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Designing and Managing Agile Informative Workspaces: Discovering and Exploring Patterns

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Abstract

An Informative Workspace (IW) consists in the use of the workplace for displaying and using information on agile environments. Some authors have provided guidelines for designing and maintaining IWs, but few are based on more formal studies. This research aims to help understanding how to optimize the use of IWs on agile software development teams. We performed a study using a mixed method research approach based on action research, survey and interviews. Our results pointed out seven heuristics for designing and managing IWs, and concepts explaining "Why", "How" and "When" they apply. These heuristics and related concepts provide effective hints on how to use an IW.

1. Introduction

The core of agile software development is the use of light-but-sufficient rules of project behavior and the use of human and communication-oriented rules [1]. One highly effective means of emphasizing communication during the project life-cycle is displaying and controlling information in a team workspace, which is often stated as having positive effects on feedback [2], communication [3], coordination of tasks [4, 5], identification of current or potential issues [6], and collaboration between team members [4].

Several agile practices aim to display information in team workplaces, such as informative workspaces [7], big visible charts [6], information radiators [8], and visual controls for self-directed work [5]. In fact, these practices support many team processes, such as team behavior [9], team cognition [3], and work procedures such as choosing and maintaining metrics [6]. Building and maintaining Informative Workspaces (IW), therefore, play a central role in agile teams. At the same time, it is a challenging task, since it should reflect several different aspects.

Even with the initial guidelines of Beck [7] and Cockburn [8], there are still few IW guidelines based on empirical studies. In fact, most of them are based on anecdotal evidence from consultants. Software development teams can benefit from concrete and situation-specific guidelines to develop, understand and maintain useful IWs. Our research aims to fill this gap by performing an empirical study. Our research question is: "How can agile software development teams optimize the use of IWs?".

In a previous paper, we have identified seven heuristics for managing IWs through an action-research approach and evaluated them using a survey [10]. In the current paper, we extend these two phases as part of a whole study divided into four phases, using action-research, interviews and, finally a survey to generate and validate IW patterns and test their suitability in other contexts. We provide additional data to better understand why and when these patterns are useful, and how to apply them.

The remainder of this paper is organized as follows: Section 2 presents some background concepts regarding informative workspaces. Section 3 describes our research question and the research methods used. In Section 4, we present the patterns that emerged from interviews, relating each heuristic to the questions "Why", "When", and "How". We also present the survey results. Section 5 discusses the results and limitations, and finally Section 6 presents our main conclusions and future work.

2. Informative Workspaces: concepts and design issues

Informative workspaces are acknowledged as a concept developed in the context of agile methods [11], and it is described as a practice in Extreme Programming [7], similar to the concept of information radiators in Crystal Clear [8]. IWs aim to provide an effective feedback mechanism for agile teams [11], including information accessibility [12] and visibility [2]. IWs can take the form of visual displays,

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Information Radiators [8], which are manually updated by the team, or electronic devices, such as lava lamps or audio signals linked to automated processes [13]. These implicit cues provide context and easily accessible information to the whole team [14], informing them of progress of their peers and important information [15]. Moreover, IWs support many agile practices such as stand-ups, pairing and collective ownership.

Recent research explores the underlying IW role in agile teams [16, 17, 3, 9, 15]. The main results are summarized in Figure 1, showing IWs key role in agile teams. We describe them as follows.

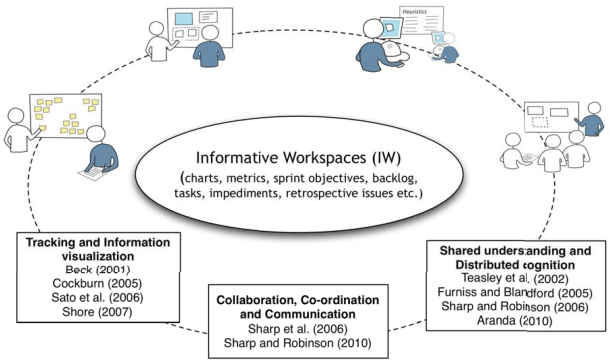

Figure 1. Informative workspaces (IW) as an important agile tool

Tracking and information visualization. One of the most important goals of IWs is to support an accessible and easy-to-read project tracking. Beck [7] claims that an interested observer should be able to walk into the workspace and get a general idea of how the project is going in 15 seconds, denoting rapid feedback as an IW requirement. The observer should be able to get more information about real or potential problems by looking more closely [7]. Cockburn [8] describes a set of artifacts known as *information radiators*, which is a "display posted in a place where people can see it as they work or walk by".

