traditional SDLC teams. The decision-making process that occurs in agile teams is unclear, particularly whether a rational process is used or should be used by agile teams.

For these reasons, this research explores whether a rational decision process occurs at certain points on an agile team. It seems likely that the advent of a more flexible team structure means that agile teams may not always use a traditional RDM process in their agile team. Consequently, this research assumes that agile teams, by their described nature, may exhibit factors that influence the use of a RDM process.

3. Research Approach

For the purposes of this study we adopted an interpretive philosophical stance. This was partially driven by the research objectives and partially by the nature of the subject under investigation. This study is exploratory in nature and examines agile teams in their natural setting with a specific focus on decision-making. As suggested by Myers[35], the best way to capture detail or to really understand people's actions or motivations is to speak with people. Therefore, we used a qualitative multiple-case study approach as case studies are considered a suitable approach for exploratory research[36] with multiple case studies considered more robust than single case studies[37]. The multiple-case study approach selected facilitated cross-case analysis and permitted an opportunity to examine if the findings were replicated across cases, which provides some foundation for generalization [36, 38]. However, the ability to generalize findings from four case studies is limited. Where findings were replicated across the four cases this only suggests that these findings may also be present in other cases.

The unit of analysis for this study was the agile team. We purposely selected teams on the basis of their diversity of distributedness and industry setting. Each of the four teams studied used an agile methodology for a minimum of six months and held SPMs and DSMs during each sprint. These cases provided the researchers with an opportunity to explore each particular situation in detail, but they are solely representative of the experiences of these four teams.

3.1. *Data collection and analysis*

Data collection consisted primarily of 34 in-depth, face-to-face semi-structured interviews with individual team members across four teams (see Table 2) using an interview protocol (see Appendix for interview protocol excerpt). The interview protocol was developed and pilot tested prior to the study. This pilot test did not result in changes to the protocol but served to develop the codes used for data analysis across all cases. Interviewees were asked specific questions in relation to their decision-making process in the SPM and DSM to determine whether these agile teams used a RDM process. The interview protocol also included questions in relation to the factors that influenced this process during these two meetings. The questions were open-ended, which allowed respondents to freely express their views as recommended by Yin[36]. Prompts were included in the interview protocol, which were solely for use by the interviewers to ensure consistency across cases. Interviews varied between 50 and 75 minutes in length with each interview audio-recorded and later transcribed. A review of the interview data was conducted by the researchers after each case. In addition, participants were provided with a written synopsis of their interview and were given an opportunity to correct any misinterpretations. Interviews were supported by direct observations of 18 SPMs and DSMs, allowing us to see and hear how the teams made decisions without participating in the meetings. Subsequently, we documented these observations as field notes and sought clarification from team members after the meetings when required. A list of interviewees and the meetings observed are detailed in Table 2.

The analysis strategy was designed to establish the decision-making process in the two meetings studied and identify and code the factors influencing decision-making in such meetings. Using multiple sources of data provided an opportunity for triangulation [38] and increased the rigor of the study. Collecting interview data from each member of the agile team ensured that we obtained different viewpoints, but it also helped to validate the data gathered when two or more participants communicated the same or similar views. Empirical data was also collected from direct observations, which further validated the interview findings.

One of the most efficient ways to analyze qualitative data is through the use of coding with each code representing a concept which is derived from asking questions about the data, or making comparisons between data [39]. Thus, we imported the interview transcripts and field notes into NVivo, software designed to track and code qualitative research, for analysis and grouped the data by team. To address the research objectives, the transcripts and field notes were read several times to obtain insight into each case. The decision-making process and factors that influenced decision-making in the two meetings were identified from a number of sources: some were explicitly stated by team members whereas others emerged from the interview data and observations. Each factor was coded to help organize the data and identify patterns and themes in the two meetings across the four teams.

A second round of coding was completed independently by each researcher, which further examined the data to identify any overlaps across the factors and to ensure there

were no oversights in relation to the coding. This ensured the data was reviewed from more than one perspective and that it had not been miscoded or misinterpreted during the initial round of coding. Consequently, this resulted in the transition of some of the text coded to a different factor as it was deemed more appropriate. In some instances a section of coded text was removed from a factor as after reflection and discussion it did not relate specifically to that factor. Finally, we compared the data across cases to identify any similarities or differences across the teams studied.

