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Higher Quality Requirements: Supporting Joint Application Development with the Nominal Group Technique

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Abstract. Miscommunication among systems developers and users has plagued systems requirements determination under conventional approaches and has contributed to several systems failures. Joint Application Development (JAD) was introduced to alleviate this problem by bringing together developers, users, and managers in face-to-face workshops designed to produce higher quality requirements. However, JAD sessions are conducted under the freely interacting group structure, which makes them susceptible to many of the classical problems commonly encountered during group deliberations. In this paper we present a case for integrating JAD and the nominal group technique (NGT), a group protocol that was designed to solve problems similar to those encountered in JAD. We tested our proposition in a laboratory experiment consisting of 24 group sessions, in which professional JAD facilitators led a diverse group of business professionals, managers, and advanced business students in specifying high-level requirements (under JAD and with the integrated techniques) for a simulated IS problem. The neutral and objective measures of their effects on the quality of the resulting requirements indicate that the combination of these group process structures seems to neutralize the negative impacts of group dynamics often experienced in JAD sessions, and contributes to improvements in the quality of the requirements.

Keywords: joint application development, nominal group technique, group facilitation, systems requirements determination, group interaction, systems management

Introduction

Despite the major strides in information technology (IT) over the last two decades, organizations continue to experience poor quality information systems [7,18]. Some have expended large amounts on systems that fail to satisfy their intended objectives and do not deliver expected benefits. Several problems, traceable to user–developer miscommunication, manifest themselves during systems development while others are only discovered after implementation and add to the large share of IS resources devoted to maintenance support.

Many systems provide inadequate solutions or become irrelevant because of the elapsed time between conception and delivery [19]. Some are of such poor quality that they are scarcely used and have very little impact on the sponsoring organization's value chain [4]. Even technically sound systems sometimes remain unused because of poor fit with the business processes they automate [32]. KPMG provided statistics (Computerworld, April 25, 1994) which indicated that approximately 57% of all major IS projects become chronic failures due to poor user–developer communication.

Software development is inherently complex [6] and systems requirements determination (SRD) is considered to be the most difficult step in the process [34,47]. At this crucial stage of systems development the precise details of the problem to be solved and the needs to be satisfied are explicated. Effective user–developer communication is considered a critical success factor [7], but this has proven to be an elusive objective.

SRD is the process of identifying the features and functionality that an information system should provide. Several variations of this term are used in the literature including systems requirements analysis, systems requirements definition, systems requirements engineering, and functional specification. In some cases *information* is used instead of *systems*. Table 1 provides an overview of the activities that are performed during this phase of systems development.

During SRD systems developers and users unearth, analyze, and document detailed information about the nature of the problem. They identify the needs of users, the features and characteristics of the system, the functions to be performed, the required interfaces, and the expected performance [25]. Several stakeholders with potentially divergent perspectives and sometimes conflicting preferences usually supply these details for system builders [16,45] who are typically more attuned to the technical (rather than the social and political) implications of the system [2]. It is not surprising therefore, that user–developer miscommunication is prevalent.

Interviewing, which is the information elicitation method that has been most widely used also contributes to the problem [15,39]. With this approach, systems devel-

Table 1
Requirements determination activities.

Preferred term	Meaning
Systems Requirements Determination (SRD) Also called Requirements definition Requirements engineering Logical design	The overall process of getting at, analyzing, and documenting the requirements. Including • Functional features (description of the requirements, e.g., provide for automatic order generation based on pre-established reorder level) • Nonfunctional arrangements (performance and reliability stipulations) • Constraints
Comprises:	
Requirements elicitation Also called Requirements gathering	Drawing out the facts, integrating and prioritizing them
Requirements analysis	Evaluating and validating the information extracted
Requirements specification Also called Functional specifications	Representing the results in a document

opers obtain information from selected users and managers about the particular problem domain and details of the solution "requirements". This information is then played back to individual interviewees for confirmation. An iteration of confirmation and refinement continues until some measure of agreement is attained. The details from all the parties interviewed are then aggregated as the requirements to be satisfied.

Scholars have expressed doubt about the accuracy, thoroughness, and internal consistency of systems requirements so determined [15,39]. Yet it is axiomatic that accurate and complete identification of information needs early in the development life cycle help to produce successful systems and reduce the overall cost of development [7]. Alternatively, the cost and difficulty of incorporating undetected requirements later in the development cycle increase exponentially over time [29].