Poppendieck & Poppendieck [5] claim that it is a good idea to make progress visible both to the development team and to the customer.

IWs in general are designed from charts, product and project metrics, sprint objectives, backlogs, tasks, impediments, and retrospective issues. The team is surrounded by information [12]. Several authors [6, 5, 8] support the use of different metrics in IWs as an important means of "gently and non-coercively communicating the need of a change". Beck [6] defines a specific role of the *tracker* as someone who manages metrics on Extreme Programming teams. The *tracker* is responsible for gathering whatever metrics are being tracked at the moment and making sure the team is aware of what was actually measured. Beck [6] also notes that this tracking needs to occur without high overload (denoting importance to practicality on these role responsibilities). Sato et al. [9] analyzed seven agile projects from both academic and governmental environments from the tracking point of view. They relate many tracking activities to IWs, showing the importance of information tracking and spreading through IWs. For instance, retrospective results can be posted in the workspace and worked as an important guideline to drive the team in the right direction.

Collaboration, Coordination and Communication. Recent studies [16, 3] have found that story cards and "the Wall" play a critical role in supporting collaboration, coordination, and communication in agile teams. They related their findings to *distributed cognition* theory and principles [18] such as *Space and cognition*, *Situation awareness*, *Horizon of observation*, *Information movement*, *Information transformation*, and *Representation-goal parity*. They emphasized the importance of human cognition in team workplaces, and its relation to IW management, usability, and team layout. Finally, Sharp and Robinson [16] conclude that agile teams rely on story cards and the wall, and their ability to collaborate, coordinate and communicate effectively is dependent on them. Changing or removing any of these practices or artifacts needs to be done with full knowledge of the consequences of such changes [16].

Shared understanding and Distributed cognition. Aranda [15] defines a theory of shared understanding as the key to explain the problems and solutions of coordination and communication in software organizations. Coordination among participants in a situation consists of sharing and negotiating an understanding of their goals and plans. Communication among participants in a situation consists of sharing an understanding of their status and context. IWs help teams to share project status, foster synchrony and, consequently, support team's shared understanding. Sharp et al. [17] related IWs and story cards to explain shared understanding. A card's absence from the wall signifies the acceptance of responsibility, and its corresponding presence in a workstation signifies that the act of coding the negotiated, shared understanding of the story is in progress.

Other studies [3, 4] have applied distributed cognition theory for analyzing collaborative work and the information flows within and around teams. Distributed cognition is a theory that views collaborative work as one cognitive system [3]. They conclude that IWs are not only important, but crucial to the agile teamwork. Sharp and Robinson [4] explain IWs and story cards as physical objects working in a sophisticated and complementary manner, whose physical nature is significant in underpinning the highly collaborative and self-organizing style of agile teams.

2.1. IW design issues

Managing IWs involves several decisions, such as choosing which information to display, which frames and board layouts to use, colors and pictures to be used, helpful artifacts (e.g., post-its, lava lamps, monitors), and frame and board positioning. Cockburn [8] provides some guidelines to design an effective information radiator. It should be large and easily visible to a casual interested observer; must be understood at a glance; changes periodically, and is easily kept up to date.

However, different issues underlie IW management decisions, such as team adaptability, continuous reflection, workspace layout, human cognition, usability, self-directed work visual controls, amount of displayed information, and project specific characteristics. Based on these different concepts and variables, maintaining an effective IW becomes a very challenging task. Our work aims to generate empirical evidence to help teams to design and manage IWs more effectively.

3. Research design

We aim to investigate the research question "How can agile software development teams optimize the use of informative workspaces (IWs)?". This main question can be divided in two sub-goals: i) discovering patterns for designing and managing IWs based on agile development experiences data, and ii) exploring pattern usefulness. To answer this research question, we performed a two-year study divided into four phases, adopting a sequential mixed method approach [19]. Figure 2 summarizes our research phases. We describe the environment and each phase as follows.