3.2. *Cases studied*

The size of the four teams was similar, with two of the teams co-located and two teams distributed. All team members were employees of their respective organizations. Agile was the chosen software development methodology for each of these teams with three of the teams (C1, C2 and C3) receiving formal training in agile methodologies. C4 obtained feedback and advice from external experienced agile coaches a number of months following the adoption of agile. All participants spoke very positively about their experience with agile to date and had no desire to reinstate the previous software development methodology. Two of the teams (C2, C3) had dedicated customer representatives, called the Product Owner, who actively participated in both meetings. In C1, the customers, based in the United States, rarely participated in any meetings with the core development team who were based in Ireland. In C4, the customer representative (Business Analyst) mainly participated in the SPM (see Table 2 for team summaries).

C1 was a multi-national financial services organization with the development team primarily based in Ireland, the Quality Assurance (QA) function based in India, and a database specialist and customers based in the United States. This team, based in the research and development division of the organization, was one of three teams within the organization that had adopted agile. This team had been using Scrum practices on their current project for over two years at the time of data collection and had retained the traditional role of the Project Manager. This was due to the hierarchical nature of the organization where individuals had specific roles and associated responsibilities with remuneration attached to a specific role. While the team used agile practices and functioned in an agile way, members retained their roles as defined by their job description. Three of the team members had prior experience working on an agile project. The team did not use all the practices as defined by the Scrum methodology. Instead, the team selected and implemented the Scrum practices they considered appropriate for their project. The team was working on a multi-year project to develop a new IT system that amalgamated five existing IT systems for financial analysts internally within the organization. The project was very technical and focused on the back-end services for the new software system, which was one of the main reasons the customer was not involved in the project on a daily basis. The front-end for the system was developed by a separate team based in the United States. The project was delivered on a phased basis with each

Table 2. Profile of Participating Case Study Teams.

	Case C1	**Case C2**	**Case C3**	**Case C4**
Organization Location	Ireland USA India	Sweden	Ireland	Ireland India
Industry Sector	Financial Services & Investments	Engineering	Software Development	Software Development
Multi-National Organization	Yes	Yes	Yes	No
Team Distribution	Distributed	Co-located	Co-located	Distributed
Team Culture	Multi-cultural	Single culture	Multi-cultural	Multi-cultural
Team Size	8	9	8	9
Team Composition	1 Project Manager 1 Business Analyst 1 Technical Architect 5 Developers	1 Scrum Master 1 Product Owner 7 Developers	1 Scrum Master 1 Product Owner 5 Developers 1 Quality Assurance	1 Scrum Master 1 Business Analyst 4 Developers 3 Quality Assurance
Average years software development experience	11 years	14 years	10 years*	8 years
Average years employed by the organization	4 years	15 years†	5 years	4 years
Length of time since agile implementation	2 years	9 months	11 months	1 year
Customer	Internal, based in the United States	Internal	External, but internal customer, representative	External
Number of Observations	2 Sprint Planning 2 Daily Scrum	1 Sprint Planning 3 Daily Scrum	1 Sprint Planning 2 Daily Scrum	3 Sprint Planning 4 Daily Scrum

* One individual had 30 years experience in the software industry. The remaining team members had between 3 years and 11 years experience in the software industry.

† One individual has been employed by Case C2 for 30 years, but worked as an electronic engineer for the first 15 years. This is included in the calculation.

release containing a number of sprints. The last release of the software was highly pressurized with the team expected to deliver a large amount of functionality in a tight timeframe.

The second team, C2, was based in a multi-national engineering company focusing on power and automation technologies for utility and industry customers. The team was co-located in one of the Swedish offices of the organization. The team studied used the Scrum methodology to develop software and were the only team within their division that had adopted an agile methodology. The team implemented and adopted Scrum nine months prior to data collection and had regularly used the two agile practices required for this study since the project commenced. The customer for the team was an internal department within the organization, represented in the team by the Product Owner, who was involved in the project on a daily basis. This team worked on three different projects simultaneously. These consisted of their main project, related to the development of one component of a generic software platform for a software product, and the maintenance and support of two other software systems. These maintenance tasks were external to the work assigned to individuals during each sprint and were generally not included in the SPM, but on occasion they were included in the SPM with team members often expected to work on three different projects in the sprint.

The third team, C3, was a co-located team based in Ireland in an organization which developed and sold software products to the insurance industry. While the team studied was part of a large multi-national organization, the Irish office remained small with approximately 50 employees employed. The software developers were divided across two teams. The Technical Director had several years experience using Scrum in a previous organization and instigated the adoption of Scrum within the organization. The team studied was the only team in this office that used Scrum to develop software, which was in use for 11 months prior to data collection. Since the adoption of Scrum, the team had gradually introduced agile practices, with the two agile practices studied in use from the outset. The organization had external customers (insurance companies and financial institutions), but from the team's perspective, their main customer was an internal team of underwriters who communicated with and represented the needs of external customers. On a daily basis, the underwriting team was represented by the Product Owner who actively participated in the agile team.

