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تقديم

عزيزي الباحث

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- العلوم المالية والإدارية، وإدارة المعرفة، والاقتصاد.
- العلوم التربوية.

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- الإعلام والصحافة والعلوم السياسية.
- اللغة العربية والدراسات الإسلامية.
- اللغة الإنجليزية وآدابها.
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"نهج FMEA لتقليل فشل تطبيق أنظمة ERP باستخدام عوامل الفشل الحرجة"

"FMEA Approach for Decreasing Failure of ERP Implementation using Critical Failure Factors"

جورج ونس

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ملخص البحث:

تتسم مشروعات تطبيق نظم تخطيط موارد المؤسسات Enterprise Resource Planning (ERP) بمعدلات فشل عالية. أي تعارض يحدث أثناء عملية تطبيق ERP يؤدي إلى أخطاء في اتخاذ القرارات، ويقلل من الإنتاجية والربحية، ويمكن أن يؤثر على نجاح المشروع. الغرض الرئيسي في هذا البحث هو استخدام تقنية تحليل آثار أوضاع الفشل Failure Modes Effects Analysis (FMEA) لزيادة معدلات نجاح تطبيق مشاريع ERP. هذا الهدف يتحقق من خلال تحديد الإخفاقات الرئيسية وعوامل الفشل المتعلقة بتطبيق مشاريع ERP. تنقسم مشاريع ERP إلى ثلاث مراحل؛ قبل وأثناء وبعد التطبيق. تم تحليل كل مرحلة لتحديد خصائصها الرئيسية وإخفاقاتها المختلفة وعوامل فشلها. يمكن أن تؤثر العديد من المخاطر وتؤدي إلى الفشل في تطبيق مشروعات ERP. تعتبر تقنيات إدارة المخاطر مفيدة للغاية قبل وأثناء وبعد مراحل تطبيق تخطيط موارد المؤسسات. تقوم تقنية FMEA بتقييم حالات الفشل المحددة وعوامل الفشل التي توفر مقياساً كمياً لكل خطر من مخاطر الفشل. تصف دراستنا كيفية تقليل حالات الفشل في تطبيق ERP من خلال تقليل قيمة المخاطر، لذلك في بحثنا نقوم بتعديل تقنية FMEA من خلال اقتراح تقنية Enhanced FMEA مقترح مُحسَّن لقياس المخاطر. استناداً إلى أربع قطاعات مؤثرة في عمل المنظمات، نستخدم في بحثنا أربعة جوانب تصنيف فرعية "four sub categorization aspects" هي: المالية "Financial"، والعملاء "Customer"، والقوانين والقواعد المنظمة للصناعات " Legal &

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"Regulation"، والعمليات الإنتاجية "Business Operation". استخدام تقنية Enhanced FMEA يؤدي إلى زيادة نجاح تطبيق مشروعات نظم ERP.

الكلمات المفتاحية:

تقنية تحليل آثار أوضاع الفشل (FMEA)، مشروعات نظم تخطيط موارد المؤسسات (ERP)، نجاح تطبيق مشروعات نظم ERP، عوامل الفشل الحرجة.

Abstract:

The Enterprise Resource Planning (ERP) implementation projects have high failure rates. Any conflict done during the ERP implementation process leads to errors in business decision making, decrease productivity and profitability, and can affect the project success. The main purpose in this paper using Failure Modes Effects Analysis (FMEA) approach to deal with help in increasing the success rate of ERP implementation projects. This achieved through defining main failures and failure factors related to ERP implementations. The ERP projects are divided into three stages; Pre, during and post implementation. Each stage analyzed to define its main characteristics and its different failures and failure factors. Many risks can affect and lead to failure in ERP Implementation. The risk management techniques are very useful before, during and post ERP Implementation phases. The FMEA approach assesses and evaluates the defined failures and failure factors providing a quantitative measure for each risk of failure. Our study describes how to reduce ERP Failures by decreasing the risk value, so the researcher enhances the FMEA approach by a Proposed Enhanced FMEA approach to measure the risk. Based on the four organizational critical areas the researcher uses four sub categorization aspects, Financial, Customer, Legal & Regulation, and Business Operation. The Enhanced FMEA approach leading to success of ERP implementation.

Keywords:

Failure Modes Effects Analysis (FMEA), Enterprise Resource Planning (ERP), Success of ERP Implementation Projects, Critical Failure Factors.

1- مقدمة

نظم تخطيط موارد المؤسسات هي حزمة برمجية قياسية تدمج جميع الأنشطة التجارية، والمعلومات عبر الشركة، وتدير الموارد المتاحة، وتحسن عملها [1، 12، 13]. نظام تخطيط موارد المؤسسات (ERP) يتحكم ويدير العمليات التجارية المعقدة ومعلومات الأعمال بشكل فعال [3،14]، الفوائد الهامة من نظم تخطيط موارد المؤسسات أنها تسمح بوصول أفضل إلى المعلومات [15]. هناك العديد من الأسباب التي تحفز المنظمات على تطبيق نظم ERP مثل استبدال النظم القديمة وتحسين الأداء الإداري [16].

أيضًا، يعد القضاء على التكرار في البيانات وبساطة عمليات الأعمال من نقاط القوة المهمة في نظم تخطيط موارد المؤسسات، الذي يتميز بالوظائف المتقاطعة التقنية للغاية highly technical cross functional من خلال المنظمة. تعمل أنظمة تخطيط موارد المؤسسات على تحسين الأداء التنظيمي والقدرة التنافسية [17، 18، 19].

تحتوي نظم تخطيط موارد المؤسسات ERP على العديد من الأنشطة التي يستخدمها المديرون لإدارة الأنشطة التنظيمية مثل: المشتريات، والموارد البشرية، والمحاسبة، والإنتاج، والمبيعات. وبشكل عام، هناك العديد من الوظائف المتاحة في كل أنظمة ERP، مثل: الشراء، والمخزون، وتخطيط سلسلة التوريد، والجدولة، ومراقبة الجودة، وإدارة الطلب. وتوجد أيضاً الأنظمة المالية التي تحتوي على العديد من الأنظمة مثل: حسابات المدفوعات، وحسابات المقبوضات، وإدارة التدفقات النقدية، والتدقيق المالي. كما توجد أنظمة المشروعات التي تحتوي على العديد من الأنظمة في إدارة الأنشطة في الشركة مثل: فواتير المشروعات، وعقود المشروعات. أيضا تحتوي الموارد البشرية على العديد من الأنظمة مثل: إدارة الوقت، والحضور،

والتدريب، وكشوف المرتبات، والتوظيف. وتحتوي إدارة علاقات العملاء على العديد من الوحدات النمطية مثل: دعم مركز الاتصال، والمبيعات، والتسويق، والتحليلات.

هناك ثلاث مراحل لتطبيق أنظمة ERP، مرحلة ما قبل تطبيق أنظمة ERP تحتوي على اختيار النظام المناسب وأيضا اختيار الموردين وتحديد مواصفات متطلبات المستخدم (URS). فعندما تبدأ الشركة في التفكير في تطبيق أنظمة ERP، يجب أن تقوم بتحليل سوق موردي هذه النظم لمعرفة المورد المناسب وإمكانيات كل نظام ومزاياه وشروط تطبيقه ومدى توافر الدعم الفني له [20]. المرحلة الثانية هي مرحلة تطبيق أنظمة ERP وتحتوي على الأنشطة المتعلقة بتكوين البرامج، ونقل البيانات، والتكامل بين الأنظمة المختلفة، والاختبار، وتدريب المستخدم. والمرحلة الثالثة هي مرحلة ما بعد تطبيق أنظمة ERP التي تحتوي على: الصيانة، وإدارة البرامج، وتحسين أداء البرامج، وتدريب إضافي للمستخدم.

ويرتبط بهذا الموضوع عدة مصطلحات مثل: الخطر، وعوامل النجاح، وعوامل الفشل، والتحقق من صحة أنظمة ERP. الخطر المحتمل معناه هو احتمال خسارة شيء ما، وبالتالي فإن المخاطر تتميز بعدم اليقين [21]. الفشل هو حالة عدم تحقيق الهدف المنشود وقد يُنظر إليه على أنه عكس النجاح [22، 23]. يتم استخدام أساليب عوامل النجاح الحرجة (CSF) وعوامل الفشل الحرجة (CFF) في تقييم نظم المعلومات. وقد تم استخدامها في مجالات نظم المعلومات مثل: إدارة المشروعات، وتطبيق نظم التصنيع، وإعادة الهندسة، وتطبيق نظم تخطيط موارد المؤسسات ERP [13، 24].

يضمن التحقق من صحة تخطيط موارد المؤسسات ERP Validation التحكم المناسب في المخاطر الوظيفية والمخاطر التشغيلية، ويضمن أيضاً رضا المستخدم ويضمن أن تخطيط موارد المؤسسات ERP يلبي متطلبات المستخدم وتوقعاته. كما يتضمن التحقق من صحة نظام تخطيط موارد المؤسسات (ERP) التحقق من صحة البرامج وتأهيل البنية التحتية للأجهزة والمعدات.

يعد تحديد إجراءات العمل وربطها بالوظائف والإجراءات على النظام Business Mapping خطوة حاسمة في مرحلة التحقق من أنظمةERP، كما يعد تحليل المخاطر مهم للغاية وذلك للتحقق من صحة النظام وهو هام أيضا لتكوين وثائق للنظام تتضمن مواصفات متطلبات المستخدم (URS)، والمواصفات الوظيفية (FS)، مواصفة التثبيت (CS)، ومؤهلات التثبيت (IQ)، ومؤهلات التشغيل (OQ).

هناك أدوات مختلفة لتقييم المخاطر تحاول قياس المخاطر، ولكل أداة خصائصها أو ميزاتها أو معاييرها، ويتم تمييز هذه الأدوات عن مناهج ونماذج تقييم نظم المعلومات أو تخطيط موارد المؤسسات. هناك العديد من الأدوات التي يمكن استخدامها لإجراء تقييم المخاطر مثل: التحليل الأولي للمخاطر (PHA)، وتحليل الفشل الوظيفي (FFA)، ودراسات المخاطر والتشغيل (HAZOP)، وتحليل شجرة الأعطال (FTA)، وتحليل المخاطر ونقطة التحكم الحرجة (HACCP)، ونمط الفشل وتحليل التأثير (FMEA).

المشكلة محل الدراسة هي أن نظام تخطيط موارد المؤسسات يعتبر استثماراً رئيسياً للشركات، وحوالي 75٪ من مشروعات تنفيذ تخطيط موارد المؤسسات تفشل في تحقيق أهدافها. ويتطلب نظام تخطيط موارد المؤسسات تخطيطًا فعالاً حتى لا يحدث فشل تطبيق تخطيط موارد المؤسسات في تحقيق الأهداف التنظيمية [12، 13، 15، 26]. لذلك، فإن إدارة مخاطر تخطيط موارد المؤسسات مهمة جدًا للحصول على نجاح نظام تخطيط موارد المؤسسات في تحقيق متطلبات العمل. أنظمة تخطيط موارد المؤسسات المختلفة لها درجات مختلفة في الوقت اللازم للتطبيق implementation، وفي حال الاحتياج إلى قدر كبير من الضبط فإن هذا قد يكون مؤشر نحو الفشل [24].

وجد العديد من الباحثين أن ضعف تقييم المخاطر هو السبب الرئيسي الذي قد يؤدي إلى فشل تطبيق تخطيط موارد المؤسسات [27،28]. ويجب على المنظمة التحقق من صحة نظام ERP للتأكد من أن النظام يلبي متطلبات المنظمة.

يتكون هذا البحث من خمسة أجزاء: الجزء الأول هو المقدمة، والجزء الثاني يحتوي على مراجعة الدراسات السابقة، والجزء الثالث يحتوي على تحليل عوامل الفشل الرئيسية، ويتضمن الجزء 4 منهج FMEA، بينما يحتوي الجزء 5 على الاستنتاج.

2- الدراسات السابقة

هناك العديد من الباحثين المهتمين في مجالات المخاطر والفشل، ومراقبة المخاطر، وتقييم المخاطر، وإدارة المخاطر كوجهة نظر عامة. أيضاً، هناك العديد من الباحثين المهتمين في مجالات مخاطر وفشل أنظمة ERP. كان الموضوع الأكثر أهمية الذي حظي بتركيز كبير من الباحثين هو تقييم المخاطر وقياسها، وعوامل

النجاح الحرجة CSF وعوامل الفشل الحرجة CFF لتطبيقات ERP، وتصنيف المخاطر وتحديد الأولويات، ورقم أولوية المخاطر (RPN)، وأدوات تقييم المخاطر وإدارتها.

1-2 مخاطر وفشل تخطيط موارد المؤسسات

مشروعات تطبيق أنظمة تخطيط موارد المؤسسات ERP هي مشروعات محفوفة بالمخاطر، ويعد تقييم المخاطر حلاً مهمًا للغاية لتحسين ونجاح أنظمة ERP. وتتضمن عملية تقييم المخاطر كل من: تحديد المخاطر، وتحليلها، وتحديد أولوياتها، وتصنيف المخاطر على أنها مخاطر وظيفية ومخاطر التثبيت configuration risk على أجهزة الحاسب.

يعد تحليل أعطال البرامج مهمة صعبة لأنها مرتبطة بعملية الأعمال المعقدة التي تحتوي على العديد من المتغيرات مقارنة بأعطال الأجهزة التي لها متغيرات محدودة. بالإضافة إلى تحديد قوة وضعف المنظمات يمكن أن يساعد في تقليل تأثير الفشل.