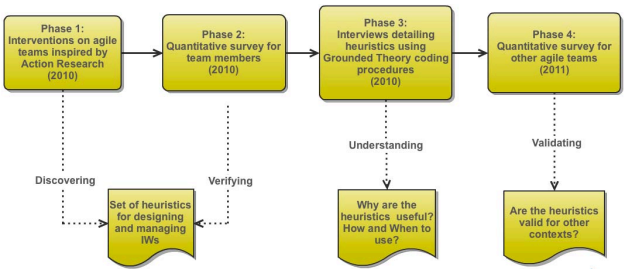

Figure 2. Research design

3.1. Environment

Our research was performed in two different environments, both from a set of agile projects developed in the Extreme Programming Lab course held at the University of São Paulo in 2010 and 2011. In the first three phases, our subjects were eight agile projects in a classroom of students (undergraduate, master's, and PhD students) in 2010. In the last phase, our subjects were students of a 2011 class. All teams (2010 and 2011) developed open source projects using agile methods techniques.

The 2010 class configuration. Teams had at least one experienced member playing the role of *coach*. Coaches were responsible for helping their teams apply agile techniques correctly in the software development. There were also experienced agile consultants called *meta-coaches* supporting all teams, especially their *coaches*. They were responsible for helping coaches and team members with advanced questions regarding agile software development. One researcher played the *meta-tracker* role in the lab. The *meta-tracker* was responsible for helping teams to better design and manage their informative workspaces by giving suggestions throughout the projects' development. We explored all *meta-tracker* interventions and subsequent actions in the first research phase (see Section 3.2).

The 2011 class configuration. The environment of 2011 was similar to 2010; however, there was no *meta-tracker* role, which was important for the last phase of our research, as described in Section 3.4. The vast majority of team members in 2011 class environment were not involved in 2010 configuration, although there were some exceptions.

3.2. Phases 1 and 2

Phase 1 aimed to discover, through cycles and interventions, a set of heuristics for IW designing and

management. One researcher played the *meta-tracker* role, and he was empowered to observe, suggest, monitor and pose questions regarding all the team's IWs. The research method was inspired by participatory action research (AR) [20], in which researchers and team members collaborated to design, test and learn IW heuristics. We chose action research because it aims to solve current practical problems while expanding scientific knowledge, and it is strongly oriented toward collaboration [20]. The *meta-tracker* followed each team to understand which actions were useful to design and manage their IWs according to each team's context.

We collected data from each project over a period of six months. Our unit of analysis was the project. Considering the cyclic nature of Action Research [20], each project had its own number of learning cycles. Table 1 summarizes the projects with a brief description, the number of team members and the number of action research cycles.

Project name	Description	# of Team Members	# of AR cycles
Archimedes[1]	Eclipse's plug-in for CAD processing	6	3
Atletismo[2]	Monitoring software for athlete training	6	5
Baile[3]	Basic software utilities based on Web services	5	3
Calopsita[4]	Agile projects administration software	6	5
CoGrOO[5]	Web interface for Portuguese spell check software	6	4
Dojo On-line[6]	Web software to perform Dojo conferences	7	3
Ingresso na Pos[7]	Graduate admissions management	6	2
Mezuro[8]	Web platform to support two other metric tools	6	3

Table 1. Agile open source projects studied in 2010

The *meta-tracker* scheduled several meetings with the development teams. The meetings were informally arranged approximately every fortnight, depending on team availability. In each meeting, we arranged an informal talk and followed a simple cyclic procedure:

1. Talk informally to the team in order to understand their current context in general (not only about their IW);
2. Identify issues that could be handled by the use of IWs or opportunities for IW improvement;
3. Transcribe summary of issues;
4. Intervene, making suggestions on how to handle each issue using the team IW;
5. For each suggestion, collect feedback after awhile, and transcribe it.

We collected and transcribed data on a regular electronic spreadsheet. We tracked each suggestion using a classification scheme. A suggestion status could be: "Positive", "Negative", "Undetermined" or "Not implemented". This evaluation was mostly qualitative, based on the team opinion. Thus, we clustered similar suggestions with similar rationales, and chose the ones considered as the most relevant (based on the 'Positive' feedback comments), to better evaluate in the research Phase 2.