The final team, C4, was also based in Ireland in an organization that is the market leader for corporate actions and custody solutions to the investment services industry. This team's customer was large financial institutions that handled corporate action events. The team studied was responsible for the component that generated messages in different protocols to notify customers of corporate action events. It was one of four teams within the organization that had adopted agile. Three of the team members had on average two years prior experience working on an agile project. The team was distributed between Ireland and India and had been using Scrum for one year. They regularly used both meetings studied. This team included a Scrum Master and Business Analyst who

were very involved in both the SPM and DSM. Both were quite vocal in prioritizing tasks and helping team members give estimates.

4. Findings

The first aim of this study was to investigate the decision-making process relating to task definition, task estimation and resource allocation in the SPM and on how to remove impediments in the DSM and secondly to identify factors that influence the decision-making process in such meetings. The findings show that the RDM process is used in certain circumstances with sprint duration, experience and resource availability influencing the decision-making process.

4.1. *Decision-making process in agile teams during the SPM and DSM*

The decision-making process, comprising the three phases in Mintzberg's model[20], the Problem Identification phase, the Solution Development phase, and the Selection of Best Alternative phase (see Fig. 1), was examined in each agile team through observations of SPMs and DSMs and interview data collected. This section will first address the decision-making process in SPMs, followed by an examination of the decision-making process in DSMs.

4.1.1. *SPM decision-making process*

The SPM is typically held at the start of a sprint and lasts approximately two hours. The data revealed that the RDM process was followed in many instances in the SPM, although some phases of the process did not always occur during the SPM.

Problem Identification was not a difficulty in C2 and C3, where teams were co-located. In particular the SPM promoted cooperation between the Product Owner and the remainder of the team and helped them to understand each other's needs. Teams in C1 and C4 were distributed, which caused difficulty with the Problem Identification phase of the rational model in SPMs. Time zone differences and dependencies on distributed team members prevented timely decision-making and made it difficult for teams to make task decisions at both meetings as whiteboards and distributed team members were not visible to each other. In C4, the co-located portion of the team followed the RDM process, but the distributed team members did not contribute [Observation C4]. In C1 the distributed team members "*tend to be quiet* [C1, Developer 1]" and contributed to a lesser extent than the co-located team members. They rarely identified problems; instead, portraying "*a more positive picture of things* [C1, Project Manager]". Additionally, in C1 the distributed customer was seldom involved in any collaborative interaction or decision-making with the team at the SPM [Observation C1].

When tasks were familiar to team members, the RDM process was followed in all teams studied during the SPM. Each item was discussed in turn, with team members proposing and discussing various alternative solutions, with conflicts and trade-offs identified, estimates determined, and resources allocated to tasks [Observation C1, C2,

C3, C4]. "*We can decide ourselves who does a task, what tasks are going to be in what sprint* [C2, Developer 4]". Sometimes decisions "*can take a long time like the estimation portion if there were an awful lot of tasks* [C3, QA]". Yet, although it may be time-consuming, the cyclical nature of the RDM process can be seen as team members identified problems, generated estimates, determined solutions and selected the best alternatives.

However, when tasks were new or complex and the teams did not know how to develop a task, only the first phase of the RDM process was used in the SPM in the teams studied when making decisions on task definition, task estimation and resource allocation. As a result, the team was not always in a position to make decisions about how to develop the functionality or about how many sub-tasks were needed and their corresponding estimates. To resolve this, additional workshops were scheduled outside of the SPM with only the relevant personnel to address these decisions to avoid a "*planning meeting that is much longer and less efficient* [C4, Developer 1]". Thus, the Solution Development and Selection of Best Alternative phases for these decisions occurred outside of the SPM and without all team members participating. C4 "*added an extra task for a research spike to allow some time to think how to do it* [C4, Developer 1]". In C2 spikes, which are time boxed periods for research and development of concepts and simple prototypes, were not used and such tasks were assigned to non-team members for investigation.

Moving these Solution Development and Selection of Best Alternative phases outside of the SPM did not detract from the SPM or the decision-making process, but instead made the SPM more efficient and ensured that sufficient time was allocated to consider various alternatives. The final decisions were then presented to the team at the next DSM so all team members were aware of the decisions made. If the functionality proved too complex, the decisions were postponed to the next SPM where a decision was either made on the most appropriate solution with the entire team or a workshop was scheduled to address the functionality during that future sprint [Observation C1, C2, C3, C4]. Therefore, the Problem Identification phase occurred during the SPM, albeit different SPMs at times, whereas the Solution Development and Selection of Best Alternative phases often occurred outside of the SPM for these decisions, which is outside the scope of this study that only examined the SPM and DSM decision process.