Joint application development (JAD) was introduced to alleviate the problem of poor SRD. It is a facilitated group technique that places momentous emphasis on the human factors of systems development and reputedly confronts the communication issues [46]. JAD brings together managers, information systems users, and technocrats from different sectors of an organization in a face-to-face workshop to specify requirements and determine functional alternatives for a system under development [26].

While JAD has been well received and has contributed to improved systems requirements, it uses the freely interacting group technique, where spontaneous communication occurs without effective control. This makes JAD critically dependent on excellent facilitation to deflect many of the dysfunctional behaviors associated with that meeting structure. These well-documented problems typically challenge even the best facilitators and impede JAD's ability to fully realize the benefits for which it was designed [1,26,46].

We therefore assessed the usefulness of interjecting the nominal group technique (NGT) at appropriate intervals during the JAD workshop to regulate group dynamics. NGT, a structured meeting approach that allows groups to work together in a highly controlled environment, allegedly increases decision-making effectiveness by minimizing the negative impacts of group dynamics on task-oriented objectives during creative problem-solving. It is anticipated that the amalgam of these seemingly compatible group structures will reduce the facilitator's burden for controlling the workshop and neutralize dysfunctional behavior, thereby restoring the process loss that JAD by itself would otherwise experience.

1. Joint application development (JAD)

JAD was originally developed for internal use at IBM in the late 1970s. Its success there prompted IBM to make it available to clients. JAD became quite popular because of its apparent usefulness in addressing several of the shortcomings of the interviewing technique and the potential to reduce the cycle time for systems development [1,8,39,46]. Early adopters were also fascinated by JAD's projected capability to assist with the development of team rapport. In addition, JAD is compatible with several development methods such as rapid application development (RAD), prototyping, information engineering, and may be used with computer aided software engineering (CASE) tools.

Originally the acronym meant joint application design, but *design* was later changed to *development* to reflect the importance attached to user involvement throughout the systems development life cycle. JAD is now known by several other names including, joint application review, joint requirements planning, facilitated work sessions, facilitated workshops, accelerated design, facilitated meetings, interactive JAD, joint sessions, modeling sessions, team analysis, and user centered design [9,46]. Several organizational adaptations of the original JAD exist; some of which have diluted its impact [12]. Its use has also been extended beyond the original intention and JAD is now employed in any decision-making context where facilitated interactions are required [1,8,27] (e.g., for making business process reengineering decisions). The formal JAD protocol consists of the five stages illustrated in table 2 [46].

In addition to assembling the "right JAD team", an excellent facilitator is a pivotal prerequisite for JAD success [9,30]. The facilitator is responsible for impartially guiding the session toward the attainment of the objectives [40]. He or she ensures productive use of the available time and attempts to obtain maximum team participation [1,9,46]. The facilitator should be multi-skilled, demonstrating competence in leadership and management, interpersonal relationships, business and systems analysis, and communication, and highly respected by the JAD team [30,40,46].

The workshop is an eventful session of fluid interactions among the facilitator, executive sponsor (who typically attends the opening and closing sessions), the project

Table 2
Five stages of JAD.

JAD stages	Activities
1. Project definition	• Determine system purpose, scope, and objectives • Identify JAD team members • Establish project schedules
2. Background research	• Gather background details about the user requirements • Explore the technical, social, political implications • Consider general system issues, agree what needs to he decided in the session
3. Pre workshop preparation	• Prepare for the session • Finalize logistics for the meeting • Procure visual aids, working documents, and other meeting apparatus • Train the scribe(s)
4. The workshop	• Pool the information and knowledge of JAD team members in the analysis of potential solution • Generate solutions (systems requirements) during t he three- to five-day session • Finalize and document meeting decisions
5. Final documentation	Prepare the final document that captures decisions and agreements arrived at during the workshop

manager(s), information systems professionals, user/managers and other system users, who are domain experts that provide information and make decisions about their respective business processes. A "scribe" (note-taker) records and documents the deliberations but does not participate in the discussions. On some occasions, non-participating observers may also attend. The participants engage in discussions, and make decisions about systems assumptions, business processes, functional requirements, and data and process models [1,46].