2-2 معوقات تطبيق أنظمة ERP

يوجد العديد من معوقات تطبيق أنظمة ERP التي تواجه الدول النامية مقارنة بالدول المتقدمة، من أهمها:

1- العوامل المحلية للدولة المتواجد بها الشركة: تمثل التحدي الكبير أمام تطبيق أنظمة ERP، فهي تشمل البنية التحتية لتكنولوجيا المعلومات والاتصالات، والوضع الاقتصادي للبلد، وقوة الصناعة، والموقع الإقليمي، والقوانين الحكومية [16، 30، 31].
2- العوامل التنظيمية: مثل ثقافة الحاسب الآلي، ونضج تكنولوجيا المعلومات، ودعم الإدارة العليا، وحجم الأعمال، وتكلفة أنظمة ERP، وإعادة تصميم إجراءات العمل [13، 16، 30، 32، 33]. جميع المنظمات في مختلف البلدان لديها طريقة مختلفة لكيفية أداء الأعمال بسبب اختلاف إجراءات العمل والمتطلبات المحلية [30]. يعود سبب العديد من حالات فشل أنظمة ERP في مصر إلى تخصيص customization نظام ERP لمطابقة العمليات الحالية بدلاً من إعادة هيكلتها [13، 31].
3- مشاكل نقل تكنولوجيا المعلومات: القضايا الثقافية التي تواجه دول الشرق النامية عند تطبيق واستخدام التقنيات الغربية وإجراءات الإدارة ونظم وتقنيات المعلومات [13، 16، 30، 32، 33].

4- مبررات العمل: كانت معظم حالات فشل تطبيق أنظمة ERP هي تبني هذه النظم مبكراً دون وجود مبررات قوية [32].

3-2 أدوات تقييم المخاطر

هناك العديد من الأدوات التي يمكن استخدامها لإجراء تقييم المخاطر مثل: التحليل الأولي للمخاطر Preliminary Hazard Analysis (PHA)، دراسات المخاطر والتشغيل Hazard & Operability Study (HAZOP)، تحليل شجرة الأعطال Fault Tree Analysis (FTA)، تحليل المخاطر ونقطة التحكم الحرجة Hazards Analysis & Critical Control Point (HACCP)، نمط الفشل وتحليل التأثير Failure Mode & Effect Analysis (FMEA).

يتم استخدام أدوات PHA، FTA، HAZOP في المراحل المبكرة في تحليل المتطلبات وفي عملية التصميم، كما أنها تدعم التحليل الوصفي وليس الكمي [34، 35]. وهذا هو السبب في عدم تفضيل هذه الأدوات عند تطبيق أنظمة تخطيط موارد المؤسسات أنظمة ERP. أيضاً FTA لا تأخذ في الاعتبار خطورة الفشل [36]، وفي النظم المعقدة مثل ERP الذي يتضمن عدداً كبيراً من المعدات ومتغيرات العمل تصبح شجرة الأعطال معقدة وتستغرق وقتًا طويلاً حتى تكتمل، ويصبح حلها أكثر صعوبة [34، 37، 38].

تعطي منهجية FMEA وصفاً واضحاً لأنماط الفشل [41]. تستخدم منهجية FMEA الآن في مجموعة متنوعة من الصناعات مثل البرمجيات [22، 40، 42، 45]. الغرض من FMEA هو فحص أوضاع الفشل المحتملة وتحديد تأثير هذه الإخفاقات على العديد من المراحل من خلال:

- عملية تصميم Design FMEA (DFMEA)
- عملية تشغيل Process FMEA (PFMEA)
- معدات وآلات Machinery or Equipment FMEA (MFMEA)
- خدمات Service FMEA (SFMEA)

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المجلة الدولية للبحوث العلمية

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FMEA هي تقنية إستراتيجية لإنشاء عمليات خدمات خالية من الأخطاء [46]. وهي منهجية تركز على إعطاء الأولوية للفشل الحرج في تحسين السلامة [47]. يأخذ FMEA في الاعتبار كل نمط من الفشل لكل مكون من مكونات النظام [45].

وفقًا للجدول رقم (1)، استنتج الباحث أن FMEA أداة قوية لتقييم المخاطر الكمية، لذلك سوف يعتمد عليها لتقييم مخاطر مشروعات تطبيق أنظمة تخطيط موارد المؤسسات ERP في مراحل التطبيق المختلفة.

جدول رقم (1): أدوات تقييم المخاطر

معايير	التقنيات				
	PHA	FTA	HAZOP	HACCP	FMEA
تستخدم في مراحل عديدة لتطبيق أنظمة ERP	X	X	X	X	✓
	[34], [25], [48], [49]	[34]	[34]	[50]	[41], [22]
أداة قياس كمية	X	X	X	✓	✓
	[34], [25], [49]	[34], [51]	[34], [52], [21], [53]	[54]	[55]
تأخذ في الاعتبار مدي خطورة الفشل	✓	X	✓	✓	✓
	[52]	[36]	[53]	[50], [54]	[55]
إعطاء الأولوية للفشل الحرج	✓	X	✓	✓	✓
	[25]	[51]	[53]	[56]	[47], [25]
تقدم وصفًا واضحًا لوضع الفشل (سبب الخطر)	✓	✓	✓	✓	✓
	[51]	[25], [51]	[51]	[54], [56]	[41], [55], [57]
قوي في الأنظمة المعقدة مثل أنظمة ERP	✓	X	✓	X	✓
	[52]	[34], [38], [51]	[52]	[50]	[55]
تستخدم في العديد من الصناعات حول العالم بما في ذلك تطوير البرمجيات	✓	✓	X	X	✓
	[48]	[58]	[59]	[39], [25], [50] [54]	[42], [43], [22] [57], [60]
المنتج خالي من الأخطاء	✓	✓	✓	✓	✓
	[25]	[25]	[25]	[50] [54]	[22]
تشغيل الخدمات خالية من الأخطاء	✓	✓	✓	X	✓
	[25]	[51]	[53]	[50]	[46]

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3- عوامل فشل مشروعات تطبيق نظم ERP

اهتم العديد من الباحثين بعوامل الفشل الحرجة (CFFs) التي تستخدم على نطاق واسع في مجال نظام المعلومات ونظم تخطيط موارد المؤسسات ERP. تؤثر هذه العوامل على نجاح تطبيق نظم ERP [12، 13، 14]. فيما يلي أكثر عوامل الفشل شيوعاً [5، 6، 12، 42]:

- ملاءمة المنظمة: توصف بأنها التوافق بين متطلبات تخطيط موارد المؤسسات والخصائص التنظيمية.
- مهارات العمل الجماعي في تخطيط موارد المؤسسات (ERP): تحتوي على تعاون الخبراء التقنيين في ERP وخبراء الأعمال بالشركة بالإضافة إلى المستخدمين النهائيين.
- إدارة المشروع: يؤدي الافتقار إلى النواحي المعرفية والخبرة في إدارة المشروع إلى مشاكل أو فشل في إدارة مشروع تطبيق ERP.
- تصميم البرامج المكونة لنظام ERP: يجب أن يتم بجودة مقبولة قبل البدء في الاعتماد على هذا النظام.
- مشاركة المستخدم والتدريب: يحتوي على التزام المستخدم بالمشاركة في المشروع بدايةً من المراحل الأولى من المشروع. وعدم المشاركة يؤدي إلى فشل تطبيق نظم ERP. كما يجب أن يكون المستخدمون الرئيسيون راضين عن منافع النظام.
- التخطيط التكنولوجي لتكوين بنية تحتية مناسبة: يمكن أن تؤدي إلى نجاح تطبيق نظم ERP.
- توصيل التوقعات أو الأهداف على كل مستوى مطلوب لنجاح تطبيق نظم ERP.
- إدارة التغيير: يجب أن يكون لدى القائمون على المشروع مهارات إدارة التغيير، وتحتوي إدارة التغيير على إدارة التغيير في هيكل المؤسسة والثقافة السائدة فيها بما يخدم مشروع تطبيق نظم ERP.
- إعادة هندسة عمليات الأعمال (BPR): هو عامل مهم للغاية في عملية تكوين نظم ERP، حيث يجب أن تحدث إعادة الهندسة لعمليات الأعمال بشكل متكرر للاستفادة من النظام الجديد.
- دعم الإدارة العليا: يحتاج نجاح المشروع إلى تحديد المشروع كأولوية قصوى لدى الإدارة العليا.
- الدعم المالي وتحليل التكاليف: قد يؤثر على تبني الاستعانة بنظم ERP، مما يتسبب في فشل مشروعات تطبيق نظم ERP.

4- نهج FMEA

يعمل نهج FMEA على تقييم عوامل الفشل المحتملة وآثارها [64]، ويمكن لهذا النهج أن يقلل أو يتحكم في حالات الفشل المحتمل [61، 62]. مزايا استخدام FMEA تشمل [41، 42]:

- تخطيط منع الفشل.
- خفض التكلفة.
- انخفاض العمليات غير ذات القيمة المضافة.
- انخفاض تكاليف الضمان.
- زيادة موثوقية المنتج.
- تعديل أقل في التصميم.
- تخطيط أفضل للجودة.
- التحسين المستمر في تصميم العملية والمنتج.
- قبول درجة عالية من التعقيد.
- ربط النتائج مباشرة بالمخاطر الفعلية.

هناك العديد من عوامل النجاح لنهج FMEA، هي: التحديد الصحيح للمخاطر وتصنيفها، والتحكم الصحيح في عوامل إدارة المخاطر بشكل مناسب، والتحديد الصحيح للأولويات وتخصيص الموارد، ومعرفة العملية، وموثوقية نظام المعلومات، ودقة البيانات، وسلامة البيانات [42].

1-4 نهج FMEA التقليدي

يستخدم نهج FMEA من قبل العديد من الشركات في مجموعة متنوعة من الصناعات حول العالم لتحديد وترتيب الأولويات ومعالجة آثار الفشل المحتملة الرئيسية وأسباب الفشل المحتمل وعوامل التحكم التي تؤثر على نجاح تطبيق أنظمة ERP.

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4-1-1 معايير تصنيف المخاطر باستخدام FMEA

تحتوي تقنية FMEA على ثلاثة معايير لتقييم الفشل:

- شدة تأثير الفشل.
- مدى تكرار احتمال حدوث الخطر.
- مدى سهولة اكتشاف الخطر.

يجب على المشاركين تحديد درجة بين 1، 5 والاتفاق عليها لمستوى الخطورة والوقوع والكشف لكل فشل.

يتم تحديد معايير الخطورة والوقوع والكشف اعتمادًا على أنواع المشكلات في كل مرحلة من مراحل تطبيق نظم ERP قبل وأثناء وبعد:

- شدة الخطر SEV "Severity": شدة الخطر هي خطورة أو تأثير الفشل [41، 60]. معايير الخطورة موضحة كما هو موضح في الجدول رقم (2).
- الحدوث OCC "Occurrence": الحدوث هو تقييم احتمالية أن الأسباب ستحدث وتؤدي إلى الفشل [41]. معايير الحدوث الموصوفة كما هو موضح في الجدول رقم (3)، الذي يصف الحدوث ومدى تكرار السبب المحتمل لحدوث الخطر؟
- الكشف DET "Detection": تقييم احتمالي بأن الضوابط الحالية ستكتشف سبب الفشل [41]. معايير الاكتشاف الموضحة في الجدول رقم (4)، حيث يصف الاكتشاف مدى احتمالية اكتشاف سبب الفشل؟

جدول رقم (2): شدة الخطر

Severity (Effect)	Rating	Criteria
Insignificant	1	No effect on data security, integrity and/or accuracy Data can be retrieved and or stored in a normal operating environment, No hardware damage.
Minor	2	System Downtime of up to 15 minutes, but without affecting data security, integrity and/or accuracy. No hardware damage.
Moderate	3	Downtime of greater than 15 minutes and less than 1 hours and/or loss of data which has been previously backup. No hardware damage. No effect on product safety and/or quality.
Major	4	Downtime of greater than 1 hours and/or loss of data security, integrity and/or accuracy. Hardware damage that can be fixed or corrected with moderate maintenance. No effect on product safety and/or quality.
Catastrophic (very High)	5	Downtime of greater than 1 day and/or loss of data security, integrity and/or accuracy. Hardware damage that cannot be fixed and require replacement. Possible effect on product safety and/or quality.

جدول رقم (3): شدة الخطر

Occurrence	Rank	Criteria
Remote	1	Failure occurs every year or more. Ex: 1 failure per 8760 hours of operation.
Rare	2	Failure occurs every 3 months (quarter). Ex: 1 failure per 2160 hours of operation.
Occasionally	3	Failure occurs every week. Ex: 1 failure per 168 hours of operation.
Frequently	4	Failure occurs every day. Ex: 1 failure per 24 hours of operation.
Continually	5	Failure occurs every shift. Ex: 1 failure per 8 hours of operation.

جدول رقم (4): معايير الاكتشاف

Detection	Rank	Criteria
Certain	1	Controls certainly detect any potential cause, and subsequent failure. Controls will prevent a potential failure and isolate the cause.
High	2	High chance that controls will detect a potential cause, and subsequent failure. Controls will prevent a potential failure and isolate the cause.
Medium likelihood	3	Medium chance that controls will detect a potential cause, and subsequent failure. Controls will provide on an indication of potential failure and may, or may not, prevents failure.
Low likelihood	4	Controls do not prevent failure from occurring. Controls will isolate the cause and failure mode after the failure has occurred.
Remote likelihood	5	Very remote chance that controls will detect a potential cause, and subsequent failure mode, or there are no controls.