Phase 2 aimed to verify whether the proposed heuristics were, in fact, valid in the given environment. For this purpose, we developed an electronic survey and invited all team members to answer it anonymously. This was important to triangulate the data collection method and, consequently, reinforce Phase 1 results. The survey contained questions evaluating each heuristic usefulness from the team member's point of view, each one scored on a 5-point Likert scale. We also prevented undesirable opinions from respondents who did not apply certain heuristics by adding filtering questions. The survey protocol is available in [10].

3.3. Phase 3

Once we found patterns for designing and managing informative workspaces, the next step was to explore pattern usefulness and applicability. After the 2010 course, we conducted semi-structured face-to-face interviews with six team members. Each interview lasted approximately one hour, and the interviewees were informed of being recorded.

We chose team members from different teams, primarily coaches. We gave priority to coaches since they were responsible for the welfare of projects, team members and customers, and this responsibility could have led them to a more comprehensive view compared to other roles. We developed an interview protocol to guide the interviews containing a list of topics to be addressed, each topic covering at least one heuristic. The main goal was to understand how and why the participant evaluates the usefulness of each heuristic. One researcher performed and transcribed all interviews. The research team members used a Grounded Theory approach [21] to analyze the data. However, our main goal was not to develop a new theory - which is the Grounded Theory's main purpose. Nevertheless, Grounded Theory defines a coding procedure that is a useful tool for gathering concepts and their relationships. Therefore, we used only part of the Grounded Theory's [21] coding procedure,

applying open and axial coding steps. In Section 4, we present the main concepts, relationships and exploratory sentences that best explain our IW heuristics.

3.4. Phase 4

In order to reinforce the heuristics proposed in Phase 1 (in the 2010 environment), in Phase 2, we applied a quantitative survey in the same environment. Phase 2 data was useful to confirm the importance of heuristics identified in Phase 1 by our action-research approach. However, Phase 2 data does not provide any guarantee that this set of heuristics would be useful in other projects and contexts, although this environment already had eight agile development teams and not only one or a couple.

The participative approach of Phase 1 provided us with insights to gather and propose this set of heuristics. However, we should not underestimate our influence on the environment, which is already expected in the action-research method, but may have affected team members in the evaluation of these heuristics. In order to decrease our influence in the results, and also to validate them in a different context, we decided it would be useful to perform a heuristic evaluation in another environment. Thus, we invited all team members in the 2011 class to anonymously answer the same survey on IW heuristics we applied in 2010. The difference now is that we did not have any kind of influence on 2011 environment. In Section 4, we present the survey results, comparing them to the 2010 results.

4. Results

We describe below results from our four-phase study, providing qualitative and quantitative evidence that supports the main findings.

4.1. Discovering heuristics and initial evaluation (Phases 1 and 2)

In Phase 1, we identified several useful patterns regarding IW design and management, based on action-research interventions and on the experiences of development teams. We represented our findings in the form of heuristics following a similar strategy used by Hartmann & Dymond's [22] to explain best practices for agile metrics and diagnostics.

In Phase 2, each heuristic was related to one survey question, which evaluated how useful a heuristic was during the respondent's project development. The overall response rate achieved by the survey was 62.5% (30 respondents out of 48). Table 2 summarizes each heuristic and survey responses.

In Table 2, we describe the percentage of participants that experienced the idea of each heuristic (ex. Divided IW related work between all team members, performed IW related tasks in pairs, etc.) and how they evaluate the usefulness/importance of these experiences in their projects by the 5 point Likert scale: Very Low / Low / Regular / High / Very High.

Heuristic	Experien-ced	Very Low	Low	Regular	High	Very High
# 1. Keep the most important frames/boards near the daily meeting place	100%	0%	7%	7%	53%	33%
# 2. Divide IW related work between all team members	80%	0%	3.7%	8.8%	58.8%	28.7%
# 3. Focus IW on specific current issues	90%	0%	0%	22.2%	59.3%	18.5%
# 4. Display information taking into account human brain assimilation	100%	0%	0%	20%	37%	43%
# 5. Make your daily IW tasks performed by a pair of team members	90%	0%	18.5%	33.3%	40.8%	7.4%
# 6. Provide an easily-maintainable and practical IW	100%	0%	3%	10%	50%	37%
# 7. Remove less valuable frames/boards from the IW	87%	0%	0%	26.9%	38.5%	34.6%

Table 2. Seven IW heuristics and survey results

4.2. Understanding IW heuristics (Phase 3)

In Phase 3, we interviewed six team members (five coaches and one team member) aiming to explore our set of heuristics. In each interview, we required that each participant express his opinions using questions such as: "Did you considered it useful/important on your project? Why? When?".

