International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

Using a coach to improve team performance when the team uses a Kanban process methodology

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Abstract:
Teams are increasing their use of the Kanban process methodology across a range of information system projects, including software development and data science projects. While the use of Kanban is growing, little has been done to explore how to improve team performance for teams that use Kanban. One possibility is to introduce a Kanban Coach (KC). This work reports on exploring the use of a Kanban Coach, with respect to both how the coach could interact with the team as well as how the use of a coach impacts team results. Specifically, this paper reports on an experiment where teams either had, or did not have, a Kanban Coach. A quantitative and qualitative analysis of the data collected during the experiment found that introducing KC led to significant improvement of team performance. Coordination Theory and Shared Mental Models were then employed to provide an explanation as to why a KC leads to better project results. While this experiment was done within a data science project context, the results are likely applicable across a range of information system projects.

Keywords:
project management; process methodology; agile; team performance; Kanban; Kanban process methodology.

DOI: 10.12821/ijispm070204

Manuscript received: 14 January 2019
Manuscript accepted: 13 June 2019

1. Introduction

Kanban, a process methodology that focuses on visualizing the flow and minimizing work in progress, is becoming increasingly prevalent within the software development community [1]-[6] and it has been shown to have a positive impact on software development projects [7]. For example, at BBC Worldwide [8], the lead time to deliver software improved by 37%, the consistency of delivery rose by 47%, and defects reported by customers fell 24% as compared to the previously adopted agile method. Its value has also been noted in other information system contexts, such as when used within a data science context [9]. More generally, it has been noted that Kanban offers improved project visibility, quality, team motivation, communication and collaboration [2], [10].

However, a key challenge in achieving the benefit from the Kanban process methodology is ensuring that the team understands and appropriately follows the methodology. For example, within Microsoft, it has been noted that some team members did not fully understand the process, and hence did not understand that they were not following the process [11]. More generally, it has been noted that some of the key challenges when teams use the Kanban approach was that the teams lacked the specialized Kanban knowledge and training, and hence, that there was often a misunderstanding of the core Kanban principles [2], [12]-[16].

One way to address this challenge of lack of knowledge is to leverage the concept of a process coach, which helps ensure the team understands and follows the process methodology. The process coach is often used within the agile Scrum methodology, with the role known as the “Scrum Coach”, which is a person who supports a team in achieving their specific goal by providing training, advice and guidance [17].

While research has shown the value of a Scrum Coach [18], the concept of a Kanban Coach (KC) has not been widely explored. While there are some new initiatives, programs and certifications on training Kanban Coaches [19], [20], there has not been significant research evaluating the effectiveness of KC, nor the appropriate scope of a KC. Hence, one potential area to explore, for teams using the Kanban methodology, is the role of a KC. Similar to a Scrum Coach, a Kanban Coach works to help ensure the team understands and follows the Kanban methodology (e.g., the number of work-in-progress tasks is not too high), and in general, supports and guides the team in their use of the Kanban process methodology.

It also should be noted that introducing a KC to a team using Kanban might not be positive. For example, there are no roles in Kanban [21], so it is possible that introducing a specific role could cause an issue and conflict with the general philosophy of the process methodology, in that adding a role to a process that does not have roles might make Kanban feel too process oriented or might suggest other roles, such as a team project manager that interacts with the KC. In addition, in terms of how the team interacts with the KC, it is not clear how the KC should interact with the team, since there are no required or well-defined meetings like there is in other agile techniques. Furthermore, the use of a KC might require extra work and/or costs that need to be justified. Finally, in terms of the scope of a KC, the role of a Kanban Coach might be different from the role of other coaches, such as a Scrum Coach, due to Kanban’s focus on the Kanban board.

To help explore the potential value of a Kanban Coach (KC), this research focuses on the following research questions:

RQ1. Do team members embrace the role of a KC?

RQ2. Does the use of a KC improve team performance?