2-1-4 تحديد تصنيف المخاطر حسب الشدة والحدوث

يمكن تصنيف المخاطر بناءً على الشدة والحدوث باستخدام مصفوفة مخاطر 5X5، كما هو موضح في الجدول رقم (5). ويمكن ملاحظة الآتي:

- يتم الحصول على الدرجة القصوى 25 بضرب درجة الخطورة x مرات الحدوث.
- أقل درجة هي 1.
- تزداد المخاطر من المستوى الأدنى الزاوية اليسرى إلى الزاوية اليمنى العلوية.
- يمثل كل لون كمية المخاطر. تتطلب المنطقة الحمراء العلوية اليمنى اهتماماً خاصاً، وهذه المنطقة الحمراء الساخنة يجب أن تحظي باهتمام وبعناية شديدة، وعالج هذه التمثيلات بمبدأ باريتو.
- تحتوي منطقة اليد اليسرى السفلية على معظم المشكلات ذات المخاطر الأقل.
- تحظى المنطقة الثانية باهتمام المستوى الثاني، تليها المنطقة الصفراء.
- يتم تصنيف المخاطر اعتمادًا على شدة المخاطر وحدوثها.

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جدول رقم (5): مصفوفة تصنيف المخاطر بناءً على الشدة والحدوث

			Severity				
Occurrence			Insignificant	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
	Continually	5	5	10	15	20	25
	Frequently	4	4	8	12	16	20
	Occasionally	3	3	6	9	12	15
	Rare	2	2	4	6	8	10
	Remote	1	1	2	3	4	5

3-1-4 تقييم المخاطر

يتم تسجيل كل فشل محتمل باستخدام جدول محدد مسبقًا بناءً على تقييم فريق خبير في الموضوع subject matter expert (SME) لمساهمة العنصر موضع الخطر. يبدأ التحليل مع قيام فريق SME بتحديد جدول تسجيل للعناصر الثلاثة. باستخدام الجدول، يسجل فريق SME العناصر الثلاثة لكل فشل. يتم حساب رقم أولوية المخاطرة Risk Priority Number (RPN) لكل فشل كمنتج للدرجات لكل عنصر من الخطورة الحدوث وامكانية الكشف كما في الجدول 6.

RPN = رقم أولوية المخاطرة ، من أجل ترتيب المخاوف ، محسوبة على أنها SEV x OCC x DET

يتم تسجيل كل فشل باستخدام جدول محدد مسبقًا بناءً على تقييم فريق خبير في الموضوع (SME) لمساهمة العنصر. يبدأ التحليل مع قيام فريق SME بتحديد جدول تسجيل للعناصر الثلاثة. باستخدام الجدول، يسجل فريق SME العناصر الثلاثة لكل فشل. يتم حساب رقم أولوية المخاطرة (RPN) لكل فشل كناتج للدرجات لكل عنصر: شدة الخطورة، والحدوث، وإمكانية الاكتشاف، كما في الجدول 6.

جدول رقم (6): مدى قيمة الخطر

Risk Range	Criteria
001: 010	Insignificant
011: 050	Minor
051: 080	Moderate
081: 100	Major
100: 125	Catastrophic (Very High)

2-4 تطبيق نهج FMEA على مشروعات تطبيق نظم ERP

لتحديد أولويات عوامل الفشل الحرجة CFFs في تطبيق أنظمة ERP باستخدام نهج FMEA، يتم أخد هذه العوامل في الاعتبار كمسببات فشل محتملة في نهج FMEA [42]، وهناك خمس خطوات على النحو التالي،

الخطوة الأولى هي تحديد مواصفات الفشل المحتمل وهي عدم القدرة على تطبيق نظام ERP بصورة صحيحة، أما الخطوة الثانية فتتمثل في تحديد تأثيرات الفشل المحتملة الذي هو نتيجة فشل النظام وهو تأثير محتمل لمواصفات أسباب الفشل المحتملة أما الخطوة الثالثة وهي عدم القدرة على تطبيق نظام ERP بصورة صحيحة، والخطوة 4 الطريقة التي يمكن استخدامها لتحديد ومنع الفشل الذي يحدث في عملية تطبيق نظام ERP، وتحديد أولويات مخاطر، وأخيرا الخطوة 5 لأنماط الفشل الوصول الي رقم أولوية المخاطر (RPN) [60].

3-4 نهج FMEA المحسن

يوفر نهج FMEA المحسن تحديد وترتيب الأولويات ومعالجة تأثير الفشل المحتمل الرئيسي وأسباب الفشل المحتملة وعوامل التحكم التي تؤثر على التطبيق الناجح لأنظمة ERP. تقيس تقنية FMEA المحسّنة المخاطر بناءً على أربعة جوانب تصنيف فرعية، المالية Financial، والعملاء Customer، والقوانين المنظمة Legal & Regulation، وعمليات التشغيل Business Operation. الشكل رقم (1) يعرض نهج FMEA المحسن.

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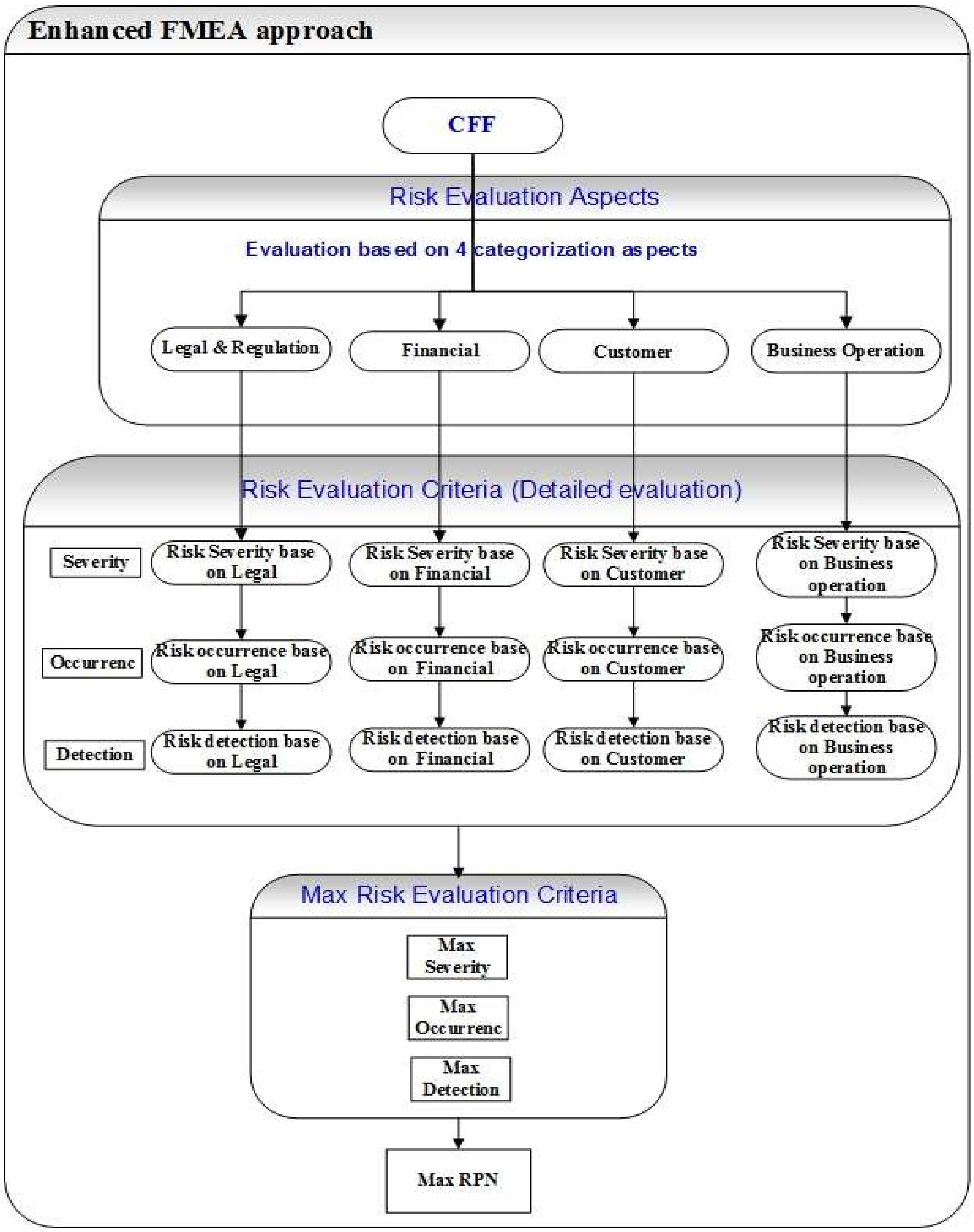

الشكل رقم (1): نهج FMEA المحسن

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1-3-4 معايير تصنيف تقييم المخاطر

استخدام تقنية FMEA المحسنة لحساب ثلاث قيم وهي:

- شدة الخطر القصوى Max Severity
- أقصى احتمالية حدوث Max Occurrence
- امكانية الكشف القصوى .Max Detection

يجب على المشاركين تحديد درجة بين 1، 5 والاتفاق عليها لمستوى الخطورة واحتمالية الحدوث وامكانية كشف الخطر لكل جوانب تصنيف فرعي للفشل. هناك امتداد أخر في طريقة الحساب لمعايير مستوى الخطورة واحتمالية الحدوث وامكانية كشف الخطر بناءً على أربعة جوانب تصنيف فرعية، وهي المالية، والعميل، والقوانين المنظمة، وعمليات التشغيل. سيحدد حساب مستوى الخطورة واحتمالية الحدوث وامكانية كشف الخطر بناءً على جوانب التصنيف الفرعية الأربعة التي توضح من خلال الجدول رقم (8).

الجدول رقم (8): جوانب التصنيف الفرعية الأربعة

		Aspect			
Criteria		**Legal & Regulation**	**Financial**	**Customer**	**Business Operation**
	Severity	Risk Severity based on Legal	Risk Severity based on Financial	Risk Severity based on Customer	Risk Severity based on Business operation
	Occurrence	Risk occurrence based on Legal	Risk occurrence based on Financial	Risk occurrence based on Customer	Risk occurrence based on Business operation
	Detection	Risk detection based on Legal	Risk detection based on Financial	Risk detection based on Customer	Risk detection based on Business operation

أقصى درجة خطورة "MSEV":

باستخدام معايير الخطورة الموضحة في جدول رقم (2)، يتم تحديد الحد الأقصى من الشدة من خلال المقارنات بين الجوانب الأربعة لمعايير الشدة، "شدة المخاطر على أساس قانوني، وشدة المخاطر على أساس المالية، وشدة المخاطر على أساس العميل، وشدة المخاطر على أساس عمليات التشغيل".

MSEV = الحد الأقصى (شدة المخاطر على أساس قانوني، وشدة المخاطر على أساس المالية، وشدة المخاطر على أساس العميل، وشدة المخاطر على أساس عمليات التشغيل)

الحد الأقصى لإمكانية حدوث الخطر "MOCC":

يساعد تطوير جداول التصنيف القصوى للمخاطر في عملية اتخاذ القرار. تستخدم معايير تصنيف المخاطر القصوى مصفوفة مخاطر 5 * 5 كما هو موضح في جدول رقم (9)، ويتم الحصول على الدرجة القصوى 25 بضرب أكبر درجة خطورة X أكبر درجة حدوث، وأقل درجة هي 1. تزداد المخاطر من المستوى الأدنى منطقة اليد اليسرى إلى منطقة اليد اليمنى العليا. يمثل كل لون مناطق ذات قيمة متساوية للمخاطر. تتطلب المنطقة الحمراء العلوية اليمنى اهتماماً خاصاً، وهذه المنطقة الحمراء الساخنة يجب أن تحظي بعناية شديدة، وتعالج هذه المشكلات بمبدأ باريتو. تحتوي المنطقة اليسرى السفلية على معظم المشكلات ذات المخاطر الأقل. تحظى المنطقة الثانية باهتمام المستوى الثاني، تليها المنطقة الصفراء. يتم حساب معايير تصنيف إدارة المخاطر اعتمادًا على الحد الأقصى من الشدة والحد الأقصى لحدوث المخاطر.

يتم عرض معايير معدل حدوث الخطر في جدول رقم (3). تحديد الحد الأقصى لحدوث الخطر من خلال المقارنات بين الجوانب الأربعة لمعايير الحدوث، "حدوث المخاطر على أساس قانوني، وحدوث المخاطر على أساس المالية، وحدوث المخاطر على أساس العميل، وحدوث المخاطر على أساس عمليات التشغيل".

MOCC = الحد الأقصى (معدل حدوث المخاطر على أساس قانوني، معدل حدوث المخاطر على أساس مالي، معدل حدوث المخاطر بناءً على العميل، حدوث المخاطر بناءً على عمليات التشغيل)

جدول رقم (9): الحد الأقصى لإمكانية حدوث الخطر

Max Occurrence			Max Severity				
			Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
			1	**2**	**3**	**4**	**5**
	Continually	**5**	5	10	15	20	25
	Frequently	**4**	4	8	12	16	20
	Occasionally	**3**	3	6	9	12	15
	Rare	**2**	2	4	6	8	10
	Remote	**1**	1	2	3	4	5

إمكانية الكشف القصوى للخطر "MDET":

باستخدام معايير إمكانية كشف الخطر موضحة في جدول رقم (6)، يتم تحديد الحد الأقصى للاكتشاف من خلال المقارنات بين الجوانب الأربعة لمعايير الكشف، "الكشف عن المخاطر على أساس قانوني، واكتشاف المخاطر على أساس المالية، واكتشاف المخاطر على أساس العميل، واكتشاف المخاطر على أساس عمليات التشغيل".