JAD workshops are typically supported by a variety of visual aids including flip charts and post-it notes that sometimes fill up all the walls of the meeting room with agenda items, requirements information, data and process models, and open items deferred for further discussions. Facilitators may also use overhead projectors, electronic white boards, and screen projection units. Now several other technology aids, such as graphics software, computer aided software engineering (CASE) tools, and Group Support Systems (GSS) are also used in JAD sessions [46]. JAD was originally (and still largely) used for face-to-face meetings but recently facilitated virtual meetings using computer-supported cooperative work technologies have been attempted.

JAD attaches immense significance to the communication aspects of systems development. Its primary intention is to achieve synergy by increasing interaction, leveraging the combined knowledge of the group, and enhancing the quality of the contribution of participants in the workshop. This, presumably, would facilitate more thorough and precise specifications, precipitate the resolution of conflicting and ambiguous requirements [1], shorten development schedules, and improve the quality of systems design and development [46]. Improved user–developer communication would also foster greater identification with JAD results and, hopefully, ownership of the requirements, which are necessary to secure commitment to the rest of the project [39].

However, the interacting group technique is the dominant meeting structure used to conduct JAD sessions. When groups deliberate in this manner, social and emotional dynamics often impede the accomplishment of assignment objectives [36]. This point has been well recognized by many proponents of JAD, who have enjoined several supplements to offset this limiting feature. That is why excellent facilitation has been touted as an almost superordinate prerequisite for minimizing dysfunctional behavior, inspiring group productivity, and resolving conflict [1,12,26,46].

2. The nominal group technique (NGT)

Among the popular prescriptions for alleviating the counter-productive effects of the freely interacting group structure are brainstorming [10] and anonymous idea generation [24]. Remedies have also been suggested for reducing destructive dominance by more forceful and higher ranked participants and for "rationalizing" participation [46]. Several proposals exist too for overcoming groupthink and building consensus [26]. The JAD facilitator bears the burden of implementing these normative tactics without structural assistance from the JAD technique.

Table 3
Steps in the NGT procedure.

Stage	Procedure
1	Participants generate a list of solutions independently and silently for a pre-specified period.
2	The facilitator methodically records one idea at a time from each participant in a round-robin format until all ideas are recorded. Participants may add to their lists at any time or "pass" in a round in which they have no further contribution.
3	Each submission is discussed and clarified without critical evaluation or lobbying. Similar ideas may be consolidated and duplicates eliminated at this stage.
4	Participants independently rate and rank the submissions.
5	Final decision-making is based on mathematical pooling of individual rankings (if necessary) and/or voting (by secret ballot, if desired) to settle disputes.

Most of these remedies, however, are embodied within the standard operating procedures of NGT, a highly structured set of procedures for conducting meetings. NGT employs creative idea-generating and problem-solving strategies to elicit individual knowledge, views, or opinions, particularly when group contributions must be assimilated, sifted, and then consolidated into consensual decisions [5,40].

It apparently derives its efficacy from the combined conveyance (idea generating) and convergence (consensus generating) effects where ideas are accumulated then evaluated and ranked to arrive at solutions that accurately reflect the combined judgment of the group [21,48]. NGT adopts the procedures indicated in table 3 [8,14,36].

The salient features that account for NGT's success at regulating group dynamics include the following:

- the separation of creative thinking from idea evaluation [14,36];
- enforced participation, which prevents freeloaders and introspective group members from opting out of the process [41,44];
- the ease of implementation of the technique reduces the critical dependence on skillful facilitation maneuvers to dampen dysfunctional behavior [9,14];
- the well-structured procedures help to reduce domination by powerful participants and shield lowly ranked group members from conformance pressure [46];
- improved conveyance (from brainstorming and the association of ideas during the round-robin submission) and speedy convergence (from ranking and voting) [21].

Scholarly proponents of NGT have provided empirical evidence to validate the claim of its effectiveness in a variety of decision-making environments:

- Van De Ven and Delbecq [44] and Delbecq et al. [14] confirmed the superiority of NGT over interacting group techniques and other methods used in problem-finding and problem-solving situations;
- Stephenson et al. [41] confirmed its effectiveness with heterogeneous groups, and for solving complex problems;
- Ho et al. [21] established that it improves decision-making;

- it has produced excellent results while generating diverse ideas for the solution of multidimensional problems [17];
- Gresham (reported by [28]) found that participants in NGT sessions were highly satisfied with the process;
- Valacich et al. [43] asserted that a substantial body of research points to the large nominal group as the "gold standard" for group ideation.