We explore these research questions via an empirical study evaluating the impact of a KC within the context of data science teams that used, or did not use, a KC. The use of Kanban within a data science context has been shown to be of value. For example, via a controlled experiment, Kanban was shown to have a significant improvement over other methodologies, such as Agile Scrum [9]. While the study focused on data science teams, the insight gained should be applicable to other information system focused projects.

The rest of the paper is organized as follows. First, some background context will be presented. Then our methodology is presented, which is followed by our findings. Finally, a synthesis of our observations will be provided within our discussion and conclusion.

2. Background

We first explore the benefits of coaching within an agile context. We then review the Kanban process methodology and finally, summarize current thoughts with respect to Kanban roles and Kanban coaches.

2.1 The benefits of agile coaching

It has been shown that coaching is an effective technique: in multiple studies undertaken, investigating whatever mode of coaching, the conclusion was the same – people like to be coached and perceive that it impacts positively upon their effectiveness [22].

The benefits of agile coaching have been well documented [23]-[24], and agile coaching has become a prominent practice in the agile world [25]. Agile coaching can bring many benefits including better understanding of agile practices [24], better teamwork [26], higher product quality, and lower overall project cost [27]. For example, it has been reported that teams migrating to Scrum without coaching support increased their productivity by 35 percent, while those with coach support recorded 300 percent or greater improvement [28].

We define a coach as a person who supports a team in achieving their specific goal by providing training, advice and guidance [17]. Coaching differs from mentoring, in that coaching focuses on specific tasks and objectives, as opposed to more general, longer terms objectives [29]. Note that this coaching advice is context and team specific, so a coach might provide different advice and guidance to two different teams, based on the team's collective background, knowledge and current challenges. The coach can play multiple roles including teacher, facilitator, coach-mentor, conflict navigator, collaboration conductor, and problem solver [24], and as noted previously, based on the challenges encountered by a team, the coach will provide specific advice for that specific team.

It has been noted that gaining the knowledge to use agile techniques cannot be acquired solely through reading books or attending lectures [30]-[37], but rather, these skills also need to be taught through practical exercises and coaching [30]. Hence, it is not surprising that the adoption of agile methodologies can be significantly facilitated by the use of agile coaching [38].

While there are several Agile Software Development (ASD) process methodologies, the most popular ASD for information systems development is Scrum [39]-[41]. Scrum was created nearly 20 years ago and is a software development process for small teams [42], [43]. When using Scrum, there is a defined Scrum coach role, where that person is responsible for guiding the team through their project, specifically through their iterative steps, with an aim of improving their agile practices [44]-[48]. The coach attends all the Scrum meetings, but does not solve technical challenges [49]. Instead, a Scrum coach discusses the various challenges with the team, and in general, helps the team to reflect on what to do next [17]. In short, the Scrum coach, working as adviser, can help the team adapt the methodology to their situation [28]. Scrum coaches are often used, and in fact, the Scrum Alliance even has a certification program for Scrum coaches [25].

Finally, with respect to data science, there is no commonly accepted agile coaching role. For example, when discussing agile data science, Jurney provides a list of data science roles but does not include a coach [50].

2.2 Reviewing the Kanban process methodology

Kanban is Japanese for "visual signal" or "card" [51], [52]. Starting in the 1940s, Toyota line-workers used Kanban (with physical cards) to improve their manufacturing process. The system's highly visual nature allowed teams to communicate more easily on what work needed to be done and when. The idea of Kanban is based on focusing on "work in progress", in that the approach aims to streamline the amount of work done at the moment.

Kanban is sometimes thought of as an agile process [53] and, at other times, as a way to execute lean principles. Based on a systematic mapping study [1], the most common definition of a Kanban methodology is the definition defined by Anderson [54, p. 6]: an “evolutionary change method that utilizes a Kanban pull system, visualization, and other tools to catalyze the introduction of Lean ideas… the process is evolutionary and incremental”.