We used the open coding procedure to identify concepts from the interviews data and related those using axial coding [21]. The analysis outcome is the relationship between the concepts behind each heuristic and their related dimensions, trying to answer questions such as "why", "how", "when" should a team adopt the heuristic. We also describe a list of explanatory statements in order to explain these relationships. The concepts we found are shown in brackets in their pure form, so they can be associated with the complete results[1].

[1] Raw data is available at http://www.ime.usp.br/~renan/tracking

4.2.1. Heuristic 1. Keep the most important frames/boards near to daily meeting place. First, keeping important frames/boards near to daily meeting place could be important because it is [valuable in daily meeting], it could help with [communication during the meeting] and in [meeting dynamics].

Having them near could also improve their use as a [memory tool] for relevant information during the meeting, which could involve [daily matters]. During the meeting, this design can also improve [information awareness], [situation awareness] and thus improve the [impact of information].

Providing this design could help the team to give [attention to information] and to [consider information], that could lead them to [account matters], both [during the meeting] and [during the working day].

In applying such a design for frames/boards, it is possible to perform an [update during the daily meeting], which could increase [information awareness] for team members. [Workspace constraints] should be considered in applying this IW design, and could demand [adaptability] in the team behavior and [changes in physical layout].

4.2.2. Heuristic 2. Divide IW related work between all team members. Dividing IW related work could be important to [IW related learning] when you have [beginners in agile development]. This heuristic could also help in [choosing useful information] to display in the IW, given that it could improve the [discussion about frames/boards]. This division can also improve [attention to information] and [information reflection] of the team members.

There were cases when having an [individual IW tracker] led to an [unsatisfying IW tracking], since it lacked [information awareness] by team members.

There are some means of applying this heuristic, such as [rotating members for IW update], which could specifically improve [IW related learning], but could have restrictions for [carrying ideas] and [propagation of information meaning]. It is also possible to have [all members in IW update], which can help the team in [understanding information] and could make [pairing in IW related tasks] unnecessary.

Having [all members in IW update] could be affected by heuristics such as having [proximity of frames to the daily meeting place], since the daily meeting occurs in a place where all team members are gathered. Diving IW related work between all team members could also be affected by [collective interest in IW management].

4.2.3. Heuristic 3. Focus IW on current specific issues. Using IWs for handling specific current issues could help on [evincing issues], and it could promote [directed work], given that it could promote giving [attention to information].

Maintaining this kind of information could also promote [interest in information updates] between team members, which could be used to [remind about issues]. Having information about specific issues displayed in the workspace can be used as [visual issue control], to a point of being claimed as [information disturbance] in some cases. Choosing [measurable information] seems to help [track information].

There were cases where IWs were not used for handling issues and coaches declared contexts of [permanency of issues].

This approach could be more useful in cases in which there is a [wish for immediate action] by the team regarding a specific issue, while displaying information on the workspace could become [less useful after issue was solved].

4.2.4. Heuristic 4. Display information taking into account human brain assimilation. This heuristic can be important for [understanding information], and can improve [information awareness] of team members. In order to generate [interest in information], it is important to have [continuous useful information] displayed. Two things that could matter while taking assimilation issues into account in an agile environment is having [cognitive separation of informations] in the IW and avoiding [visual pollution].

Taking assimilation into account could also provide [rapid reading] of information and can improve [external understanding] by people outside the development team.

To help improve an IW in regard to this subject, aspects such as [clear information] and [information meaning] should be pursued. It is also important to rethink the [information representation] used, trying to achieve a [simple representation] on an [informal information display].

4.2.5. Heuristic 5. Make your daily IW tasks performed by a pair of team members. Performing IW related tasks in pairs of team members could be used to improve [speed in IW maintenance]. This could also be useful for providing [guidance on IW related tasks] and thus promoting [certainty in IW maintenance] by team members, which could be useful

when having [beginners in agile development] on the team.