Other authors have cited evidence of the successful application of NGT or recommended its use in information systems projects; our proposal is for its integration with JAD:

- Lederer [29] has proposed the use of NGT on its own for determining objectives and goals during SRD;
- Cougar et al. [11] and Miles [35] have advocated its use for improving the creativity of information systems solutions;
- Henrich and Greene [20] described an application of NGT in a Fortune 100 company where NGT was used to identify roadblocks to an MRP II implementation and improve communication between members of the implementation team;
- Teltumbde [42] combined NGT with analytical hierarchy process (AHP) for evaluating ERP projects.

3. Anticipated effects of the integration

Some of the group-related problems facilitators may encounter in a JAD workshop are highlighted in table 4. They result mainly from the composition and other characteristics of the group. During SRD especially, the workshop atmosphere is typically emotive as

Table 4
Typical group problems.

Problem	Manifestation in JAD
• Conforming behavior	Participants conform to emergent group norms [14]
• Search behavior	Groups generate sub-optimal solutions before complete problem diagnosis [44]
• Destructive dominance	Influential group members dominate the process and exclude the useful ideas and opinions of other members [46]
• Elective participation	Members opt in and out of the deliberations and need not contribute at all [9,46]
• Anchoring	Group members react to tangential ideas or opinions expressed by senior members of the group in a manner that leads to digression from the main agenda [44]
• Groupthink	Memers place undue emphasis on group harmony, which then becomes a de facto decision criterion [22,26]
• Risky-shift behavior	Groups make more risky decisions than individual members normally would [26,33]
• Commitment and goal-setting errors	The group arbitrarily commits organizational resources to unattainable objectives and unrealistic targets [26]
• The abilene paradox	The group arrives at a decision that is contrary to the desires of its individual members [26]

stakeholders grapple with political "turf" issues, conflicting and competing interests, power and knowledge asymmetry, and status incongruity. These potentially problematic conditions, that have been recognized in JAD sessions [9,26,46], impact the nature of the social interaction among heterogeneous groups and influence the effectiveness of their decisions [37]. Effective resolution is particularly important (for the acceptance of the eventual system) because SRD decisions cannot be imposed but must be negotiated [23].

The extent to which facilitators succeed in minimizing the social and emotional obstacles to objective decision-making largely determines the caliber of the results of the JAD workshop. JAD's Achilles' heel is this critical dependence on the competence of the facilitator to deflect problems and diminish these threats. But excellent facilitation is a scarce commodity [8,30] and in their respective studies, Carmel et al. [9] and Davidson [12] have observed that even excellent facilitators have not always alleviated the negative impact of these behaviors. They have tacitly contributed to JAD outcomes that do not necessarily reflect the decision preferences of the entire group [46]. Despite several other desirable features of JAD [13], the continuation of these problems, motivated the proposal for using NGT in JAD sessions.

3.1. NGT assistance in JAD workshops

The expectation that the combination of JAD and NGT will reduce the problems (that have curtailed JAD's effectiveness is based on the presumption that the more structured NGT technique will help to alleviate the JAD facilitator's burden in addressing these problems. This notion is also encouraged by empirical and anecdotal indications of the successful uses of NGT in similar settings (involving heterogeneous groups in consensus seeking decision-making) to those encountered during SRD.

3.1.1. Conforming and search behaviors

The status of participants in a systems development project derives from either rank or perceived knowledge. In a group setting, lower ranked members tend to acquiesce unnecessarily to the suggestions and desires of their superiors. The underlying felt threat of sanction from the powerful, the fear to be thought a fool, and the forcefulness of naturally dominant participants may combine to suppress worthwhile contributions of lowly ranked group members and induce involuntary conformance.

The NGT tactic of reducing the impact of the social and emotional interactions of the group on its task-related activities and the act of separating the creative product from its producer combine to repel this threat [44]. Similarly, because NGT intentionally sequences deliberations into conceptualization, evaluation, and decision-making it is more difficult to commingle problem diagnosis with solution generation (search behavior) unless the group abandons the NGT structure entirely.