In the first academic study [52] about Kanban, three reasons for its use were proposed: reduction in information processing cost, rapid and precise acquisition of facts, and limiting surplus capacity of preceding shops or stages. More specifically, Kanban is based on three key principles:

- *Visualize the workflow* – Split the work into pieces; write each item on a “card” and put on the “wall” and using named columns to illustrate where each item is in the workflow. By creating a visual model of work and workflow, the team can observe the flow of work moving through its Kanban system. Making the work visible – leads to increased communication and collaboration.
- *Limit WIP* (work in progress) – Assign explicit limits to how many items may be in progress at each workflow state. By limiting how much unfinished work is in process, the team can reduce the time it takes for an item to travel through the Kanban system. The team can also avoid problems caused by task switching and reduce the need to constantly reprioritize items.
- *Focus on Flow* – By using work-in-process (WIP) limits and developing team-driven policies, the team can smooth the flow of work and make sure the team is focused on getting work completed.

Limiting the amount of work-in-progress (WIP), at each step in the process, prevents overproduction and reveals bottlenecks dynamically and is one of the key differences between a Kanban board and any other visual storyboards used within other methodologies.

2.3 Kanban roles and Kanban Coaching

Kanban does not prescribe any roles, rather, it requires the team to decide if there should be defined roles [55]. For example, Kanban recommends minimizing the cycle time, so if adding a role helps minimize the cycle time, the role can be added and if it makes the process slower, then the role should not be there [55]. Thus, a Kanban team can have a Kanban coach (a person who works as an adviser and can help the team leverage the methodology within their situation), or any other role, if that role is deemed useful for the team. Currently, as previously noted, there is not a lot of reported research on the value or even the use of a Kanban Coach [56]. However, it has been suggested that Kanban coaching can help to avoid failures with Kanban initiatives [57]. As suggested by Anderson [58], a KC could focus on discussing Kanban policies, visualization of the Kanban board, and metrics generated by the team. The role could help the team understand their capabilities and help them think about possible improvements [58]. Harzl [59] noted the presence of a Kanban coach, and it was rated very beneficial by all team members, but a clear definition of a KC and his/her responsibilities was not clearly defined.

2.4 Theoretical Background: Coordination Theory and Shared Mental Models (SMM)

In order to help understand why a Kanban Coach might improve the effectiveness of Kanban teams, we leverage Coordination Theory [60], in that we view that improved group work can be enabled via improved coordination between team members. In fact, it has been shown that improved coordination leads to benefits such as cost savings, shorter development cycles, and better-integrated products [61]. One way to improve team coordination, and thus, improve project work, is to have improved knowledge about dependencies between tasks and improved knowledge about tasks currently in progress. This follows other information system research that notes that teams will improve their performance by focusing on improving the team’s collective understanding of the dependencies between the tasks that the different group members are performing [62], as well by improving the team’s knowledge of what has been done so far [63], [64].

Coordination has been a long-standing interest of organizational scholars and computer scientists including [65]-[69] . One of the most common and concise definitions of coordination was proposed in [60] as “managing dependences between activities”. Furthermore, it has been noted that there several factors that impact the success of Coordination

Theory adoption, including empirical, theoretical and social factors [70]. In short, the more complex the situation, the more coordination is necessary. Thus, Coordination Theory is a suitable tool to study how the coordination of team members will be changed after introducing Kanban Coach. This complexity might be due to a large number of actors/tasks or where temporality is factor [71].

In addition to Coordination Theory, Shared Mental Models are also leveraged for this research. Shared mental models (SMMs) can help enable teams to interact efficiently in the tracking of progress towards team goals [72]. In fact, empirical studies have shown that shared mental models are of substantial benefit to both team processes and performance [73]-[75] and researchers have become increasingly confident that one of the keys to team effectiveness lies with shared mental models within the team [75], [76]. This is due to the fact that if a team has improved team knowledge, which is shared knowledge across the team, then that team can better prioritize the work that needs to be done.