4.1.2. *DSM decision-making process*

The DSMs were generally much shorter in duration (approx. 15 minutes) [Observation C1, C2, C3, C4] than the SPMs. The DSMs have a different focus to the SPM as they require team members to update each other daily on progress made, identify any impediments to their task completion and help to coordinate and synchronize work. Decisions in these meetings tended to be quicker as they focused on how to address any impediments, e.g. resource dependencies or blockers, in order to progress tasks: "*I don't spend much time on decisions because you don't get much time* [C4, QA 1]".

For the most part the DSM decisions did follow the RDM process if the impediments were not difficult to resolve. Teams particularly noted the importance of the DSM for the Problem Identification phase. For example, the DSM is "*very important because it is a good point to discover problems…a point where a task is blocked…But, if you raise a problem that is linked with a long conversation, you postpone the conversation until after the meeting just for the people that are involved in that* [C3, Developer 3]". Thus, the Selection of Best Alternative did not always happen during the DSM and often didn't necessarily include the entire agile team.

Similar to the SPM, having distributed QA team members affected the Problem Identification phase during the DSM because these QA team members regularly did not attend the DSM like they did the SPM as it required them to work additional hours every day. When distributed QA members did attend the DSM, team members in C1 felt that QA's participation and their contribution to decisions were limited. They rarely identified problems during the DSM; for example, "*they give their status and then just go back and speak to their domestic team* [C1, Developer1]".

The Solution Development and Selection of Best Alternative phases did occur during the DSM for less complex impediments. But, where all information or personnel were not available to make a decision, the Selection of Best Alternative phase was affected because the evaluation of alternative solutions was not possible. Additional meetings were scheduled with only the relevant team members to discuss the problem and decide the most appropriate solution, *"Sometimes you'd have a couple of different ways to do something and we'd spend a bit of time looking at options* [C4, Business Analyst]".

In C1 where the customer was rarely present, a different approach was adopted. In order to complete a sprint, this team often made decisions based on information available at that point in time in order to progress a task as "*it might take a week to get a response from a customer* [C1, Developer 2]". But, the team recognized that the customer may "*want some things differently to what we have planned* [C1, Developer 3]", which sometimes resulted in revised decisions at a later date when the customer provided feedback to the team. This did not detract from the use of the RDM process as the team evaluated the options available to them at a point in time and chose the best solution based on information available. If the requirements changed then the team still followed the RDM process by evaluating new possible solutions and choosing the best solution for the task in question in a cyclical pattern of moving between and within the decision phases of the model.

4.2. *Factors that influence the decision-making process in the SPM and DSM*

Three factors were identified that influenced the decision-making process in the two meetings studied: sprint duration, experience and resource availability. Sprint duration affected task definition and resource allocation; experience impacted agile decision-making, affecting task definition, task estimation, resource allocation and decisions relating to the removal of impediments. Finally, resource availability impacted task

definition, resource allocation and decisions relating to the removal of impediments. These findings are summarized in Table 3.

Table 3. Factors that Influenced the Decisions Studied

Factors Influencing the Decision-Making Process	**SPM Decisions**			**DSM Decisions**
	Task Definition	**Task Estimation**	**Resource Allocation**	**Removal of Impediments**
Sprint Duration	Yes	No	Yes	No
Experience	Yes	Yes	Yes	Yes
Resource Availability	Yes	No	Yes	Yes

4.2.1. *Sprint duration*

The teams worked in short, intense sprint cycles, as short as two and three weeks, which placed pressure on teams to make decisions quickly during the SPM and DSM, affecting the second and third phases (Solution Development and Selection of Best Alternative) of the decision-making process (see Table 4 for a summary). The decisions on the definition of tasks were made during the SPM. However, the short timeframe of the sprint made it difficult for teams to decide how large tasks could be incorporated as *"you have such a short perspective in everything* [C2, Developer4]" with all tasks typically broken down into small tasks of a few hours or days. In C2 this resulted in a decision to exclude larger tasks from the sprint and the delegation of work to an individual outside of the team. The short timeframe of a sprint also put teams under pressure "*to get stuff done, which leaves no time to think of the long-term* [C3, Product Owner]" and in C1 resulted in the allocation of work to those who could complete it in the shortest timeframe in order to achieve the sprint deadline. This meant that the decision phases were often limited in scope so that the team did not always cycle back and forth through a broad range of options. They instead searched through a limited number of solutions and quickly selected a solution from this limited list, often allocating the task to the resource who could complete the task the quickest.