MDET= الحد الأقصى (الكشف عن المخاطر على أساس قانوني ، اكتشاف المخاطر على أساس مالي ، اكتشاف المخاطر بناءً على العميل ، اكتشاف المخاطر بناءً على عمليات التشغيل)

1-3-4 معايير التصنيف القصوى لتقييم المخاطر

يساعد تطوير جداول التصنيف القصوى للمخاطر في عملية اتخاذ القرار. تستخدم معايير تصنيف المخاطر القصوى مصفوفة مخاطر 5 * 5 كما هو موضح في جدول رقم (9)، ويتم الحصول على الدرجة القصوى 25 بضرب أكبر درجة خطورة X أكبر درجة حدوث، وأقل درجة هي 1. تزداد المخاطر من المستوى الأدنى منطقة اليد اليسرى إلى منطقة اليد اليمنى العليا. يمثل كل لون مناطق ذات قيمة متساوية للمخاطر. تتطلب المنطقة الحمراء العلوية اليمنى اهتمامًا خاصًا، وهذه المنطقة الحمراء الساخنة يجب أن تحظي بعناية شديدة، وتعالج

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هذه المشكلات بمبدأ باريتو. تحتوي المنطقة اليسرى السفلية على معظم المشكلات ذات المخاطر الأقل. تحظى المنطقة الثانية باهتمام المستوى الثاني، تليها المنطقة الصفراء. يتم حساب معايير تصنيف إدارة المخاطر اعتمادًا على الحد الأقصى من الشدة والحد الأقصى لحدوث المخاطر.

يتم تسجيل كل فشل محتمل باستخدام جدول محدد مسبقًا بناءً على تقييم من فريق خبير في الموضوع (SME)لمساهمة العناصر المهددة بالخطر. يبدأ التحليل مع قيام فريق SME بتحديد جدول تسجيل للعناصر الثلاثة. باستخدام الجدول، يسجل فريق SME العناصر الثلاثة لكل فشل محتمل. استنادًا إلى أربعة جوانب التصنيف الفرعية المالية (F) ، والعميل (C) ، والقوانين المنظمة (L) ، و عمليات التشغيل (B) ، يتم حساب رقم أولوية المخاطر القصوى (MRPN) لكل فشل محتمل كناتج ضرب للدرجات لكل العناصر و هي الخطورة القصوى ، الحد الأقصى لاحتمالية الحدوث و الحد الأقصى لإمكانية اكتشاف الخطر كما في جدول رقم (10) والشكل 1.

رقم أولوية المخاطر القصوى من أجل تصنيف الخطر ، محسوب على أنه MRPN = MSEV x MOCC x MDET.

يصف المثال جوانب التصنيف الفرعية الأربعة المتعلقة بالمخاطر، إذا استخدمت الشركة تطبيقات غير قانونية، بناءً على الجوانب القانونية والتنظيمية، فستتلقى الشركة شكاوى من مالك التطبيق، وبناءً على الجوانب المالية، ستدفع الشركة الكثير من المال للشكاوى بناءً على جانب التشغيل التجاري، قد يكون تعطل النظام وعدم وجود صيانة تشغيلية، وبناءً على جانب العميل، قد يكون نظام الفواتير للتطبيقات غير القانونية غير مستقر مما يعرض الشركة لفقدان عملائها.

جدول رقم (10): نهج FMEA المحسن

Process step	Potential failure	FSEV	CSEV	LSEV	BSEV	MSEV	Potential causes	FOCC	COCC	LOCC	BOCC	MOCC	RATE	FDET	CDET	LDET	BDET	MDET	MRPN	Actions recommended	Responsibility	New MSEV	New MOCC	New RATE	New MDET	New MRPN

حيث يشير FSEV إلى شدة المخاطر على أساس الجانب المالي، ويشير CSEV إلى درجة خطورة المخاطر بناءً على جانب العميل، ويشير LSEV إلى شدة المخاطر بناءً على الجانب القانوني والتنظيمي، ويشير BSEV إلى شدة المخاطر بناءً على جانب عمليات التشغيل، ويشير MSEV إلى الحد الأقصى من الخطورة، ويشير FOCCإلى حدوث المخاطر بناءً على الجانب المالي، ويشير COCC إلى حدوث المخاطر بناءً على جانب العميل، ويشير LOCC إلى حدوث المخاطر بناءً على الجانب القانوني والتنظيمي، ويشير BOCC إلى حدوث المخاطر بناءً على جانب عمليات التشغيل، ويشير MOCC إلى الحد الأقصى لإمكانية حدوث الخطر، ويشير FDETإلى الكشف عن المخاطر على أساس الجانب المالي، ويشير CDET إلى اكتشاف المخاطر بناءً على جانب العميل، ويشير LDET إلى اكتشاف المخاطر على أساس الجانب القانوني والتنظيمي، ويشير BDET إلى اكتشاف المخاطر بناءً على جانب عمليات التشغيل، ويشير MDET إلى الحد الأقصى لإمكانية اكتشاف الخطر، ويشير MRPN إلى رقم أولوية المخاطرة القصوى، ويشير MSEV New إلى الحد الأقصى من الخطورة الجديد، ويشير MOCC New إلى الحد الأقصى للحدوث الجديد، ويشير MDET New إلى الحد الأقصى لإمكانية اكتشاف الخطر الجديد، ويشير MRPN New إلى رقم أولوية المخاطرة القصوى الجديد.

5- الاستنتاجات

نخلص إلى أن أنظمة ERP معقدة ومتعددة الوظائف تتحكم في جميع أنشطة المنظمة. وتعتبر مشروعات تطبيق أنظمة ERP الناجحة واحدة من الكفاءات الأساسية لأي منظمة. تتضمن تنفيذ أنظمة ERP العديد

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من المخاطر التي يجب معالجتها والتحكم فيها على أسس علمية. تحتوي أنظمة ERP على معدل فشل مرتفع يجب معرفتها وينخفض في كل مراحل تطبيق أنظمة ERP، قبل التنفيذ، وأثناء التنفيذ وبعده. باستخدام تقنية CFF المفيدة لتحديد حالات الفشل الرئيسية وعوامل الفشل المتعلقة بتطبيق أنظمة ERP، ومن المفيد جدًا تطبيق تقنية FMEA المحسّنة في المراحل الثلاث من تطبيق أنظمة ERP، قبل وأثناء وبعد تطبيق أنظمة ERP، وهناك ثلاثة معايير مهمة في FMEA، مستوى الخطورة واحتمالية الحدوث وإمكانية كشف الخطر. تقنية FMEA المحسّنة مفيدة للمساعدة في زيادة معدل نجاح مشاريع تطبيق أنظمة ERP، يساهم الباحث في تصميم تقنية FMEA المحسّنة استنادًا إلى أربعة جوانب تصنيف فرعية، المالية "Financial"، والعملاء "Customer"، والقوانين والقواعد المنظمة للصناعات "Legal & Regulation"، والعمليات الإنتاجية "Business Operation".

بالنسبة للعمل المستقبلي في هذا المجال، تعتمد عوامل الخطر بشكل كبير ويعتمد قبول قيم المخاطر على نوع الصناعة. لذلك، قد يحتاج مستوى قبول المخاطر إلى مزيد من التحسينات ليتم تبريره تلقائياً دون تدخل من الإنسان. سيقوم الباحث بتطبيق التقنية المقترحة في العديد من مشاريع تطبيق أنظمة ERP.

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"Improved Scrum Framework using Agile Features"

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Abstract:

This paper provides an enhanced Scrum framework that combines some practices of eXtreme Programming (XP) approach in Scrum framework to gain quality software on time. XP and Scrum are two agile software development methods. While Scrum is focused on project management, XP is focused on Software development; nevertheless, they both can be used to participate in the development of any software project independently or together. This paper presents the main concepts, features, phases, artifacts, and roles of Scrum as well as a brief introduction to XP and its practices. In this paper, the researchers present how to combine some XP practices into Scrum activities. The researchers exploit the features and best practices of the two methods to propose an improved Scrum framework that includes guidelines for achieving each Scrum activity or process. So, the improved Scrum framework is more applicable than many previous attempts in this domain. The improved Scrum framework has been validated by a group of 40 experts and specialists in agile software projects.

Keywords:

Scrum; Agile Methods Software Development; XP Approach; Agile Best Practices; Software Project.

1- Introduction and Problem Definition

Recently, agile software development methods have gained popularity and are increasingly important to a significant number of software development organizations [2]. The use of agile methodologies enables software developers to produce higher-quality software in a shorter period [8]. Agile software development methods include XP, Scrum, Crystal, Feature Driven Development (FDD), Dynamic System Development Methodology (DSDM), and Adaptive Software Development (ASD) [4].

Scrum was introduced by Ken Schwaber and Jeff Sutherland in 1995. They also held an implementation workshop at OOPSLA ’95 in Austin, Texas [25]. It is an agile software development framework that is widely used to achieve the agility, iterative, and incremental development in the software field. It is used for managing software projects in a changing environment [21]. Scrum is not a process or a technique for building products; rather, it is a framework within which we can employ various processes and techniques [13]. Scrum has the advantage of being very visible and its focus on functional software shows results to management that they can see and get excited about [24]. It increases revenues generated through the provided software. A well-functioning Scrum will deliver the highest business value features first and will avoid building features that will never be used by the customer [6]. Scrum has been adopted by large companies such as Yahoo!, Microsoft, Intel, and Nokia [2].

XP was developed at Chrysler by Kent Beck while working on a payroll project as a member of a 15-person team. Beck continued to refine and improve the XP methodology after the project was completed until it gained worldwide acceptance in 2000 and 2001 [8]. XP software development process focuses on iterative and rapid development [21]. XP approach stresses communication and coordination among the team members always; and requires cooperation between the customer, management and development team to form the supportive business culture for the successful implementation of XP [1]. XP is designed for use in an environment of rapidly changing requirements.

While Scrum is focused on project management, XP is focused on software development. Each of them is used independently to produce software products. Any software project needs both management skills and software engineering practices. Therefore, focusing on either management skills or software engineering practices doesn't guarantee the success of the software projects. In other words, in case of using Scrum individually, the absence of good practices of software development will not lead to a quality software product even though there are good management skills. Similarly, in case of using XP individually, the absence of good management skills will not lead to a quality software product. Many research and surveys proved that Scrum and XP provide complementary practices and rules [3, 9, 11]. In addition, increasing number of surveys is supporting the anecdotal evidence that variations of combination of Scrum with XP are the most popular agile methods [26]. This finding is backed up by the results of surveys conducted by VersionOne that report on the status of organizations currently implementing or practicing agile methods.

Therefore, this paper proposes an improved Scrum framework that combines some XP practices into Scrum framework. The enhanced Scrum framework shows the cooperative relationship between Scrum and XP. The enhanced Scrum framework includes the Scrum activities and guidelines for achieving each activity. So, the improved Scrum framework is more applicable than many previous attempts in this domain. The improved Scrum framework may increase the success of software projects. The improved Scrum framework has been validated by a group of 40 experts and specialists in agile software projects.

2- Scrum Framework

Scrum is a project management framework that can manage and control software development. The Scrum name is derived from a strategy used in Rugby match where the ball is passed among team members to move the ball down the field. Scrum moves a project forward by improving communication and collaboration among team members and breaking the work into a series of sprints. In more detail, the Scrum framework consists of Scrum teams and their associated roles, events, artifacts, and rules. Each component within the framework serves a specific purpose and is essential to Scrum's success and usage [13]. Table (1) illustrates the components of the Scrum framework and their items that will be explained in more detail in the following subsections.

Figure (1) illustrates a graphical representation of the typical Scrum framework that shows its components. Depending on table (1) and figure (1), the researchers extract the main activities that are performed within the Scrum framework and relate its components. The Scrum activities are:

1. Preparing product backlog.
2. Sprint planning meeting and preparing sprint backlog.
3. Sprint.
4. Daily Scrum.

5. Sprint review and presenting an increment.
6. Sprint retrospective.

These activities represent a simple and cohesive framework that will be used by the researchers to explain his main contribution in sections (5) and (6). In the following subsections, a summary of each component of the typical scrum framework will be provided.

Table (1): Scrum Framework - The Components and their Items.

Scrum Component	Items or Description
Scrum Team	Scrum team includes of three roles: Product Owner, Development Team, and Scrum Master.
Scrum Events	Scrum events include of five events: Sprint, Sprint Planning Meeting, Daily Scrum, Sprint Review, and Sprint Retrospective.
Scrum Artifacts	Scrum artifacts include of three artifacts: Product Backlog, Sprint Backlog, and Increment.
The Rules of Scrum	The rules of Scrum bind together the events, roles, and artifacts, governing the relationships and interaction between them.