Pairing in IW related tasks can be particularly useful in environments practicing [pair programming] instead of [solo programming]. This denotes the importance of aligning IW management with the [working style] of the team. Performing such tasks in pairs could also improve [IW related learning].

One way of dealing with IW management performed by pairs is by [rotating members for IW update], which could have restrictions in regard to [carrying ideas].

4.2.6. Heuristic 6. Provide an easily-maintainable and practical IW. One outcome that practicality in an IW can promote is [speed in IW maintenance]. Having a practical IW can also promote interest in manipulation between team members, thus enhancing [collective IW management]. One of its major benefits is supporting [IW updates], which makes it easier to apply [current updates].

Not having a practical IW can result in [outdated information], since it would have an increased [IW maintenance weight], which could even render [information usefulness]. An impractical IW can result in [inconvenience] and [waste of time] for the team, reducing its aim of [helping instead of disturbing].

It could be important to analyze the [cost/benefit] of information when displaying it, giving priority to [choosing simple information]. Besides, issues such as [workspace constraints] could interfere with developing a practical IW.

An important issue to address is [means of displaying information] (frames or boards or electronic displays, etc.), which could affect practicality of an IW. This sort of constraint could emerge in cases when the [display should be adapted] to suit the current context of the team, and not doing it properly could have an impact on maintaining [clear information] displayed on the environment.

There are cases when [information removal] of unnecessary information is needed to promote a practical IW. It is also possible to propose [information drafts] from new information. These drafts could be used to verify [information usefulness] before raising the quality of its display, and also improve [physical space management].

4.2.7. Heuristic 7. Remove less valuable frames/boards from the IW. Performing this task could be useful since it considers [restricted information awareness] of team members. Besides, managing an IW with information overload seems to be an [information disturbance], and removing less valuable information could be compared to [removing worries]. It can also promote [information substitution] in the environment, in order to maintain the [focus on important subjects]. Not removing less valuable information from an IW could negatively affect team [information awareness] on important information, and generate [waste of time].

One means of dealing with this issue is through promoting [collective IW management], since it could help in [choosing useful information] and in [collective interest in IW management]. A [history] of earlier used information could be useful in [IW related learning] scenarios.

The decision about to remove information or not should be based on [information usefulness]. It could not be worth to maintain an information when its related issue is already [good enough], or it has shown [stable results]. It also should be removed [out of context] information, or in an IW which contains [excess of information].

4.3. Validating IW heuristics (Phase 4)

In Phase 2, our results showed the usefulness of the seven proposed heuristics in 2010 environment. In order to validate the set of heuristics in another context, we conducted a new survey using the same protocol of Phase 2, but in the class of 2011. The 2011 environment did not have intervention by the researchers regarding the use of IWs. The overall response rate achieved by the survey was 54.05% (20 respondents out 37). Table 3 shows the 2011 survey results, comparing them with results from 2010 application (Phase 2). We highlighted in dark gray and light gray the two strongest results for each question. We also present the relative frequency of respondents who experienced the heuristic.

Heuristic	Year	Experienced	Very Low	Low	Regular	High	Very High
# 1. Keep the most important frames/boards near to daily meeting place	2010	100%	0%	7%	7%	53%	33%
	2011	60%	0%	16.7%	41.7%	33.3%	8.3%
# 2. Divide IW related work between all team members	2010	80%	0%	3.7%	8.8%	58.8%	28.7%
	2011	65%	0%	7.7%	61.5%	30.8%	0%
# 3. Focus your IW on current specific issues	2010	90%	0%	0%	22.2%	59.3%	18.5%
	2011	65%	0%	15.4%	23.1%	38.4%	23.1%
# 4. Display information taking human brain assimilation into account	2010	100%	0%	0%	20%	37%	43%
	2011	85%	0%	5.9%	47%	35.3%	11.8%
# 5. Make your daily IW tasks done by a pair of team members	2010	90%	0%	18.5%	33.3%	40.8%	7.4%
	2011	80%	0%	18.8%	50%	25%	6.2%
# 6. Provide an easily-maintainable and practical IW	2010	100%	0%	3%	10%	50%	37%
	2011	100%	0%	5%	30%	55%	10%
# 7. Remove less valuable frames/boards from your IW	2010	87%	0%	0%	26.9%	38.5%	34.6%
	2011	95%	0%	0%	15.8%	63.2%	21%

Table 3. Heuristics validation - Comparing 2010 and 2011 surveys

Most heuristics had a slight decrease in importance in the 2011 survey. However, all heuristics appeared, at least, as having a regular importance in the new context. Considering both surveys, heuristics 3, 6 and 7 are the most important from the respondent's point of view.