SMMs can be useful in improving team knowledge about dependencies between tasks and improved knowledge about the currently in progress tasks. An earlier study [61] noted two types of team knowledge: (a) shared knowledge of the task, and (b) shared knowledge of the team. A more recent model [77], expanded this view into four team knowledge categories, which are described as follows:

- *Task related knowledge* includes shared understanding about the content of the task, how the parts of the tasks interact, and how a task is connected to its environment. It also includes shared understanding about how a task is supposed to be accomplished by the team so that a sufficient level of performance can be achieved, and how task work is allocated to members.
- *Team-related knowledge* includes team members' knowledge, skills, attitudes, preferences, and tendencies. It also includes shared knowledge of where expertise is located and where it is needed.
- *Process-related knowledge* includes shared understanding of team processes such as communication, leadership and coordination. It also includes shared expectations of how to behave (norms) and useful patterns of action.
- *Goal-related knowledge* includes shared understanding of the goals, visions, and overall agreements pertaining to the team's work. Such goals are mental representations of the overall goal or mission for the team, its performance objectives, and also strategic goals for the organization.

Thus, taken together, we hypothesize that a KC can improve the coordination of a team via the use of SMMs.

3. Methodology

To evaluate the impact of a Kanban Coach on a Kanban team, a controlled experiment was conducted within a graduate level Introduction to Applied Data Science course, where teams that had a KC were compared to those that did not have an assigned KC. The aim of the study was to understand if a KC was helpful for the team. Specifically, during a 10 week student project, teams of 5 to 7 students analyzed a realistic, but not real, dataset of customer survey responses, within the context of a global hotel chain. Even though this was a student project, the project was designed as realistic as possible, which is a best practice when using students to understand how teams work in industry [9], [36], [78]. In this course, the students acted as consultants, with the class instructor acting as the client. The goal for each team was to obtain valuable actionable insights from the data analysis and present those results to their client.

The dataset contained approximately three million responses and each response contained information about the person who responded to the survey (ex. place of residence, a member of their rewards program, and if so, what level), information about the hotel (ex. location) and information about the responses to the survey from the customer who stayed at the hotel (ex. would they recommend the hotel to a friend). The goal of the project was to utilize data mining techniques to predict guest return probability through identification of key drivers/factors that could improve customer satisfaction (ex. room tranquility or customer service).

3.1 Experimental conditions

The students were randomly assigned to teams for the project. Each team was then randomly assigned to either have, or not have a KC. Specifically, students were randomly assigned a class section. The team members for a project were all from the same section and all the teams in the section either had a Kanban Coach (the "KC" condition), or did not have a Kanban Coach (the "noKC" condition).

Across both conditions, at the beginning of the semester, the Kanban methodology was introduced and explained to the teams (almost all students had no previous experience with Kanban). Specifically, all team members were provided training on how to use the Kanban process including the overall Kanban methodology and the key points of focus when using Kanban (e.g., limit work in progress, visualize the flow). In addition, the online Kanban board (trello – a web-based Kanban board) was demonstrated and it was explained what kinds of tasks were expected to be placed on the board. As per the typical Kanban process, the teams were instructed to work through their project pipeline throughout the project with no defined schedule. The goal was to make sure that there was not a lot of time spent on an effort that was not completed (it was better to get a fewer number of tasks all the way through the pipeline). It was required, across both conditions, that the teams use the online Kanban tool and that they keep their Kanban board up-to-date and hold at least weekly team meetings. Time for questions with respect to how to use Kanban was provided for all teams, and throughout the semester, if students had additional questions, they were able to reach out to a TA for the class (who had knowledge of the Kanban process).

In addition, for teams in the KC condition, a Kanban Coach was assigned to each team (one KC covered more than one team), and those teams were provided with a clear process of how to work with their KC. The KC was a TA for the class who had knowledge and experience using Kanban. To facilitate the discussion between the team and the KC, teams in the KC condition were required to use a special first column on their Kanban Board, labeled "proposed". Specifically, the teams put suggested tasks in the "proposed" column, and the KC would then move those tasks to the "to do" column (i.e., the next column on the board). Only the KC moved tasks from "proposed" to the "to do" column. This helped to provide a structure such that the team could easily get feedback from the KC, and the team (and the KC) could ensure that the task was appropriate and well defined. Then, as with teams in both conditions, when someone was ready to work on the task, that task would then be moved from the "to do" column to the next appropriate column. The Kanban Coach mainly interacted with the team via the Kanban board, typically once or twice a week. More generally, the KC focused on:

- Providing feedback via the board (ex. the moving tasks from the "proposed" column);
- Making sure a team used an appropriate level of granularity for the tasks (ex. not too broad or too specific tasks);
- Reviewing progress since last update (via reviewing the movement of the tasks on the board);
- Encouraging the team to make sure the Kanban board is up-to-date.