Agile methodologies promote autonomy at the team level. In some of the cases studied, the "*team has autonomy over what is included in the sprint - the team decide together with the product owner, prioritize the list and then we discuss. Decision-making and estimating is a team effort* [C3, Scrum Master]". In C2 and C3 the teams self-selected tasks or allocated resources to tasks. Team members selected tasks because a task must be completed "*really quickly now or else other people have problems, but it's not something that we inflict, it's something that these persons take on themselves* [C2, Developer 1]". C2 have "*sacrificed time in order for a new person to start doing a task that hasn't been done before* [C2, Developer 5]" even though this sometimes affected the

ability of the team to deliver all the functionality agreed for the sprint. The short duration of the sprint required teams to limit the tasks they would complete in the sprint if extra time was required for a team member to become familiar with a task.

However, in C1, the Project Manager admitted that he "*initially decided*" tasks for team members early in their agile transition as this team was under pressure to deliver a large quantity of functionality in each sprint. Due to the short nature of the sprint, the quickest way for the team to achieve the sprint goals was to assign tasks to the most appropriate person. At the point of data collection, the pressure to deliver had eased and the Project Manager emphasized that now he "*tries not to assign tasks*" and encourages the team to be "*more collaborative*" as they had gained experience and can make these decisions themselves. In C4 the team's general consensus was that the Scrum Master "*dictates* [C4, Developer 2]" or "*suggests somebody take a task* [C4, QA 1]". The Scrum Master "*comes up with the initial task*" and "*gains consent of the corresponding stakeholder...the developer or QA* [C4, QA 2]". Observation of the SPMs supported this as due to the short nature of the sprint, the Scrum Master often quickly assigned team members to tasks due to their experience rather than allowing team members to decide.

4.2.2. *Experience*

Teams did not always make decisions entirely collaboratively with experience influencing the decision-making process. During the SPM, certain individuals placed undue influence on the team due to their experience or seniority within the team, which influenced the Solution Development and Selection of Best Alternative, the second and third phases of the decision-making process (see Table 4 for a summary). Rather than incorporate perspectives from all members, in C2 the person with the most knowledge influenced the task definition and task estimation decisions and team members often did not question it: *"It's usually the one that has the knowledge to take the decision that suggests, 'Okay, we do it like this', and then everyone else accepts it* [C2, Developer 4]". This also occurred in C3 where individuals, even though they had many years experience, were slightly intimidated and felt they could not question the decision of one particular expert, who was employed by the organization for 30 years: *"If you disagree with what people with more experience said, you are little bit in a difficult time and you start doing what other people ask* [C3, Developer 3]". In C4, inexperienced team members felt that the senior members *"don't like being told what to do* [C4, Developer 3]" and were reluctant to verbalize their opinions, resulting in a lack of collaborative decision-making since the junior member was not contributing to the same extent.

Team members used prior experience when making decisions in the SPM, which influenced the Solution Development and Selection of Best Alternative phases of the decision-making process. For example, if "*someone has done a task before, then we usually have good estimates...and they are quite realistic* [C2, Developer 7]". Conversely, inexperienced individuals had difficulty contributing to a discussion in relation to the design of unknown or complex tasks because they lacked experience or knowledge to comment and were passive: "*Sometimes I may not know anything about the*

task, so I sit and listen [C2, Developer 3]". New or inexperienced staff often underestimated the time required to complete tasks: "*You wouldn't have seen some challenge or some obstacle, so your initial estimate would have been delayed* [C1, Developer 4]", or based their estimates on those set by experienced developers even though they themselves may not be able to complete the task in the same amount of time. Yet, they agreed with the experienced developer as they did "*not want to be seen to be wrong* [C3, Scrum Master]".

It was also difficult for all teams to make decisions about impediments during the DSM when they had insufficient experience or information, "*especially for the ones [tasks] that take investigation* [C3, Scrum Master]". This was due to the complexity of the task or lack of information from other team members or customers, so decisions in the DSM about how to address impediments could be postponed indefinitely. "*If we cannot do anything then generally we postpone the task because it cannot be done* [C3, Developer 1]". As the time available for each sprint was short, insufficient knowledge sometimes impacted the ability of the team to deliver the functionality agreed. In C1 and C4 team members were transferred from the team or left the organization, resulting in the departure of valuable sources of information from the team, which was problematic for decisions. But, sometimes there was "*no real way of getting around that* [C4, Developer 5]" and so in the DSM, the remaining team members decided to reallocate tasks to the most appropriate member. The three phases of the decision-making model could therefore occur in the DSM but with less collaboration as a team member was absent.