5. Discussion

Focusing on specific current needs could be related to Beck & Andres [7] statement that "if you have an issue that requires steady progress, begin charting it". Pursuing practical IW management could be related to Cockburn [8] claim that an *information radiator* should be "Is easily kept up to date". Providing easily assimilated IW artifacts could be related to another characteristic of a good *information radiator* [8] that "Is understood at a glance", and to studies from Sharp et al [3] relating human cognition to "the Wall", which involves assimilation issues. Removing less valuable information can be related to Beck & Andres' [7] advice that "if the chart stops getting updated, take it down".

We could not directly relate "having most relevant artifacts near to daily meeting place" to any study. However, it could be indirectly related Sharp et al. [17], who describe the use of the wall as a discussion point during daily meetings. We could not relate to any other study performing IW tasks in pairs and having IW management responsibilities well divided between team members.

Several concepts related to each heuristic can be useful to practitioners for designing and maintaining an IW. Some benefits already known by using IWs emerged from phase 3 results, such as using IW for evincing current issues [7] and its use for visual work controls [5].

Our results suggest that many ideas already described in Section 2 could be expanded. Cockburn's [8] easily kept up-to-date artifact characteristic could be expanded to a cost/benefit analysis for displaying new information, given the weight and waste of time necessary to maintain it. Recognizing the disturbing effect that an information related to a current issue can have on the team, and cases where its removal was directly related to removing worries of team members, can be an expansion of Cockburn's [8] demotivating effect of negative reinforcement without its correspondent positive reinforcement.

Sharp et al. [17] describe some cases where agile teams had "The Wall" as a focal point during their daily meeting. Our findings show that the proximity of important displayed information during this meeting can improve the meeting dynamics, situation awareness of team members and the impact of this information.

Authors such as Beck [6] claim to use metrics on the team to communicate the need for a change, but our findings show that displaying certain information can have a negative effect on the team if the it does not want to address the issue by taking immediate actions.

Our findings point out a difference in levels of interaction between team members and IWs from: paying attention to, understanding, being aware of, reflecting, and taking actions based on information. However, team members seem to have restrictions on their amount of information awareness, since there were cases that excess information had a negative influence on the team. So, the choice of which information is the most relevant to display is important, and several contextual matters should be considered.

Based on the results, we could also notice the important role of a collective IW management, since it seems to improve information reflection by team members, to help choose useful information to display and to propagate IW related learning. The importance of a collective IW management interest seems to be required in such an environment.

All heuristics seem to have at least some regular value in both environments, which reinforces their use for ordinary agile teams on the industry. However, not having a more experienced individual providing guidance in IW related issues could reduce experiences with IW, since 2011 environment results presented a reduced percentage of team members with experiences on each approach.

The results of this research were based on academic agile teams, which is a limitation of this research. Another limitation is that most team members were new to agile development, although coaches had earlier experiences in agile teams. Phase 3 data was gathered based on only six interviews, and analyzed by only one researcher, which could also be considered as limitations of the research. In Phase 1, the researcher made several interventions with the teams, which could have affected opinions of team members, which we tried to decrease by applying the survey in a different environment, but can also be considered a limitation of this research.

6. Conclusion

In Phases 1 and 2, we proposed a set of seven heuristics for using/managing IWs based on a participative action-research based approach in the 2010 environment. We also applied a survey in the same environment, which resulted in evaluating each one as having at least regular value by most respondents.

Phase 3 results provided several concepts related to the use of these heuristics, trying to answer questions such as "why", "how", "when", etc. These relationships could be valuable in order to apply these heuristics in other agile environments since it provides more contextual information, which is important in agile development.

Using a sequential mixed method approach was useful, since it permits expanding results from each phase of the research [19]. By using this approach, we could provide useful quantitative and qualitative data. These heuristics could be seen as patterns for using and managing Informative Workspaces and can be valuable for practitioners who want to take more benefits from this tool.

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