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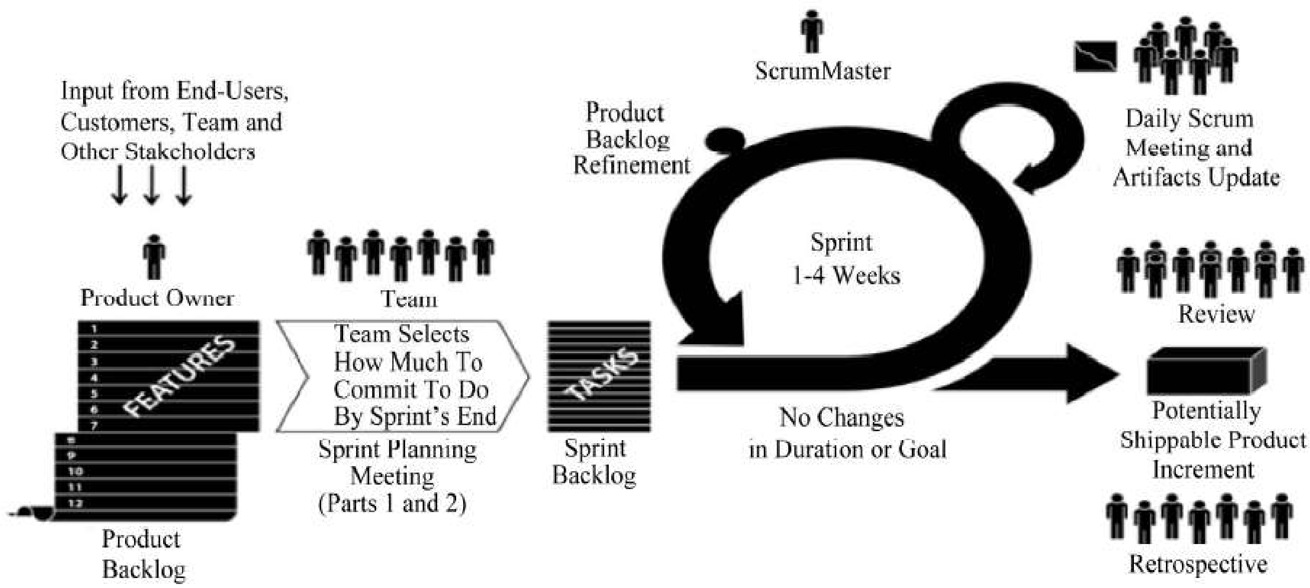

Figure (1): The Scrum Framework [23].

2-1 Scrum Team and Roles

Scrum Teams are self-organizing and cross-functional [13, 24]. Scrum team is designed to optimize flexibility, creativity, and productivity. Scrum team has three roles of people: product owner, Scrum master, and development team [25].

- Product owner is the person who is responsible for creating and prioritizing the Product Backlog, choosing what will be included in the next iteration/Sprint, and reviewing the system (with other stakeholders) at the end of the Sprint [15].
- Scrum master is responsible for ensuring that Scrum values, practices, and rules are understood and enforced. The Scrum master is responsible for facilitating Scrum events, conducting daily Scrum meeting, reviewing and evaluating sprint, removing obstacles, motivating the team, participating in product development, coaching development team.

- Development team is responsible for designing, building, and testing the desired product [14]. The development team is typically five to nine people in size; its members must have all the skills needed to produce quality software. Development team is self-organizing and cross-functional; thus the team members perform all design, development, and tests together. They have full authority to do whatever is necessary to achieve the sprint goal .

2-2 Scrum Events

Prescribed events are used in Scrum to create regularity and to minimize the need for meetings not defined in Scrum [13]. Every event in Scrum has a time-box that implies a maximum duration. Scrum events consist of sprint, sprint planning meeting, daily Scrum, sprint review, and sprint retrospective.

- Sprint: The heart of Scrum is a Sprint, a time-box of one month or less during which a “Done”, useable, and potentially releasable product increment is created [13]. During the sprint, the team is supposed to have full authority over its actions and no external influence from the product owner, or anybody else, is allowed [2].
- Sprint planning meeting: During sprint planning, the product owner and development team agree on a sprint goal that defines what the upcoming sprint is supposed to achieve [14]. Using the sprint goal, the development team reviews the product backlog to identify the highest priority items that will be included and accomplished in the upcoming sprint.
- Daily Scrum: Crucial to the sprint phase are Scrum meetings, which are held daily to determine the progress of the release and to respond to problems encountered along the way. Daily Scrum meeting is a 15-minute time-boxed event led by the Scrum master, who asks the same three questions to each team member every day to evaluate the development progress:

1. What did you do yesterday?
2. What will you do today?
3. What's in your way?

- Sprint review: A sprint review is held at the end of the sprint to inspect the increment and adapt the product backlog if needed [13]. In the sprint review, the Scrum team and stakeholders collaborate about the work was done in the sprint and the next things that could be done. In the sprint review, the presentation of the increment is intended to elicit feedback and foster collaboration.
- Sprint retrospective: The Sprint Retrospective frequently occurs after the sprint review and before the next sprint planning [14]. It is useful for the Scrum team to inspect itself and identify the possible improvements to be considered during the upcoming sprint.

2-3 Scrum Artifacts

Scrum artifacts consist of product backlog, sprint backlog, and increment [13].

- Product backlog: The first activity of the product owner is to visualize the product and generate a refined and prioritized list of tasks which defines the product [25]. Then, she/he communicates it in the form of an ordered list known as the product backlog. The product backlog evolves as the product evolves. For ongoing product development, the product backlog might also contain new features, changes to existing features, defects needing repair, technical improvements, and so on [14].
- Sprint Backlog: The Sprint Backlog is the set of Product Backlog items selected for the Sprint plus a plan for delivering the product Increment and realizing the Sprint Goal. The Sprint Backlog is a forecast by the Development Team about what functionality will be in the next Increment and the work needed to deliver that functionality [13].

- Increment: The Increment is the total of all the product backlog items accomplished during the current sprint and all previous sprints. At the end of each sprint, the product owner will receive a deliverable, and will be able to see the incremental growing of the product [7].

3- XP Practices

XP is a software development methodology that does not rely on any particular tool, but rather is based on the common understanding of fundamental values and on a disciplined application of best practices [16, 22]. In addition, XP approach can be viewed as life cycle phases that include six phases. Table (2) illustrates the value, practices, and phases of XP approach. This paper focuses on XP practices.

Table (2): XP Approach – Values, Practices, and Phases.

XP Component	Items or Description
XP Value	XP is based on four values: • Simplicity • Communication • Feedback • Courage
XP Practices	XP values are implemented with twelve practices: • Planning Game • Small Releases • Metaphor • Simple Design • Testing • Refactoring • Pair Programming • Collective Code Ownership • Continuous Integration • 40-hour Week • On-site Customer • Coding Standard
Phases **(XP Process)**	The Phases of XP Approach: 1.Exploration 2.Planning 3.Iterations to Release 4.Productionizing 5.Maintenance 6.Death

XP approach is based on four main values: simplicity, communication, feedback, and courage. XP values are implemented with twelve core practices. There are mutual relationships among XP practices because each XP practice requires the other practices to be performed with an accepted level of quality.

- Planning Game: The planning game embodies the tension between what the customer wants and what the developers can deliver by allowing each of them to order the user stories by value and risk respectively [19]. The developers estimate the effort required to implement customers' stories and show the results to the customers to decide on the scope and timing of releases.
- Small Releases: The development is divided into a sequence of small iterations, each implementing new features separately testable by the customer [5]. These short iterations of 3-4 weeks accelerate the software delivery. At the end of a release, the customer reviews the software product to determine defects and adjust future requirements to be achieved in a new iteration. This process is repeated a little number of times till an initial version of the software is put into production.
- Metaphor: The metaphor is used to guide all team members with a simple, shared story of how the overall system works [18]. It is an effective way of getting all members of the project team to visualize the project. It provides inspiration, vocabulary, and basic architecture of the system.
- Simple Design: In XP, developers use the simplest possible design that will satisfy the current needs. The right design of the software at any given time is the one that runs all the tests, has no duplicated logic, states every intention important to the programmers, and has the fewest possible classes and methods [10].
- Testing: Sometimes, this practice is called "test first" because tests in XP must be created prior to coding. All code must have automated unit tests and

acceptance tests, and must pass all tests before it can be released [5]. The result is a program that becomes more and more confident over time.

- Refactoring: Refactoring is the process of restructuring the system without changing its behavior to remove duplication, improve communication, simplify, or add flexibility [18]. Refactoring throughout the development process saves time of development and increases quality.
- Pair Programming: Pair Programming means that two programmers work together to accomplish a development task using one shared computer. Pair programming provides an immediate peer review of code and its intended test case, and is one of the main reasons that XP induces quality into the code work product [4]. Moreover, it reduces the time required for task completion and it is useful in complex tasks and training.
- Collective Code Ownership: Once code and its associated tests are checked into the code base, the code can be altered by any team member. This collective code ownership provides each team member with the feeling of owning the whole code base and prevents bottlenecks that might have been caused if the "owner" of a component was not available to make a necessary change [15].
- Continuous Integration: In XP, all changes are integrated and tested every few hours, or at least daily in the worst case [4]. All tests are run, and they have to be passed for accepting the changes in the code. XP team integrates and builds the software multiple times per day. Continuous integration helps the team to solve the development conflicts and participates in improving the quality of the development process.
- 40-Hour Weeks: In XP, the developers should not work more than 40-hour weeks. The people perform best and most creatively if they are rested, fresh, and healthy [22].

- On-Site Customer: A customer always works with the development team to answer questions, perform acceptance tests, and ensure that development is progressing as expected. This customer-driven software development led to a deep redefinition of the structure and features of the system [5]. It supports customer-developer communication [12].
- Coding Standards: This practice indicates that the developers must agree on a common set of rules enforcing how the system shall be coded. This makes the understanding easier and helps in producing a consistent code. Coding standards are almost unavoidable in XP, due to the continuous integration and collective ownership properties.

4- Previous Attempts of Combining Scrum and XP

There were many attempts to combine Scrum framework and XP approach. In the following, some of these attempts are briefly introduced:

- Jorge Edison Lascano dedicated a great part of his paper to provide an overview of software development phases, Scrum, and XP [9]. He presented the characteristics shared by XP and Scrum. He considered that Scrum can be viewed as a wrapper to XP projects. XP fits inside the sprint phase in Scrum. In other words, XP practices: simple design, testing, refactoring, pair programming, collective ownership, continuous integration, and coding standards can be used inside the sprint phase. He didn't present how they can be used.
- Kane Mar and Ken Schwaber found that Scrum and XP provide complementary practices and rules [11]. They overlap at the planning game (XP) and Sprit planning (Scrum). Both encourage similar values, minimizing otherwise troublesome disconnects between management and developers. Combined, they provide a structure within which a customer can evolve a software product that

best meets his or her needs and can implement quality functionality incrementally to take advantage of business opportunities. Following are several shared practices that facilitate this functionality: iterations, increments, emergence, self-organization, and collaboration. Iterations mean that all work is done iteratively, with the ability of the customer to direct the project through iterations. Increments mean that every iteration produces an increment of the customer's highest-priority functionality. If desired, the customer can direct the developers to turn these increments into live, operational functionality at any time. Emergence means that only the functionality that the customer has selected for the next iteration is considered and built. The customer doesn't pay for functionality that he or she might not select, and the developers don't have to code, debug, and maintain irrelevant code. Self-organization means that the customer says what he or she wants; development determines how much they can develop during an iteration and figures out the tasks to do so. Collaboration means that business and engineering collaborate about how best to build the product and what the product should do between iterations. They illustrated some important data about the application of Scrum and XP in two projects. They illustrated briefly the use of Scrum to manage the steps taken to develop software, in conjunction with the use of XP practices to ensure the quality of the software.

- Bashir and Qureshi proposed a framework that is based on a combination of the strengths of Rational Unified Process (RUP), XP and SCRUM to be used for small, medium and large projects [17]. Their framework focused on modifying RUP using XP and scrum. RUP is an object-oriented process model that takes an incremental and iterative approach and is based on sound software engineering principles. It describes well defined discipline that acts as a skeleton for all kinds of projects, especially for large scale but doesn’t give best engineering practices to achieve simplicity, reliability, and quick adaptation to changing requirements. Scrum provides the best mechanism to manage and track the application development but lacks structured approach and best engineering practices. XP has best engineering practices, but lacks structured and formalized nature as well as lack of best managerial aspects. I find that the proposed framework provides a preliminary idea of merging the three approaches, but it doesn't achieve the agility because it tends to RUP.

- Malhotra and Chug proposed "IXSCRUM" which is a framework that integrates Scrum and XP [3]. This model was based on merging the processes of Scrum and XP to achieve higher quality. This model has the engineering approach of XP along with the management approach of Scrum. The authors tried to ensure the suitability of this approach by applying it on a Shopping application which involves buying products from the categories like hardware goods, software goods etc. HP's Quick Test Professional was chosen as a testing tool. I find that this merging isn't practical and need a lot of efforts to be executed. In other words, the model doesn't include guidelines or details needed for applying the model.

Finally, most of the efforts that were made to combine Scrum and XP is not enough because most of them don't introduce a guide that includes the activities and steps of applying their combination. In addition, some efforts decrease the agility. Therefore, this paper focuses on introducing an enhanced Scrum framework that includes guidelines for applying it.

5- The Stages of Preparing the Enhanced Scrum Framework

This paper proposes an enhanced Scrum framework that combines some XP practices into Scrum framework activities to enhance it. The enhanced Scrum framework includes a set of elaborated guidelines that are required to achieve each Scrum activity. Then, these guidelines are validated to reach the final enhanced Scrum framework. The stages of preparing the enhanced Scrum framework are shown in figure (2) and will be explained in the following subsections. The stages are:

1- Preparing the outline of the enhanced Scrum framework.
2- Elaborating a preliminary set of guidelines.
3- Validating the guidelines.
4- Finalizing the guidelines.

5-1 Preparing the Outline of the Enhanced Scrum Framework

The researchers studied many attempts of combining Scrum and XP and quality improvements of software projects that were based on Scrum, XP, or both. Also, the researchers studied in detail the features of Scrum and XP. The main sources of this stage are papers, books, technical reports, and opinions of experts published on the web sites. At the end of this stage, the researchers concluded that the Scrum framework activities can be enhanced by a set of XP practices.