3.1.2. Destructive dominance

JAD teams are usually highly heterogeneous which is often manifested in knowledge and power asymmetry, incongruity in the psychological profiles of the members, and different levels of speaking ability, among other characteristics. Influential, extroverted, eloquent, or merely garrulous participants may exploit these conditions and dominate the deliberations to the exclusion of the useful ideas and opinions of the less effusive or "lower-level" members.

NGT facilitates the balancing of participation. Every member generates written ideas in the initial brainstorming stage. The subsequent round-robin presentation guarantees that the ideas generated are submitted undisturbed by the burden of immediate clarification and evaluation, which obviates lobbying and encourages participation. The round-robin presentation, during which a member with no more contribution may pass, also affords contributions commensurate with the knowledge level of the participants. Some domination may be possible at the evaluation stage but its effect on the solution is likely to be reduced by the subsequent ranking and voting (by secret ballot if participants so desire) to resolve competing propositions [46].

3.1.3. Elective participation

Even if destructive dominance and the compulsion to conform were eliminated in a JAD session, participation is voluntary so individual members contribute at their own volition. The construction of a perfectly knowledgeable group for a JAD session will not produce high-caliber results if introspective members opt out of idea generation and decision-making. Participation is involuntary within NGT; the structure compels the involvement of all participants in all of its five phases [36].

3.1.4. Anchoring

During JAD workshops, digression from the main agenda is sometimes attributable to anchoring, where other participants feel compelled to respond to peripheral contributions of influential group members. Anchoring usually causes time to be wasted on tangential discussion, which disrupts complete and creative focus on the relevant issues. NGT provides some protection against this problem. It is not possible during the ideation and reporting steps and in the evaluation and ranking stages participants focus only on those ideas brought to the table. This mitigates the opportunity for anchoring and the diversions it encourages.

3.1.5. Groupthink

According to Janis [22], groupthink is a deleterious feature of cohesive groups whose objectivity is often impaired because of the obsession with preserving group harmony. Under these circumstances a group may sometimes ignore important (but controversial) problem-solving information. This often results in the erosion of the combined thinking capacity of the group, and prevents synergy. Groupthink results from a combination of process conditions that includes problem complexity, stress, and pressure to expedite decision-making.

There is some doubt that groups constructed for SRD projects could coalesce enough to experience groupthink. However, in many organizations similar groups may work on multiple projects over time. In JAD workshops achieving consensus is a preoccupation which may produce anxiety to obtain closure. In addition, the complexity of the issues involved and difficulty in arriving at a desired solution may impose extreme pressure on the group and create conditions conducive to groupthink.

The NGT structure helps to dissolve some of the basis for groupthink by ensuring that individual ideation is untainted by the influences of other group members. The structure makes it more difficult for influential members to steer the meeting into preferred domains [44] and prohibits the selective exclusion of information. Typically NGT contributes to the generation and evaluation of a large number of creative ideas [11,17] that are all evaluated.

3.1.6. Risky-shift behavior

Risky-shift behavior has been empirically observed in groups that "shift" away from the risk aversion of individual members. This phenomenon has been attributed to the absence of personal accountability and the fear of retribution that attends poor individual decision-making. The elimination of this behavior is more of a by-product than a direct consequence of NGT. It could possibly result from the psychological attachment to, and the feeling of ownership of the meeting outcome, which may be fostered by increased participation in the deliberation [28].

3.1.7. Commitment and goal-setting errors

Commitment errors arise when a senior group member arbitrarily commits organizational resources to unattainable objectives. Similarly, goal-setting errors may result from a group's unrealistic aspirations that ignore prior experience for similar projects. Both may be encountered in JAD sessions where the focus is on what is to be done rather than how to do it. The improved decision-making [10] at the evaluation stage of NGT usually unearths the dangers of these problems. The fact that a large number of ideas are generated [11,17] increases the possibility that the evaluation and ranking would steer the group toward more attainable commitments. If indeed, the group as a whole, or a subset of its members, accept ownership (induced by enhanced participation) of the outcome, this could also offer some protection against such problems.