4.2.3. *Resource availability*

All decision-making phases were affected in the SPM and the DSM in C2 and C4 when individuals had to complete tasks for other projects (see Table 4 for a summary). While team members participated in the meetings, their time during each sprint was often divided between projects. This impacted in particular on Problem Identification and Solution Development in the DSM with the availability of team members varying from one meeting to the next. C4 experienced a problem where the composition of the team was unknown at the start of the sprint as resources were often temporarily transferred to other projects mid-sprint to resolve a customer issue. This caused difficulty when one developer was dependent on another to evaluate and develop solutions and that resource was temporarily unavailable. It "*throws your plan out the window so we have to re-evaluate* [C4, Developer 1]" at the DSM, which is in keeping with the RDM model. But the resource is still missing at the DSM so decisions around this impediment do not involve that resource and are often not made. Thus, the Selection of Best Alternative phase also doesn't always happen in the DSM. Besides being disruptive to the team, specific information known to that individual was no longer available to the rest of the team. This contrasted with C1 and C3 where team membership was stable as teams focused solely on one project for each sprint.

In Scrum it is recommended that the customer (Product Owner or Business Analyst) is a key resource, is part of the team, and participates in SPMs to assist in all phases of

the decision-making process. This occurred in C2, C3 and C4 where all phases of the decision-making process were evident. Tasks were identified and prioritized by the team in conjunction with the Product Owner [Observation C2, C3, C4] who was considered a valuable part of the team. The team was able to *"ask him [questions] and get instant feedback on decisions* [C3, Scrum Master]". Team members proposed alternative solutions for discussion and identified time estimates and resources required for each solution. The Product Owner evaluated and selected the most appropriate solution for a task based on the information provided by the team and their own knowledge of the customer's requirements and priorities [Observation C2, C3, C4].

This contrasted with C1 where the Project Manager identified and prioritized tasks as the customer rarely participated in the SPM for a number of reasons: the technical nature of the system developed; their distributed location; and the fact that there was no one, single defined customer. Instead, there were "*a few different people in a few different areas…with no one person who understands it all* [C1, Developer 1]". Therefore, C1 rarely had input from the customer and regularly experienced difficulties in obtaining decisions from the customer as it was *"hard to get their time…they are very slow to make decisions* [C1, Developer2]". As a result, the team often made "*assumptions* [C1, Developer1]" in order to progress the sprint, which sometimes needed to be reversed in a later sprint. The team believed that the customer's lack of participation and untimely decision-making was a result of using an agile methodology and caused them frustration and difficulty with setting and achieving goals for the sprint. Although, reversing their assumptions at a later point in time did not detract from the RDM process as it only reflected the cyclical nature of moving between the decisions phases and revisiting prior decisions when they obtained new information.

Table 4. Decision Phases Affected by the Identified Factors

Factors Identified Affecting Decision-Making	**Affected Decision-Making Phase**		
	Problem Identification	**Solution Development**	**Selection of Best Alternative**
Sprint Duration	No	Yes	Yes
Experience	No	Yes	Yes
Resource Availability	Yes	Yes	Yes

5. Discussion

This study provides an insight into the decision-making process in four agile teams and identifies three factors that influence decision-making in two agile team meetings, the SPM and DSM. The two meetings studied are critical for decision-making in agile teams because they are forums where team members regularly communicate, are informed of

progress and make key decisions. Each team structured the meetings to suit their specific needs, which is unsurprising given that many teams tailor agile methodologies and practices [40, 41]. The findings are therefore not generalizeable to all agile teams, but are specific to the four teams studied.

Many organizations either ignore or lack adequate decision-making processes[26], which may also be true of the decision-making process within teams. Our study found that the RDM process was followed in the SPM and DSM, although the teams may not have been consciously aware that they were following a specific decision-making process. During both meetings, the Problem Identification phase took place as agile teams recognized that decisions were required and often must be made quickly. They then moved to the second phase, and if ready-made solutions existed they move to the third phase to evaluate these options, selecting one to implement. Their experience helped drive the process for repeat decisions, e.g. selecting tasks and making estimates in the SPM or deciding how to resolve issues in the DSM. If ready-made solutions did not exist, teams attempted to develop a workable solution in the time allotted to the particular meeting. If a solution was not determined quickly, workshops were scheduled outside of the meeting where selected team members would complete a series of design and search cycles of potential solutions. However, they did not necessarily do this in a sequential format as RDM suggests[19], though they often developed only one solution, as Mintzberg predicts[20], rather than a number of solutions from which to choose. Agile teams did not cycle back to a prior solution in a sequential format if they realized a potential solution would not work. Instead, they seemed to modify the solution and develop it in an iterative way by going back and forth within the Solution Development phase but not necessarily determining all the potential solutions at the outset or evaluating a number of options as RDM suggests[18].