In summary, teams in the KC condition had a structured communication mechanism to communicate with the KC, via the "proposed" column.

3.2 Data collection

To evaluate the impact of the KC, we compared the effectiveness of the teams that had a KC to the teams that did not receive the coaching (i.e., the noKC teams). Following a case study best practice from Eisenhardt [79], multiple data sources were used. We focused on qualitative data (from the instructors and the students) as well as quantitative data (board quality, progress on the board, as well as the final project quality). We discuss each of these in more detail below.

First, in terms of the quantitative data, an evaluation of the Kanban boards generated during the project provided a leading indicator with respect to the quality of the project. Specifically, there were three evaluations of the boards during the project. The first evaluation was three weeks after the project started, the second evaluation was one month later, and the last evaluation was two weeks before the end of semester.

The boards were evaluated according to the following criteria, with each criterion being scored on a scale of 0 to 5:

- *Board Quality* - this metric was calculated by examining key aspects of the board, such as whether teams were minimizing their work-in-progress, if there enough tasks on the board to keep the team busy and if the tasks were described in a reasonable manner.
- *Board Progress* – this metric captured the amount of progress, as shown on the board, that the team had made from the previous update (i.e., were there enough tasks being created and "moving through the pipeline").

In addition, a *final project evaluation* was also performed, with a score ranging from 0 to 20. The final project evaluation criteria were not focused on the use of Kanban, but rather, the quality of the overall analysis. So, for example, a key aspect of the grading rubric included the quality of the actionable insight generated. The Kanban board evaluation was conducted by two annotators and the final project was evaluated by three independent reviewers. For these evaluations, there was a high degree of agreement between the reviewers and any differences of opinion were identified, discussed and resolved.

In terms of qualitative data, *instructor observations* provided insight into how effectively the teams were working together, as well as the group dynamics within the team. For example, during each lab session, the instructor observed the student teams and documented and reflected on those observations via answering semi-structured questions. The observations focused on the perceived satisfaction, productivity and cohesiveness of the team members. In addition, at the end of each semester, a semi-structured *student survey* was distributed to each student to explore their perceptions with respect to the methodology that they used. The key question to the students was a neutral stimulus: "What were the advantages / disadvantages of using the Agile Kanban process methodology?" Students in the KC condition were also asked about their use of the proposed column and their interaction with their KC. The qualitative data was analyzed via an iterative process of item surfacing, refinement and regrouping.

4. Findings

331 students participated in the study across 59 teams. Of those 331 students, 206 were in the KC condition (in 39 of the 59 teams studied) and 125 in noKC condition (in 20 teams). Thus, the average team size was 5.3 in the KC condition, and 6.3 in the noKC condition. Across both conditions, the students had a diverse set of undergraduate degrees, ranging from chemical engineering to business. The students also had diverse geographic/cultural backgrounds, with students gaining their undergraduate degree from Asia, Europe and North America. In fact, while all the students attended the course in a face-to-face format in North America, the majority of students had previously been educated outside of the United States. In addition, forty percent of the students were female. Finally, the majority of the students had two to five years of work experience, typically within the IT industry, thus supporting the notion that these graduate students were a good proxy for junior level staff within a corporate context.