3.1.8. The Abilene paradox

The Abilene paradox got its name from the experience of a family in Texas who traveled 50 miles to Abilene for dinner against the (unexpressed) wishes of the family members. It is evident among groups where the pressure to arrive at consensual decisions causes the avoidance of conflict. NGT moderates this eventuality by providing the framework for resolving (instead of ignoring) conflict and precipitating decision convergence in the face of competing ideas [44].

3.2. Research hypotheses

Table 5 identifies a set of input (independent) variables (adapted from several group interaction frameworks [2,33,38]) that interplay to set the tenor of the group's deliberation

Table 5
Input and dependent variables.

Input variables	Dependent variables
• Group characteristics	• Decision quality
– Size	• Number of unique solutions generated
– Experience	• Process efficiency
– Level of effort	• Degree of consensus
• Task characteristics	
• Contextual characteristics	
– Facilitation	
– Time pressure	
– Process structure (e.g., JAD, NGT)	

(e.g., in a JAD session) and produce particular performance outcomes – the dependent variables of interest. Our thesis is directed to the effect of process structure on the nature of the interaction, and ultimately on the quality of the group's performance.

The presumption (based on our analysis in the preceding section) is that the NGT process structure will help to ameliorate dysfunctional group behaviors typically encountered under JAD, which will enhance the effectiveness and quality of the interaction and contribute to more desirable results. The research hypotheses that follow reflect the general expectation that (all else being equal) JAD supported by NGT will outperform JAD alone in the four dimensions measured.

3.2.1. Decision quality

The quality of the requirements is largely determined by the extent to which the process is conducive to the reliable description of the desired features required for overall system success. These specifications should be accurate, understandable, complete, internally consistent, unambiguous, and relevant. NGT in combination with JAD is expected to positively impact SRD quality by enhancing user–developer communication and contributing to the reduction of the negative effects of group dynamics on group deliberations. Hence we propose:

H1: The requirements produced by groups using JAD supported by NGT will be of a higher quality than those produced by groups using JAD alone.[1]

3.2.2. Number of unique solutions generated

Because of the brainstorming allowed in NGT, the combined process is also expected to be more effective in stimulating improved conveyance by helping to unearth a larger number of unique (non-redundant) system features. We therefore propose:

H2: Groups using JAD supported by NGT will generate a larger number of unique requirements than groups using JAD alone.

[1] This hypothesis involves nine tests involving scores for eight quality criteria and the aggregate quality score.

3.2.3. Process efficiency

One of JAD's acknowledged strengths is the speed with which it generates requirements in comparison to conventional techniques. Because of the anticipated gains in process effectiveness, the integration of JAD and NGT structures is expected to extend this benefit by facilitating more efficient use of the available time to generate more useful features. Thus we expect that:

H3: Groups using JAD supported by NGT will experience greater process efficiency than those using JAD alone.

3.2.4. Group consensus

In addition to better conveyance, the integrated process structure is expected to help precipitate convergence toward group consensus. By providing a method for exploring (as opposed to ignoring) differences in the submissions of participants and then resolving resulting conflict without destructive dominance, it is expected to moderate the negative impact of conflict avoidance. We therefore propose that:

H4: Groups using JAD supported by NGT will attain a higher degree of consensus than those using JAD alone.

4. Empirical assessment of the approach

A series of 24 laboratory experiments involving groups of six participants was used to test the research hypotheses. The primary concern in this paper is the effect of the experimental conditions – JAD supported by NGT and JAD alone – on group dynamics and ultimately on the quality of the systems requirements generated. The other input variables depicted in table 5 were either controlled experimentally or statistically.

4.1. Research design

4.1.1. Subjects

12 professional JAD facilitators from four regional facilitator forums (formerly JAD user groups), 24 groups of six role-players, and 12 note takers (scribes) participated in this study. Role-players included a diverse group of non-facilitator members of the forums (who were themselves business professionals and managers in several disciplines), other systems and business professionals, and managers from educational institutions, consulting firms, and other corporate entities who had domain expertise in the business areas covered in the case. There were also student volunteers from two major tertiary institutions including senior undergraduate students in computer information systems and graduate (masters and doctoral) business students, all with some work experience.

The groups were randomly assigned to one of the experimental conditions (12 groups to each). Each facilitator was randomly assigned to and conducted two experimental sessions – one under JAD and one with the integrated structure. The participating organizations volunteered because of their interest in the outcome and for the opportunity to learn additional techniques to bolster their "toolkit", and student participants were awarded bonus points in their systems analysis and design courses.