Prior research found that traditional software development teams use a RDM process, e.g. [14, 20], and our research also found that agile teams use the same process in the two meetings studied in certain circumstances. However, some conditions, e.g. task complexity, led to phases of the RDM taking place outside these two meetings without all team members present. As agile teams cycled back and forth between the three decision phases[20] (see Fig. 1), often their experience guided the decision process with complex or unknown tasks causing particular difficulty. This finding demonstrates that sometimes the quickest way for the team to make a decision was to take the decision out of the meeting and limit the decision-making to those who had the most experience or knowledge to investigate the task. However, decisions made were communicated to the team at the next appropriate opportunity, so that the remaining team members were aware of the decisions made. This was important as team members may feel isolated from the decision process if they are not informed of why specific decisions are made[26].

In an agile team it is important that decisions are made as quickly as possible as slow decisions, revisiting decisions, or poor participation in the decision-making process can potentially delay the sprint and the project[26]. Moving the decision-making process outside of the two meetings studied did not detract from the use of the process, but indicated that

agile teams use RDM despite the flexible and unstructured nature of the agile team. This suggests to practitioners that agile teams can implement and follow a RDM process so long as it allows for a number of cycles within the process where the team moves back and forth between decision phases. It is plausible to expect that the decision-making process in agile teams is shorter due to the nature of the sprint and the need to make decisions quickly in order to progress tasks, bearing in mind that the decision may be to postpone the task until the next sprint.

How a team makes decisions determines how collaborative it really is with decisions made by the team leading to its success or failure[26]. But, moving decisions outside of the two meetings studied without all team members present also demonstrated that agile teams do not always make decisions collaboratively. Collaboration is core to an agile team[4]. As agile teams self-organize and are meant to contribute collaboratively to decisions[1, 5], we chose to focus on the SPM and DSM because all team members are present during them. We felt these meetings would exhibit collaborative decisions. But from the data, we can see that decisions were sometimes postponed to a later point in the sprint with only relevant team members present or made by the experienced team member rather than incorporating input from all members, even those with less experience. Thus, the Scrum Master did not necessarily facilitate decision-making[9] as agile calls for, but often made the decision him or herself, for example assigning resources to tasks, which prevents the team from being fully agile and collaborative in the true sense of the word. This seems contradictory to working in an agile way as agile teams are purported to be flatter and more flexible[5].

While the data supports agile teams using the RDM model, there were times when the decision process during these two meetings did not follow the RDM model[20]. Research has shown that ASD teams do not make decisions in a linear manner in line with normative models[42]. In this current study, people's experience often drove decisions and agile teams did not always identify and evaluate a series of options as the RDM process outlines. For example, team members in C1 and C4 did not evaluate each other's estimates, which may be due to the size and complexity of the project as each team member did not necessarily understand every area of the project, or an assumption that team members are the most knowledgeable to complete a particular task, and that they will provide accurate and honest estimates. Either way, this decision process was neither rational nor collaborative (i.e. where everyone participates).

Additionally, the decisions requiring new solutions, as opposed to re-using existing solutions, are where the RDM model[20] was most severely hindered in the meetings studied. These decisions required research spikes or additional workshops to discuss and decide how to develop functionality. Likewise, the DSM is so short that often decisions regarding issues were made quickly or postponed to additional meetings where different options were discussed and decisions made on how to progress. The decision-making process could be different for different decisions with teams even going through the decision-making process to decide on the criteria for making a decision[26].

Our study found three factors: sprint duration, experience and resource availability that influenced the use of the RDM process within the SPM and DSM. These factors may impact on the ability of the team to deliver agreed functionality during a sprint, although this impact was not examined in this study. While these factors influence the RDM process, it is unclear how a collaborative decision-making process based on participation and experience can improve the quality of a decision process as conclusions cannot be drawn about this because it is beyond the scope of this research. How experience in the context of collaboration drives decisions on agile teams should be a topic of future research as experience drove many decisions in all teams studied.