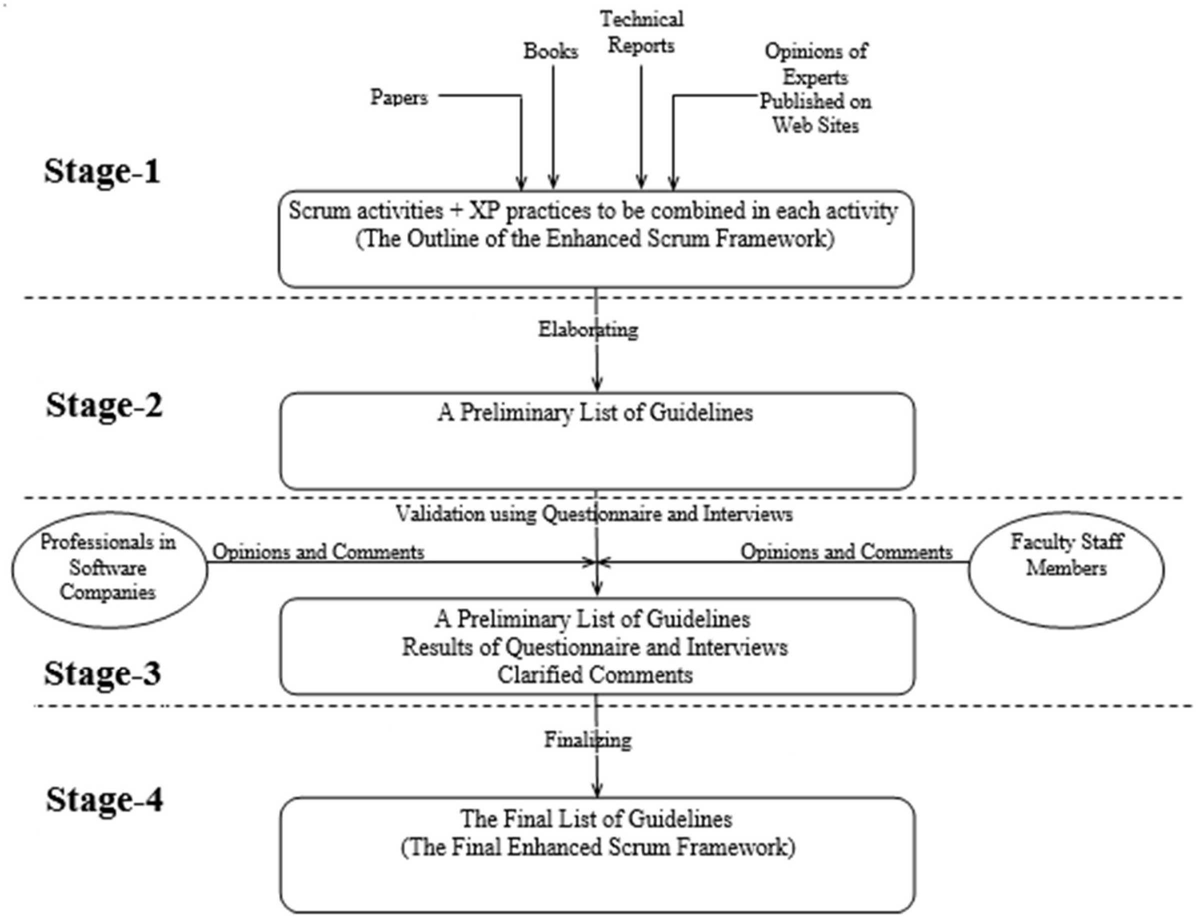

Figure (2): The Stages of Preparing the Enhanced Scrum Framework.

Table (3) illustrates the Scrum activities and XP practices to be combined in each activity. In table (3), the researchers used the Scrum framework activities that mentioned at the beginning of section (2). These activities are: preparing product backlog, sprint planning meeting and preparing sprint backlog, sprint, daily Scrum, sprint review and presenting an increment, and sprint retrospective. XP practices that should be combined with each Scrum activity are shown in the table. This table is the base of the enhanced Scrum framework that shows the cooperative relationship between Scrum and XP. In addition, this table represents the outline of the enhanced Scrum framework. In the following subsections, more efforts will be done to complete the details of this outline framework.

Table (3): Scrum Activities and XP Practices.

Scrum Activity	XP Practices to be Combined in the Activity
• Preparing Product Backlog	• Simple Design
• Sprint Planning Meeting and Preparing Sprint Backlog	• Simple Design • User Stories (it is XP feature)
• Sprint	• Testing • Pair Programming • Coding Standards
• Daily Scrum	-
• Sprint Review and Presenting an Increment	• Refactoring • Continuous Integration • Collective Code Ownership
• Sprint Retrospective	-

5-2 Elaborating a Preliminary Set of Guidelines

The researchers elaborated a preliminary set of guidelines for achieving each activity in the Scrum framework taking into consideration XP practices that increase the quality of performing this activity. Table (4) illustrates a sample of the guidelines for the activity titled “Sprint Planning Meeting and Preparing Sprint Backlog”. During this activity, the XP practice titled "simple design" can be used in planning the sprint goal. In general, the researchers consider the simplicity and understandability during the formation of the guidelines of all Scrum activities.

Table (4): Sample of the Preliminary Guidelines of a Scrum Activity.

Scrum Activity	Guidelines
Sprint Planning Meeting and Preparing Sprint Backlog	1. The Scrum master calls a sprint planning meeting that must be attended by the whole team and the product owner. 2. The attendees decide the sprint duration that may range from one week to one month. The maturity of the team is one of the factors that are considered when taking this decision. 3. The product owner and development team identify a sprint goal and agree on it. 4. The team and Scrum master select a section of items/features from the top of the product backlog that can be achieved in the sprint duration. 5. The product owner presents each item and explains how it is working from a functional perspective. The whole team discusses the item in detail. The product owner can use the concept of writing 'User Stories' which are used in XP. 6. The Scrum master and the team estimate and calculate the team's sprint budget. This is the available number of hours the team has to actually work on the sprint. 7. The Scrum master and the team break the requirements into tasks that are necessary to make the product backlog item complete and potentially shippable within the sprint. The Scrum master and the team agree on a definition of "done", so everyone is aware what will have to be completed and included in the estimates. 8. The team and Scrum master must keep tasks small and estimate all tasks in hours. Ideally task estimates should be no more than one day. 9. The team and Scrum master add up all the task estimates for the selected product backlog items. If they are significantly over the team's sprint budget, the number of selected product backlog items must be reduced. 10. The team should commit to delivering the sprint backlog.

5-3 Validating the Guidelines

The researchers planned to validate the elaborated guidelines using a questionnaire that must be answered by a set of 60 experts and specialists. The respondents were originally classified into two groups equal in the number of members; where the first group includes 30 faculty staff members who are interested in software projects, agile methods, and quality assurance. The second group includes 30 professionals who work in software companies that have some attempts of using agile methods in their software projects. The actual number of respondents who completed the questionnaires were 40; 21 from the first group and 19 from the second group.

For the purpose of validation, the researchers designed a simple questionnaire as shown in figure (3) that gives the respondent a space to set his comments on each guideline. Then, the researchers sent the questionnaire form by email to the two groups. The researchers showed in the email the purposes of the questionnaire and determined two weeks for answering it and resend. After collecting the responses, the researchers held an interview with each respondent individually to discuss his comment on each guideline to reveal the ambiguity and to reach to a clarified comment.

Figure (3): Sample of the Questionnaire - Validation of the Guidelines.

Important Notes:
- If you agree on the guideline, please put (✓) on OK
- If you don't agree on the guideline, please put (✓) on NO and give your comment below
- If you see that the guideline must be modified, please put (✓) on MODIFY and give your comment below

Scrum Activity	Guidelines	Opinion and Comments
Sprint Planning Meeting and Preparing Sprint Backlog	1. The Scrum master calls a sprint planning meeting that must be attended by the whole team and the product owner.	☐ OK ☐ NO ☐ MODIFY Comments: ....
	2. The attendees decide the sprint duration that may range from one week to one month. The maturity of the team is one of the factors that are considered when taking this decision.	☐ OK ☐ NO ☐ MODIFY Comments: ....
	3. The product owner and development team identify a sprint goal and agree on it.	☐ OK ☐ NO ☐ MODIFY Comments: ....
	4. ...	
	5. ...	

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5-4 Finalizing the Guidelines

After reaching the clarified comment on each guideline, the researchers studied it carefully to form the final one. In section (6), a final list of guidelines will be presented for each Scrum activity. Some important results extracted from the questionnaire are valuable to be stated in the following:

- 61 % of the guidelines had the answer “OK” and they didn’t need any modifications.
- 8 % of the guidelines had the answer “NO” and they were eliminated.
- 31 % of the guidelines had the answer “MODIFY” and they were subjected to modifications. Some modifications were done to reveal the ambiguity and the confusion in meaning. Other modifications were done to rearrange the sequence of some guidelines. Also, there were some modifications that were done to add or remove guidelines.

6- The Enhanced Scrum Framework

The enhanced Scrum framework combines some XP practices into Scrum activities to enhance them. Also, it includes a set of guidelines that are required to achieve each Scrum activity. In the following subsections, a final list of guidelines will be presented for each Scrum activity.

6-1 Preparing Product Backlog

In this activity, XP practice titled "simple design" can be used during determining system requirements and priorities. The product owner must emphasize on designing only what was needed to support the functionality being implemented. The guidelines that can be used to achieve this activity are:

1. The product owner collects the features that are required in the new product. These features are collected from users, customers, and other stakeholders. These features may represent whole project, fixing bugs, and/or enhancements.
2. Ensuring that the items in the product backlog are expressed in business terms, including functional and non-functional requirements.
3. The product owner identifies an initial list of the required features.
4. The product owner validates the required features and solve conflicts if found.
5. The Scrum master discusses the product backlog with the product owner.
6. The product owner prioritizes the features and prepares an ordered list of features which is known "product backlog".
7. The Scrum master provides high-level initial estimates for the product backlog items using points system such as Fibonacci numbers which are a sequence of numbers where each number is the sum of the previous two. Fibonacci numbers are 1, 2, 3, 5, 8, 13, 21 … etc. The Scrum master can use these numbers for indicating the size of each item in the product backlog according to the item complexity.
8. The Scrum team and the Scrum master should participate in the estimation process and then negotiate the size of each backlog item as a team.
9. Once the backlog size is estimated, the Scrum master can ask the product owner to review the priorities. The product owner can see the relative size of the features and he/she might change these priorities.

6-2 Sprint Planning Meeting and Preparing Sprint Backlog

In this activity, XP practice titled "simple design" can be used during planning out the sprint's goals. The guidelines that can be used to achieve this activity are:

1. The Scrum master calls a sprint planning meeting that must be attended by the whole team and the product owner.
2. The attendees decide the sprint duration that may range from one week to one month. The maturity of the team is one of the factors that are considered when taking this decision.
3. The product owner and development team identify a sprint goal and agree on it.
4. The team and Scrum master select a section of items/features from the top of the product backlog that can be achieved in the sprint duration.
5. The product owner presents each item and explains how it is working from a functional perspective. The whole team discusses the item in detail. The product owner can use the concept of writing 'User Stories' which are used in XP.
6. The Scrum master and the team estimate and calculate the team's sprint budget. This is the available number of hours the team has to actually work on the sprint.
7. The Scrum master and the team break the requirements into tasks that are necessary to make the product backlog item complete and potentially shippable within the sprint. The Scrum master and the team agree on a definition of "done", so everyone is aware what will have to be completed and included in the estimates.
8. The team and Scrum master must keep tasks small and estimate all tasks in hours. Ideally task estimates should be no more than one day.
9. The team and Scrum master add up all the task estimates for the selected product backlog items. If they are significantly over the team's sprint budget, the number of selected product backlog items must be reduced.
10. The team should commit to delivering the sprint backlog.

6-3 Sprint

In this activity, the Scrum team can use XP practices: Testing, Pair Programming, and Coding Standards. Unit tests are written prior to the construction of code. This practice forces developers to understand the interface and the expected functionality. The tests accumulate over the duration of a project, providing a library of regression tests. Once programming is started, all the tasks would be accomplished through pair programming conforming to coding standards. Although Scrum does not really prescribe how we should go about delivering the tasks in the sprint, the researchers proposes some important guidelines that can be used to achieve this activity.

1. The Scrum master must provide the team with a suitable environment for work. During Scrum, the Scrum master must provide them with support, guidance, coaching and assistance.
2. The Scrum master and the team must take into consideration that the sprint duration is fixed. They can add tasks if they discover the necessity of these tasks. However, additions to scope should be offset by compensating reductions in scope.
3. Ensuring that the concept of "Done" is clear to all team members. The team must complete one feature at a time before moving on to the next.
4. Testing is integrated throughout the lifecycle.
5. The Scrum master protects the team from any interference during the sprint. Ideally, once a Scrum team has committed to a sprint, they should be left to focus on delivering what they’ve committed to.
6. The Scrum master and the team track the progress using daily burndown chart and daily Scrum meeting.

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6-4 Daily Scrum

The Scrum master holds a daily stand-up meeting with the team and the product owner. The guidelines that can be used to achieve this activity are:

1. The Scrum master and the team hold a daily routine meeting that must be in the same place and at the same time
2. The Scrum master facilitates the Scrum meeting and keeping it focused, timely, and ‘on topic’.
3. The team stands in a half circle around their sprint whiteboard.
4. Each team member reports back to the team in turn. Only the person reporting back should speak at one time. The report should be concise and focused.
5. The report should address three key questions about what did they do yesterday, what will they do today, and what’s in their way.
6. If an issue needs further discussion, the Scrum master avoids discussing it in detail until finishing the Scrum meeting. Only the members who have this issue can stay to complete their discussion.