4.1.2. Procedure

Facilitators were randomly selected from a pool provided by the four participating forums. They led their respective groups in generating and documenting a set of requirements for a simulated case [31], using the process structure assigned to that group. The groups were required to provide high-level systems requirements for an integrated order processing, inventory management, accounts receivable, and distribution management system to support a chain of owned and franchised deli-style sandwich shop.

The case was sent to the facilitators a week before the session with scripts for guiding the conduct of NGT, and they were debriefed for approximately an hour immediately preceding the experiments, which were scheduled for two hours. At the beginning of each session, role-players completed a questionnaire with background information about themselves, then assimilated the case details (for 15 minutes) before deliberations began.

At the end of the session, the documented requirements were reviewed and signed by the facilitator and scribe, and the facilitator completed a standard, preformatted report. Later, an independent office professional typed and copied the documented requirements for submission to the panel of three expert judges (academics with a combined 49 years of practitioner experience in MIS), who were unaware of both the treatment and the hypotheses. The raters were provided a rating sheet, which was adapted from a similar instrument developed by Bailey and Pearson [3] that assessed the quality of the requirements along eight dimensions (elaborated in table 6).

4.1.3. Variables and measures

Process structure was manipulated to generate the performance measures. The other input (independent) variables were either controlled experimentally or statistically. Group size (6 members per group), the task (all groups analyzed the same case), facilitation (random assignment to groups), and time pressure (all groups were allotted 2 hours, although some used less) are examples of the former. Group experience (data cap-

Table 6
Quality criteria.

Criteria	Meaning
Accuracy	The correctness of the requirements
Precision	The extent to which the requirements are clear and understandable
Completeness	The comprehensiveness of the requirements
Conciseness	The extent to which redundancy is avoided
Relevance	The degree of congruence between what is required and what is specified
Creativity	The innovativeness and novelty of the solution
Consistency	The internal consistency of the overall solution
Feasibility	The extent to which the requirements are workable and achievable

tured from participants' background information) and the level of effort expended by the group (reported by the facilitator) could not be controlled and were analyzed to determine whether statistical procedures were required to control potentially confounding influences.

The performance (dependent) variables of interest were obtained from neutral and objective measures. Three judges rated the requirements on a scale of zero to five using the eight quality criteria in table 6 and provided a count of the number of unique solutions generated by each group. Process efficiency was computed from the number of unique solutions generated divided by the session time (in minutes), which was recorded for each session. The facilitators also reported the number of unresolved issues that remained at the end of the exercise and this was used as a surrogate measure of the degree of consensus achieved.

4.2. Discussion of the results

The statistical comparison of "participants' experience" and "level of group effort" between treatment categories, indicated no significant difference for either variable ($t\{22\} = 0.653$, $p < 0.52$; $t\{22\} = 1.670$, $p < 0.109$, respectively), which obviated statistical control of these variables for possible confounding influences on the outcomes, and the inter-rater reliability of the judges' ratings (Cronbach's coefficient alpha of 0.9754) suggested that they were internally consistent. The results of the tests of the hypotheses, summarized in table 7, substantiate the claim, for all but the conciseness dimension, that NGT in combination with JAD provides improvements in the quality of SRD beyond those that JAD by itself produces. The other hypotheses were not supported.

Producing high-quality systems requirements, which is highly correlated with overall system quality, is a key systems development objective. It permits earlier detection and correction of design errors and prevents costly design alterations that often result in system errors. High quality requirements contribute to the reduction in scope creep, and shorter development times. Together these may also help organizations reduce the resources they allocate to systems maintenance efforts.

Although H2 (more unique features), H3 (greater process efficiency), and H4 (fewer unresolved issues) were not supported, the results indicate that the JAD/NGT means were better, though not significantly so, than the equivalent JAD means in all three cases. This implies that the integrated approach was no worse than JAD for these measures. A reasonable inference is that the integrated approach appears to be synergistic in preserving the desirable features of both techniques: successfully circumventing the problems that inhibited JAD, while maintaining the benefits that practitioners have lauded.