4.1 Board and project evaluation

The impact of a KC on the quality of the Kanban boards and the progress each team made (via an analysis of the progress of their Kanban board) was evaluated using independent sample t-tests, the results of which are shown in Table 1. Specifically, there was a significant difference in the board quality with a KC ($M=4.84$, $SD=0.3$) and with no KC ($M=4.2$, $SD=1.07$) conditions; $t(20)=2.6$, $p = 0.008$. In addition, there was a significant difference in the board progress with a KC ($M=4.14$, $SD=0.79$) and with no KC ($M=3.48$, $SD=0.86$) conditions; $t(36)=2.85$, $p = 0.004$. Furthermore, there was also a significant difference in the final project evaluation with a KC ($M=18.25$, $SD=1.6$) and with no KC ($M=16.43$, $SD=2.0$) conditions; $t(57)=3.78$, $p = 0.0002$.

This shows that introducing the KC role helped to improve the teams' overall performance as well improve the leading indicators of team performance (board quality and progress).

Table 1. Comparing KC vs noKC using an independent sample t-test

Statistic	**Board Quality (KC / noKC)**	**Board Progress (KC / noKC)**	**Final Project Evaluation (KC / noKC)**
Means	4.84 / 4.2 (5 is highest score)	4.14 / 3.48 (5 is highest score)	18.25 / 16.43 (20 is highest score)
Variances	0.09 / 1.15	0.62 / 0.73	2.58 / 4
Standard Deviation	0.3 / 1.07	0.79 / 0.86	1.6 / 2
Observations	39 / 20	39 / 20	39 / 20
Hypothesized Mean Difference	0	0	0
df	20	36	57
t Stat	2.6	2.85	3.78
P(T<=t) one-tail	0.008	0.004	0.0002

4.2 Perceived differences across the conditions

In analyzing student comments and the instructor observations, three key themes emerged for teams that had access to a Kanban Coach as compared to those teams that did not have access to a Kanban Coach (systematizing work, clarity of objectives, required time). We discuss each of these below, integrating comments from students with the instructor observations.

Improved Ability to Track Progress: People in KC condition much more often reported that the Kanban methodology helped them systemize their work and structure their knowledge. For example, one student noted that “It helped to keep a track of progress, and move [us] ahead with the project in a systematic manner”, another noted that “This process kept everything organized” and yet a different student commented that “It’s easy to organize new tasks as well as add notes when we are doing discussions”. Finally, yet a different student noted that “[it] helped to keep a track of the activities to be performed and so, in a way, helped in planning during the project”. This was re-enforced by the instructor observations, such as one instructor that noted “the teams seemed much more organized when they had access to a KC”.

Clarity of Objectives: Multiple teams in KC condition noted that the methodology helped to make the project objectives clearer. For example, one student commented that “we have a clear understanding of what were our research objectives and what activities we needed to perform to reach that objectives”, and another stated that “it [the process when using a KC] made us segment our work, have clear objectives and coordinate team effort”. This clarity of objectives might have been driven by the fact that the instructors perceived that the students in the KC condition both understood and followed the process better, as suggested by one instructor who noted that “the more focused feedback [by the KC] encouraged the students to be more focused on ensuring that they adhered to the process methodology”.

Improved Efficiency in using Kanban: It is interesting to note that only the noKC teams stated that they thought that their methodology was time consuming. This included comments by students in the noNC condition such as “[it was] time consuming to update and maintain [the Kanban Board]”. This suggests that the KC helped the teams be more efficient in the use of the Kanban process and also helped the team understand the value of the process (and thus, they thought the time discussing the Kanban board, for example, was time well spent). This was perhaps due to some noKC teams using Kanban as a way to communicate to the instructors, as explained by one instructor “some of the teams in the noKC condition sometimes seemed to use the Kanban process as a reporting mechanism to me, rather than using Kanban as a project management process that I could observe”.

4.3 Perceived similarities across the two conditions

There were also three themes (project efficiency, clear responsibilities, team collaboration) that were noted across both conditions, below we review these themes.

Project Efficiency: Many students noted a perceived increase in team efficiency. For example, one student in the KC condition noted that the "main advantage of this process is saving of time and it also helps us to improve our efficiency". Other students also noted that Kanban improved efficiency, such as a student (in the KC condition) who stated that "[it] also made it easy to manage the class project and proved very helpful in improving the overall productivity and work efficiency" and, by a student in the noKC condition who stated that "Kanban offers a systematic approach to identifying opportunities for improving efficiency".