6-5 Sprint Review and Presenting an Increment

In this activity, the Scrum team can use XP practices: refactoring, continuous integration, and collective code ownership. When the sprint finishes and the release is evaluated in the sprint review, any refactoring of the system requirements can be added to the backlog before a new sprint begins. Refactoring allows for the incremental improvement of the design and class structure to support new functionality. The Increment is the total of all the product backlog items accomplished during the current sprint and all previous sprints. At the end of each sprint, the product owner will receive a deliverable, and will be able to see the incremental growing of the product [7]. The guidelines that can be used to achieve this activity are:

1. The Scrum master ensures that the team has followed the concept "Done". They should 100% complete each feature before moving on to the next. The completed features will form a perfectly shippable product.
2. The team members review what they've achieved and demonstrate their contribution to the product.
3. The team and Scrum master show all key stakeholders what's been done and ask them to provide feedback.
4. The team and Scrum master identify the changes and document them.
5. The team and Scrum master must ensure that the software is always in a shippable state.
6. The team restructures the system without changing its behaviour to remove duplication, improve communication, simplify, or add flexibility [18].
7. The team must ensure that all changes are integrated and tested every few hours, or at least daily in the worst case [4].
8. All tests are run, and they must be passed for accepting the changes in the code. The team integrates and builds the software multiple times per day.
9. Once code and its associated tests are checked into the code base, the code can be altered by any team member.

6-6 Sprint Retrospective

The sprint retrospective meeting is useful for the Scrum team to inspect itself and identify the possible improvements to be considered during the upcoming sprint. The guidelines that can be used to achieve this activity are:

1. The Scrum master invite the development team and product owner to the sprint retrospective meeting.
2. Review the final Burndown Chart and answer the questions: How did it go? Did the team deliver what they committed to at the start of the Sprint?
3. Review and track the team's velocity. Velocity is the number of points estimated on the original product backlog for the 100% completed items in the sprint. Velocity can be used in sprint planning as a gauge for how much the team could realistically achieve.
4. Discuss what went well and document it to make sure it's repeated next time.
5. Discuss what could have gone better and document it to understand why.
6. Decide what the team will do differently in the next sprint. In other words, they pick a few actionable points that can actually be done differently in the next sprint.

7- Conclusion

This paper aimed to propose an enhanced Scrum framework that combines some practices of XP approach in Scrum framework to produce quality software on time. Therefore, the researchers studied many attempts of combining Scrum and XP and quality improvements of software projects that were based on Scrum, XP, or both. Also, the researchers studied in detail the features of Scrum and XP.

Then, the researchers proposed an enhanced Scrum framework that is based on Scrum activities and some XP practices and features. The Scrum framework activities are: preparing product backlog, sprint planning meeting and preparing sprint backlog, sprint, daily Scrum, sprint review and presenting an increment, and sprint retrospective. XP practices that should be combined with Scrum activities are: Simple Design, Testing, Pair Programming, Coding Standards, Refactoring, Continuous Integration, and Collective Code Ownership. Also, the XP feature titled

"User Stories" that can be used during the activity titled "Sprint Planning Meeting and Preparing Sprint Backlog". To make the enhanced Scrum framework more applicable than many previous attempts in this domain, the researchers elaborated a set of guidelines for achieving each Scrum activity. The enhanced Scrum framework was validated by a group of 40 experts and specialists in software projects.

The researchers concludes that the cooperative relationship between Scrum activities and some XP practices, which is exploited in the enhanced Scrum framework, can help the Scrum team to produce software with higher quality. In addition, the researchers concludes that more attention must be given to the combinations of agile methods.

8- Future Work

There are many issues and ideas can be tackled in future. Most of these issues and ideas are related to the domain of agile methods, such as:

- Using Scrum framework to achieve higher levels of Capability Maturity Model Integration (CMMI) for software companies.
- Studying the relationships among XP practices.
- Using the enhanced Scrum framework to improve the quality of web sites.
- Extending the enhanced Scrum framework to be applied to large-scale projects.
- Proposing a quality assurance model for software projects based on the enhanced Scrum framework.

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"Performance Indicators of Information Systems Projects"

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Abstract:

This paper is concerned with the calculation of performance indicators of Information Systems Project Management (ISPM). It clarifies the relationships between ISPM domains, performance metrics, and performance indicators. This paper presents a proposed list of metrics for ISPM. Based on these ISPM metrics and a combination of statistical techniques, we built a model for calculating ISPM performance indicators. The quality reviewers can use this model to evaluate and track the performance of IS projects managers.

Keywords:

Projects Management; Software Projects; Metrics; Measures; Performance Indicators

1- Introduction and Problem Definition

A metric is a quantitative measure of the degree to which the project manager performs ISPM domain. The metrics can be used for measuring the performance of the project manager in IS projects. They can be useful in extracting performance indicators that can help in increasing capability level and productivity, improving quality, tracking project progress, and assessing project status. An indicator can be defined as a function of metrics. Calculating metrics is a simple process because it depends on simple or known statistical or mathematical formulas such as percentage, ratio, present value, and time deviation (in hours, days, weeks, or months). On the other hand, calculating indicators from metrics is not easy process because the indicator value may depend on a combination of metrics and each of them doesn't have the same level of importance and they may not have the same nature [1].

The rate of failure in large IS projects is larger than the rate of success [12]. So, there is a need to a set of performance indicators that may help for managing ISs projects to reduce the failure rate of these projects. The mismanaged projects may lead to the following results: unfulfilled or unidentified requirements, uncontrolled change of project scope, uncontrolled change of technology, uncontrolled risk of the project, uncontrolled subcontracting and integration, cost overruns, and/or late delivery [8].

The problem is that there are no agreed or clear performance indicators that can be used for evaluating ISPM practices. The process of evaluating performance indicators is very complicated and there are no clear or sufficient techniques for this process. For previous reasons, evaluating the performance indicators is the main concern of this paper.

2- ISPM Domains and Phases

ISPM activities can be organized in ISPM domains, and each domain includes a set of activities related to a specific field in ISPM practices. From our survey, ISPM domains include: project scope management, project schedule management, project costs management, project integration management, project quality management, project human resources management, project communication management, project risk management, project subcontracting management, project documentation management, users' participation management, review and approval process management, systems development management, and feasibility study management.

ISPM activities are encountered through the project life cycle. So, ISPM activities can be organized in life cycle phases. Each phase includes activities, and each activity can be achieved through steps by using standards. A common ISPM life cycle includes the phases [7]: initiating the project, planning the project, executing the project, and closing the project.

3- Key Performance Metrics and Indicators

Performance measurements are used in project management and quality processes to determine and communicate status and accomplishments measured against specific objectives, schedules, and milestones. These measurements extend to include delivery of desired products and services to customers, whether external or internal [2]. Performance measurement can be useful to improve future work estimates [11]. Performance measurement is the ongoing monitoring and reporting of project accomplishments, particularly progress towards pre-established goals. Performance measures may address: the type or level of project activities conducted, the direct products and services delivered by a program, and/or the results of those products and services [1].

3-1 Key Performance Indicators for ISPM Domains

Metrics should be objective, timely, simple, accurate, useful, and cost-effective. An indicator may be extracted from a metric or a combination of metrics. Figure (1) illustrates the relationships between ISPM domains, metrics, measures, and indicators.

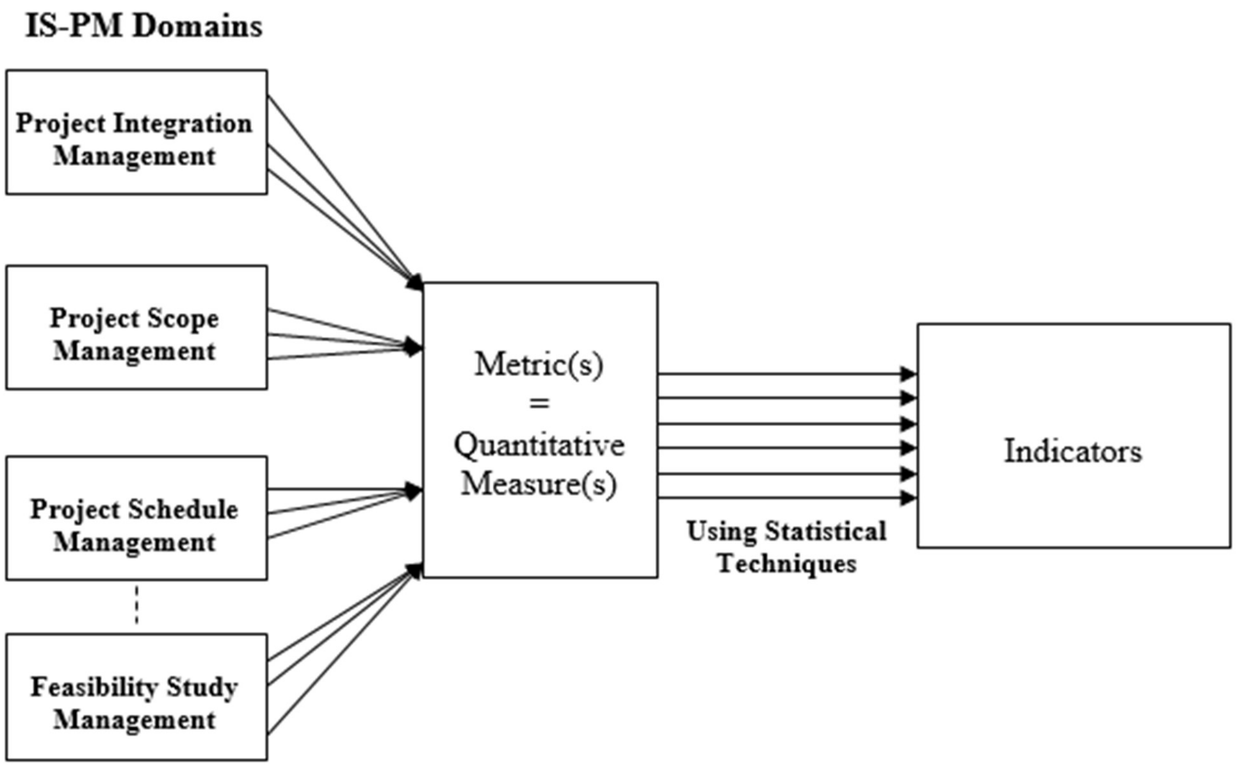

Figure (1): IS-PM Domains, Metrics, Measures, and Indicators.

The typical performance measurement for an ISPM domain includes: identifying performance metrics, collecting measurement data, calculating metrics, and calculating performance indicators.

The performance metrics can be divided into three basic categories: measures of efforts, measures of accomplishments, and measures that relate efforts to accomplishments [1].

- Measures of efforts: Efforts are the amount of resources, in terms of money, people, etc., applied to a project. Examples: The amount of money spent, and the number of person-hours burned on a project.
- Measures of accomplishments: Accomplishments are milestones achieved with the resources used. Examples: number of modules coded and number of deliverables.
- Measures that relate efforts to accomplishments: These measures are associated with resources or cost relative to accomplishments achieved. Examples may include: amount of money expended for the portion of project completed versus the amount of money planned to be expended for this portion of work.

Table (1) presents examples of ISPM performance metrics. These performance metrics includes the three categories of performance metrics.

3-2 Quality Metrics for ISPM Domains

There are many ISPM performance metrics that are not have the same degree of importance or efficiency in measuring the performance of IS project manager. So, we proposed a set of ISPM quality metrics. ISPM quality metrics are the most important or efficient performance metrics for each ISPM domain. So, we can say that the set of ISPM quality metrics is a subset of the set of ISPM performance metrics. Figure (2) illustrates the relationships between quality metrics, performance metrics, and performance indicators.

Table (1): Examples of Performance Metrics for ISPM Domains.

ISPM Domains	Performance Metrics
Project Scope Management	• No. of business areas involved in the project scope. • No. of users involved in defining scope and deliverables. • No. of acceptance and approval criteria identified for the project. • No. of assumptions and constraints identified for the project. • No. of modifications of the project scope statement. • No. of meetings of the project team. • No. of scope changes requested, documented, and analyzed. • Percentage of users involved in defining scope and deliverables vs. total number of users. • Percentage of scope management procedures applied vs. planned. • Percentage of project deliverables achieved vs. planned. • Percentage of project deliverables reviewed and approved vs. achieved. • Percentage of major milestones met vs. planned. • Percentage of project team meetings vs. planned. • Average ratio of feasibility studies to scope change requests. • Average ratio of integration tests related to scope change requests. • Average ratio of configuration management tests related to scope change requests.
Project Schedule Management	• No. of identified activities in Work Breakdown Structure (WBS). • No. of modifications of the approved plan. • Percentage of schedule management procedures applied vs. planned. • Percentage of tasks completed vs. planned at a point of time. • Percentage of major milestones met vs. planned. • Percentage of project deliverables achieved vs. planned. • Slippage time of the project schedule (in days).

ISPM quality metrics can be effectively used in calculating performance indicators. Table (2) provides examples of the proposed quality metrics for ISPM domains. Appendix (B) includes a list of these proposed quality metrics. We classified the proposed ISPM quality metrics into two categories:

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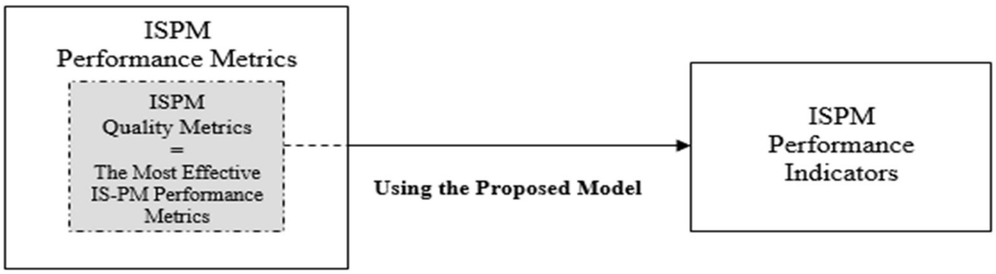

Figure (2): Quality Metrics, Performance Metrics, and Performance Indicators.