The additional effort and time required to apply NGT may have accounted for the non-support for hypotheses two and three, but the finding that they were not diminished under JAD/NGT is important. One of JAD's acknowledged advantage over conventional techniques is SRD cycle time reduction – from months to days. The integrated approach

Table 7
Summary of statistical tests.

Performance measures	Process structure	Mean	Standard deviation	t-value	df	Sig.	Hypothesis supported
H1. Quality points (total)	JAD	23.00	9.390	−2.869	70	0.005	YES
	JAD/NGT	28.83	7.788			0.005	
(a) Accuracy	JAD	2.86	1.268	−2.658		0.010	YES
	JAD/NGT	3.58	1.025			0.010	
(b) Precision	JAD	2.69	1.369	−3.266		0.002	YES
	JAD/NGT	3.67	1.146			0.002	
(c) Completeness	JAD	2.89	1.237	−2.513		0.014	YES
	JAD/NGT	3.61	1.202			0.014	
(d) Conciseness	JAD	3.11	0.950	−1.904		0.061	NO
	JAD/NGT	3.50	0.775			0.061	
(e) Relevance	JAD	2.94	1.372	−2.327		0.023	YES
	JAD/NGT	3.64	1.150			0.023	
(f) Creativity	JAD	2.53	1.464	−2.389		0.020	YES
	JAD/NGT	3.28	1.186			0.020	
(g) Consistency	JAD	3.00	1.242	−2.907		0.005	YES
	JAD/NGT	3.78	1.017			0.005	
(h) Feasibility	JAD	2.97	1.253	−3.098		0.003	YES
	JAD/NGT	3.78	0.929			0.003	
H2. Number of unique features generated	JAD	14.83	9.422	−1.856		0.068	NO
	JAD/NGT	19.17	10.363			0.068	
H3. Efficiency	JAD	0.1486	0.05427	−0.994	22	0.331	NO
	JAD/NGT	0.1714	0.05821				
H4. Unresolved issues	JAD	2.58	2.353	1.767	22	0.091	NO
	JAD/NGT	1.25	1.138				

would be less attractive if it eroded this benefit, especially in many organizations already reluctant to release key performers for extended periods. Carmel [9] noted that SRD is an economic process to which the objective of resource optimization appropriately applies. Similarly, the absence of highly emotive issues and intense conflicts during the experimental sessions (in comparison to more realistic settings) might not have provided the requisite conditions for NGT to adequately exhibit its reported capability to facilitate convergence.

5. Conclusions

The interpretation of these results must be tempered because of the experimental conditions under which they were obtained: The task was simulated; the time for its accomplishment compressed; and the requirements were specified at a higher level than would be the case in field sessions. Further, role-play under experimental conditions cannot fully capture the intensity, or provide the exposure to the range of problems encountered in the natural process. It may be argued, however, that JAD should need the NGT intervention even more as group problems become more pernicious.

Notwithstanding, the results provide reasons for optimism that the inclusion of NGT should leverage JAD's acknowledged strengths and help to remedy some of its deficiencies to improve SRD quality. The objective, however, is not to replace JAD (which is widely used) by NGT, but to introduce NGT procedures into the JAD workshop, wherever it is necessary to regulate group dynamics to improve results. Some JAD workshop activities (e.g., the construction of process models) would be encumbered rather than helped by NGT procedures.

This approach is not the elusive "silver bullet" for slaying the werewolf that afflicts software development. Several other SRD techniques have targeted improved systems development quality and other process structures have been used in JAD workshops to address group-related problems. Hopefully the individual and combined effects of these approaches will improve the quality of information systems. JAD has contributed to some progress in this area; it appears that the integration of JAD and NGT may provide additional benefits. On this basis, JAD facilitators may include NGT in their "toolkits" to help reduce the negative impact of group dynamics on decision outcomes. This could help to address the pervasive problem of user–developer miscommunication during SRD and eventually to improve the quality of information systems.

These results suggest at least two useful objectives for further research. The first is to repeat these experiments in the field, where the emotiveness, political conditions, and turf issues that characterize SRD activities in their natural settings may accommodate a more realistic evaluation of these process structures and increase the external validity of the conclusions. The second is to extend the test of the applicability of this approach to systems design efforts, where failure to resolve divergent interests among technical stakeholders could also contribute to poor system quality.

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