Clear Responsibilities: Some students stated that they liked their process methodology because it provided a clear view of who is contributing in the team, such as a student in the noKC condition who stated that "…it also holds accountability among group members". Students also felt that it became more clear who was responsible for each task, such as a student in the noKC condition who noted that it "allows us to track which individual is responsible for which task" (noKC) as well as from a student in the KC condition who reported a similar thought via their comment of "it's very important to track the progress of the project life cycle and for keeping team aware of the tasks and responsibilities".

Team Collaboration: The ability for the team to collaborate was highlighted by both conditions, but was noted more frequently by teams that had access to a KC. For example, a student in the KC condition noted that Kanban has "flexibility and [makes it] easy to collaborate". Other similar comments included that "collaboration between team members was easy" by a student in the KC condition, and via a student in the noKC condition, who noted that "I think this project management… can boost the efficiency and communication within a group".

5. Discussion and Conclusion

Qualitative student feedback, reviewed in Section 4.2, makes it clear that team members embraced the concept of a KC. Furthermore, the quantitative analysis, in Section 4.1, shows that introducing the KC improved the teams' overall performance as well improved the leading indicators of team performance (board quality and progress).

To explore why the KC was useful to the Kanban teams, we leverage coordination theory and shared mental models, which were described in Section 3 and provides a foundation to help understand the impact of a Kanban Coach. Specifically, leveraging coordination theory and SMMs, a Kanban Coach was helpful because the KC helped to improve the team's coordination via an improved shared mental model of process related knowledge (i.e., knowledge of the Kanban process) as well as the team's task-related knowledge (i.e., knowledge of the tasks the team were actually doing). This improved task-related related knowledge is a result of the team's more effective use of the Kanban process, which provides a visual view of the work in progress. The model in figure 1 explains how a KC improves project outcomes.

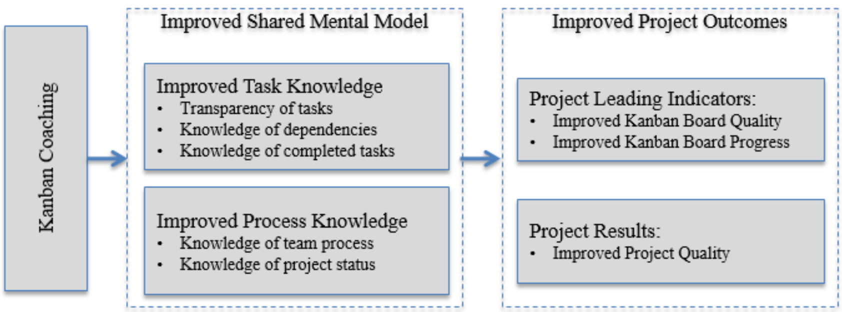

Fig. 1. Model explaining how a KC improves project outcomes

Thus, as shown in Figure 1, a Kanban Coach helps a team improve their project outcome by creating an improved shared mental model of task and process knowledge. In short, the team's coordination improved via improved knowledge of what tasks are in progress, done and need to be done.

5.1 Reliability and Threats to Validity

There are several threats to the validity with respect to our results. First, some teams might consider having a new aspect to the methodology as being helpful, independent of that enhancement's actual value [80]. To help mitigate this potential issue, the students did not know if having access to a KC was a new capability within the methodology. Furthermore, students did not get specific credit for correctly using "proposed" column.

With respect to selection bias (participants might have been selected who have certain characteristics that predispose them to have certain outcomes), this potential bias was eliminated due to the fact that the class was randomly split into teams, and teams were randomly selected to have, or not have, a Kanban Coach.