An additional important finding is that agile teams are missing key information for decisions because resources are either not participating in complex functionality decisions due to thinking that their inexperience precludes them from doing so, or resources are pulled from teams from one sprint to the next. As agile teams already use less documentation than traditional SDLCs[4], they are making decisions with incomplete information and the very nature of agile cannot mitigate this risk because there is little documentation to fall back on when resources are pulled from the team mid-sprint. This suggests that agile methodologies may not be suitable for projects that contain a large number of unknown, complex tasks as it is difficult to make informed and accurate decisions in SPMs due to a lack of knowledge.

Finally, this research contributes to project management by providing an insight into the decision-making process in the SPM and DSM. The agile teams followed the RDM process for familiar tasks in the SPM. But, if teams used the SPM to decide how to address complex functionality, the rational decision model was not used as these complex tasks required more information gathering and discussion. These took place in separate meetings to more accurately determine tasks and estimates, the outcomes of which were incorporated into the next SPM. There is some suggestion in the data that distributed team members of a different culture did not participate as fully in the decision-making process as the co-located team members, particularly in the Problem Identification phase. Also, the lack of customer involvement in C1 inhibited the decision-making process of the team. This team had to deal with the lack of participation and adjusted their decision-making process accordingly, even though it sometimes required the team to revisit and redevelop functionality. While these were not core investigations of this study, they are worth exploring in future research.

6. Limitations of the Study and Conclusion

This study exhibits shortcomings, which are highlighted here. They first relate to the limitations of the study itself and secondly to the limitations of the research design. The study was limited to an investigation of one agile methodology and two agile practices, which was deliberate to bound the study and to allow for close examination of two specific meetings and how they influence decision-making in agile teams. But, future research should investigate other agile methodologies and practices and how they

influence the decision-making process in agile teams, particularly complex projects where a large number of tasks are unknown.

Secondly, the study was also limited to specific types of decisions. We recognize that other types of decisions are made in the SPM and DSM and also outside these meetings, but these were not explored in this research, which is a further limitation and should be considered for future research. Thirdly, this study did not measure the quality of the decisions or the sprint outcomes. Future research should incorporate these measures to determine how the decision process affects outcomes. A potential avenue is examining factors that characterize successful information technology projects. These include factors such as a working system, user satisfaction, and improved efficiency[43], all of which seem likely to be tied to successful decision-making.

Fourthly, the views presented in the findings are solely representative of the teams studied at a point in time. Other research could examine additional teams, both co-located and distributed, or multiple teams within the same organization to investigate if similar findings are evident. Finally, the number of observations was limited in each of the cases studied, and the study may have benefited from additional observations over a longer period of time.

As this study was exploratory, it was not attempting to generalize the findings, but rather to present the uniqueness of each case and identify where there are similarities and differences across the teams studied. A limitation of the research design is the period of time in which the data was collected. As data was collected at a single point in time, this set a frame of reference for the study and reflected the perspective of participants during that time period[44]. Both interviews and observations have limitations, which are generally recognized in the literature. The researchers attempted to address these by following an interview protocol for each interview and observing each agile practice several times, capturing as much detail as possible during each observation and subsequently clarifying the meaning of certain events and behaviors to ensure that the researcher did not assign a particular (incorrect) meaning to an event as recommended by Corbin and Strauss[24].

Despite these limitations, the results of the study provide some interesting insights on the decision-making process in agile teams. Much agile research focuses on the positive aspects of agile methodologies[45-47], even when discussing agile challenges[5, 12] with little focus on difficulties that agile teams face in practice. Some research has begun exploring obstacles to agile decision-making, including conflicting priorities, lack of commitment, inconsistent resources and lack of empowerment[23]. This current study further contributes to agile research by examining whether agile teams use a RDM process during the SPM and DSM and identifying factors that influence decision-making during the SPM and DSM: sprint duration, experience and resource availability. From a project management perspective, it is important to understand the decision-making process in agile teams and the factors that influence the decision-making process in such meetings. This study highlights such factors and also contributes to the literature on how these meetings are implemented in four agile teams.

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Appendix

Table 5. Interview Protocol Excerpt.

This appendix details an excerpt of the interview protocol. The protocol included general demographics information such as years of experience with software development and agile methods, role, team size, team location, length of sprints, length of project, and agile method and practices used. Questions specific to decision-making included:
1. In a few short sentences, can you explain how your agile team makes decisions? a. During the SPM? b. During the DSM?
2. How do you decide your estimates?
3. How do you decide to whom to assign tasks?
4. How do you decide which tasks go in this sprint versus a later one?
5. What factors or issues prevent your team from making decisions during SPMs?
6. What factors or issues prevent your team from making decisions during DSMs?

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