An external threat to validity is the generalizability of our findings (e.g., generalizing the in-class experiment to an industry context), such as when a researcher generalizes beyond the groups in the experiment to other groups not under study, or to settings not studied [80]. In fact, the generalization of student results to industry has been often questioned [81]-[84]. One key issue, with respect to generalizing student results to industry is that sometimes in-class tasks are not representative of typical industry tasks, and therefore, the results of an in-class experiment might not transferable to industry [83]. However, this research had students work on a 10-week project that was representative of tasks that one would do within an industry context. Furthermore, it has been noted that classifying experimental subjects (students) by their status (experience or being a student or worker) is a proxy for a more important and meaningful classification, specifically classifying the subjects according to their abilities, and effort should be invested in defining and using these more meaningful classifications [85]. This research leveraged graduate level students with an average of three years IT experience. Thus, while using students as subjects is threat to validity, we view these subjects as a reasonable proxy for junior level employees.

Finally, this study focused on a data science project, and hence, it is possible that generalizing to other domains, such as software development might not be appropriate.

5.2 Potential Next Steps

Even though previous research has noted that students are a good proxy for junior team members and can be viewed as the next generation of professionals, and hence, are suitable subjects for information systems experiments [84], since this experiment was conducted within an academic setting, it is possible that the results might be different within an industry setting and thus one next step is to evaluate the impact of a KC within an industry project.

In addition, as previously noted, it is not clear if the results from this experiment, which focused on a data science project, are applicable to other domains. In other words, it is possible that other projects, such as software development, might yield different results. So, another next step is to explore the benefit of a KC within other project contexts, such as software development. Yet different avenue to explore could be that, rather than using a Kanban Coach, one could consider the use of a Kanban Master (KM). In contrast to the KC, a KM would attend all the teams' meetings and would be thought of as a key member of the team, not an advisor to the team.

Furthermore, Design Thinking, which is generally defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign [86], could be an interesting avenue to explore. For example, agile methodologies such as Kanban can be viewed from Design Thinking perspective. Thus, exploring how to improve Kanban via a Design Thinking framework might provide new ideas and insights, since this approach has recently applied to agile methodologies [87].

Finally, in this study, a proposed column was used as a way to facilitate communication between the KC and the team. A future area of research could explore other mechanisms to facilitate/improve the communication between the KC and the team, as well as how the proposed column itself could play a role in improving the teams' performance, independent of a KC. For example, one avenue to explore is if the proposed column could be used even without KC to improve the team's internal communication with respect to collectively deciding on which tasks are appropriate to be prioritized by the team.

5.3 Conclusion

While the use of a coach has proven to be useful in many contexts, including agile scrum, to date, there has been minimal research exploring the effectiveness of a coach within a Kanban context. This paper addresses that gap by investigating the impact of a coach within data science teams that use Kanban.

To address our first research question (*do team members embrace the role of a KC*), we evaluated qualitative team member feedback for the students that had access to a KC. The feedback suggests that the teams did indeed embrace a KC, in that the team members thought that the KC helped them improve their collective ability to track progress, ensure there is a clarity of objectives, and be more efficient in the use of the Kanban process. This suggests that the team members (students) did perceive their interactions with the KC as being helpful. To address our second research question (*does the use of a KC improve team performance*), a quantitative analysis was conducted across the two conditions (teams with, and without, a KC) and it was found that introducing a KC did indeed lead to an improvement of the team performance (grades) and as well as a leading indicator of project performance (i.e., board quality).

This research makes several contributions to the field. First, the coaching role was introduced within a Kanban context. In particular, a definition of KC was provided and the responsibilities of a KC were explained. Second, the use of the proposed column, which defines a paradigm specific to Kanban for establishing a structured way for teams to communicate with the Kanban Coach, was defined. Third, an in-class experiment demonstrated that the KC role was indeed helpful. Fourth, coordination theory and shared mental models were leveraged as a theoretical foundation to help explain why the KC was helpful. Finally, this research also provides some additional context on why Kanban is useful, as some key themes (such as improved collaboration) were noted across teams that had the KC as well as teams that did not have access to the KC.

Thus, there are both theoretical and managerial implications of this research. From a theoretical perspective, this research demonstrates how coordination theory and can be integrated with Shared Mental Models to provide a theoretical foundation to explore how process refinements can improve team outcomes. From a manager's perspective, this research suggests that organizations should use a Kanban Coach for their Kanban-based projects.

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