Category “Q”: It can be used to give a quick vision on the performance of the IS project manager. So, they are called “Q” or “Quick”. Category “R”: It includes the rest of ISPM quality metrics. So, they are called “R” or “Regular”. If the quality group decided to evaluate the detailed performance of the IS project manager, they should use the two categories “Q” and “R” in calculating performance indicators.

ISPM Domains	ISPM Quality Metrics	Type
Project Scope Management	Percentage of users involved in defining scope and deliverables vs. total number of users.	R
	Percentage of scope management procedures applied vs. planned.	R
	Percentage of project deliverables achieved vs. planned.	Q
	Percentage of project deliverables reviewed and approved vs. achieved.	Q
	Percentage of major milestones met vs. planned.	Q
	Percentage of project team meetings vs. planned.	R
	Average ratio of feasibility studies to scope change requests.	R
	Average ratio of integration tests related to scope change requests.	R
	Average ratio of configuration management tests related to scope change requests.	R
Project Schedule Management	Percentage of schedule management procedures applied vs. planned.	R
	Percentage of tasks completed vs. planned at a point of time.	R
	Percentage of major milestones met vs. planned.	Q
	Percentage of project deliverables achieved vs. planned.	R
	Slippage time of the project schedule (in days).	Q

Table (2): Examples of Quality Metrics for ISPM Domains.

4- The Proposed Model for Calculating Performance Indicators

Calculating indicators is not easy process because the indicator value may depend on a combination of different metrics. So, we propose a simple model for calculating the performance indicators for ISPM domains. Figure (3) illustrates a general flowchart that presents the proposed model. The proposed model includes the following main procedures:

1. Define quality metrics, weights, and required implementation range for ISPM domains.
2. Calculate the quality metrics for an ISPM domain.
3. Input the data of the quality metrics.
4. Calculate the performance indicator.
5. Interpret and analyze the performance indicator.

4-1 Define ISPM Quality Metrics

The quality group should define quality metrics for ISPM domains. The definition of each ISPM quality metric should include the mathematical or statistical techniques for calculating this metric. The quality metrics for a specific domain are not having the same level of importance. So, each metric must have a weight of 1, 2, or 3. Weight is a measure of the importance of each metric. A weight 3 is used to show the quality metric of the most importance. A weight 1 is used to show the quality metric of the lowest importance. A weight 2 is used to show the quality metric of the average importance. So, the quality group should determine the appropriate weight for each quality metric that is required for calculating the performance indicator for each ISPM domain.

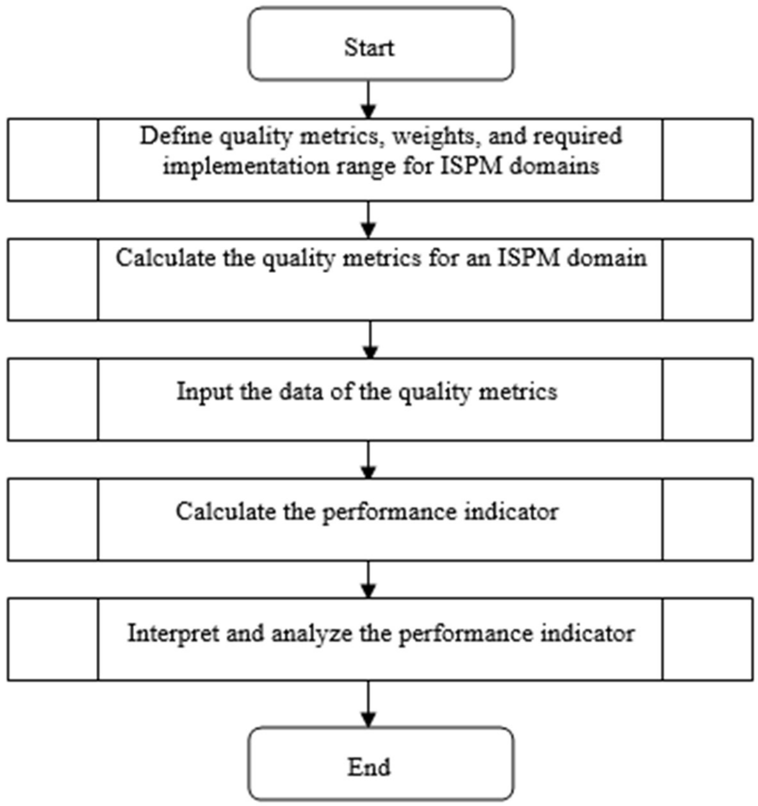

Figure (3): The Proposed Model for Evaluating the Performance Indicator.

Also, the quality group should determine the required implementation range for each ISPM quality metric. The required implementation range is the acceptable range of the quality metric. The time check points for calculating the ISPM quality metrics. These metrics can be calculated weekly as a part of project progress report. The project manager should be involved in this process. The quality group should present the ISPM quality metrics to the project manager and deal with his objections by clarifying, negotiating, or modifying these metrics.

The previous experience from similar projects can be useful in this process. Also, this process can be achieved with the assistance of external consultants to define and validate the ISPM quality metrics. Figure (4) illustrates a flowchart that presents the algorithm of this procedure.

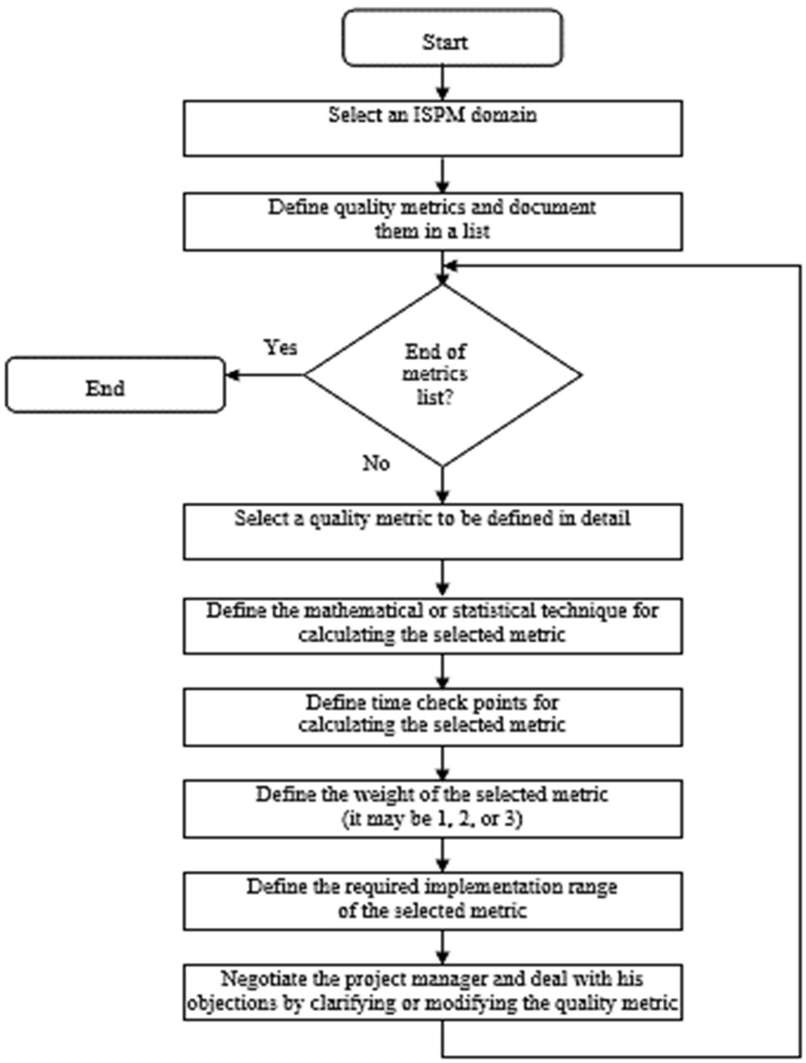

Figure (4): The Proposed Algorithm for Defining ISPM Quality Metrics.

4-2 Calculate the Quality Metrics for an ISPM Domain

The second procedure in the proposed model is calculating the quality metrics for a specific ISPM domain. The quality group should select an ISPM domain to calculate its quality metrics. Figure (5) illustrates a flowchart that presents the algorithm of this procedure.

4-3 Input the Data of the Quality Metrics

The third procedure in the proposed model is entering the data of the quality metrics for a specific ISPM domain. For achieving the purpose of the proposed model, the quality metrics are organized in table as in table (3). We proposed a scale for measuring the implementation of the quality metrics. The proposed scale is based on that each quality metric value is compared with the required implementation range. If the metric value is in the required range, the implementation value will be "Accepted" or equal the numeric value "2". If the metric value is greater than the required range, the implementation value will be "Excellent" or equal the numeric value "3". If the metric value is less than the required range, the implementation value will be "Poor" or equal the numeric value "1".

Some quality metrics may be not applicable in some specific cases. So, there is a column titled "NA" in the table [13]. During computing the performance indicator, the not applicable quality metrics will be eliminated. The quality group input the actual data for each quality metric related to the performance indicator to be evaluated. Table (3) presents a sample of the actual data for ISPM quality metrics related to a real IS project. This project is GAZADCO project. Gazan Agricultural Development Company (GAZADCO) is one of the largest companies in the Kingdom of Saudi Arabia. In the next section, the performance indicators of these ISPM domains listed in table (3) will be calculated.

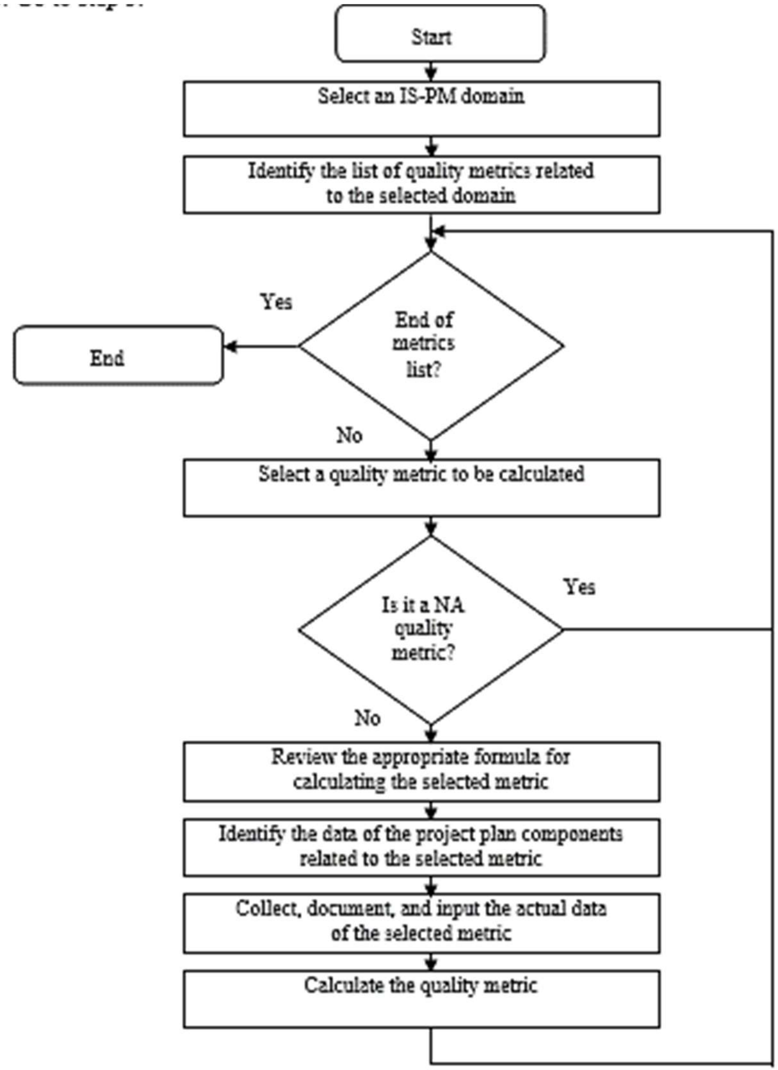

Figure (5): The Proposed Algorithm for Calculating the Quality Metrics for a Specific Domain.

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Table (3): The Organization of Quality Metrics.

ISPM Domains and Quality Metrics	Metric Value	Required Range	Metric Weight	NA	Poor	Accepted	Excellent
Domain - Project Scope Management							
Percentage of users involved in defining scope and deliverables vs. total number of users.	90%	85-95 %	2			√	
Percentage of scope management procedures applied vs. planned.	100%	95-100 %	3				√
Percentage of project deliverables achieved vs. planned.	70%	80-90 %	3		√		
Percentage of project deliverables reviewed and approved vs. achieved.	65%	80-90 %	3		√		
Percentage of major milestones met vs. planned.	75%	80-90 %	3		√		
Percentage of project team meetings vs. planned.	90%	80-90 %	2			√	
Average ratio of feasibility studies to scope change requests.	4:1	4:1	3			√	
Average ratio of integration tests related to scope change requests.	2:1	2:1	3			√	
Average ratio of configuration management tests related to scope change requests.	2:1	2:1	3			√	
Domain - Project Schedule Management							
Percentage of schedule management procedures applied vs. planned.	100%	95-100 %	3				√
Percentage of tasks completed vs. planned at a point of time.	90%	85-95 %	3			√	
Percentage of major milestones met vs. planned.	75%	85-95 %	3		√		
Percentage of project deliverables achieved vs. planned.	70%	85-95 %	3		√		
Slippage time of the project schedule (in days).	45	30	3		√		

Figure (6) illustrates the proposed algorithm for entering the data of the quality metrics for a specific domain.

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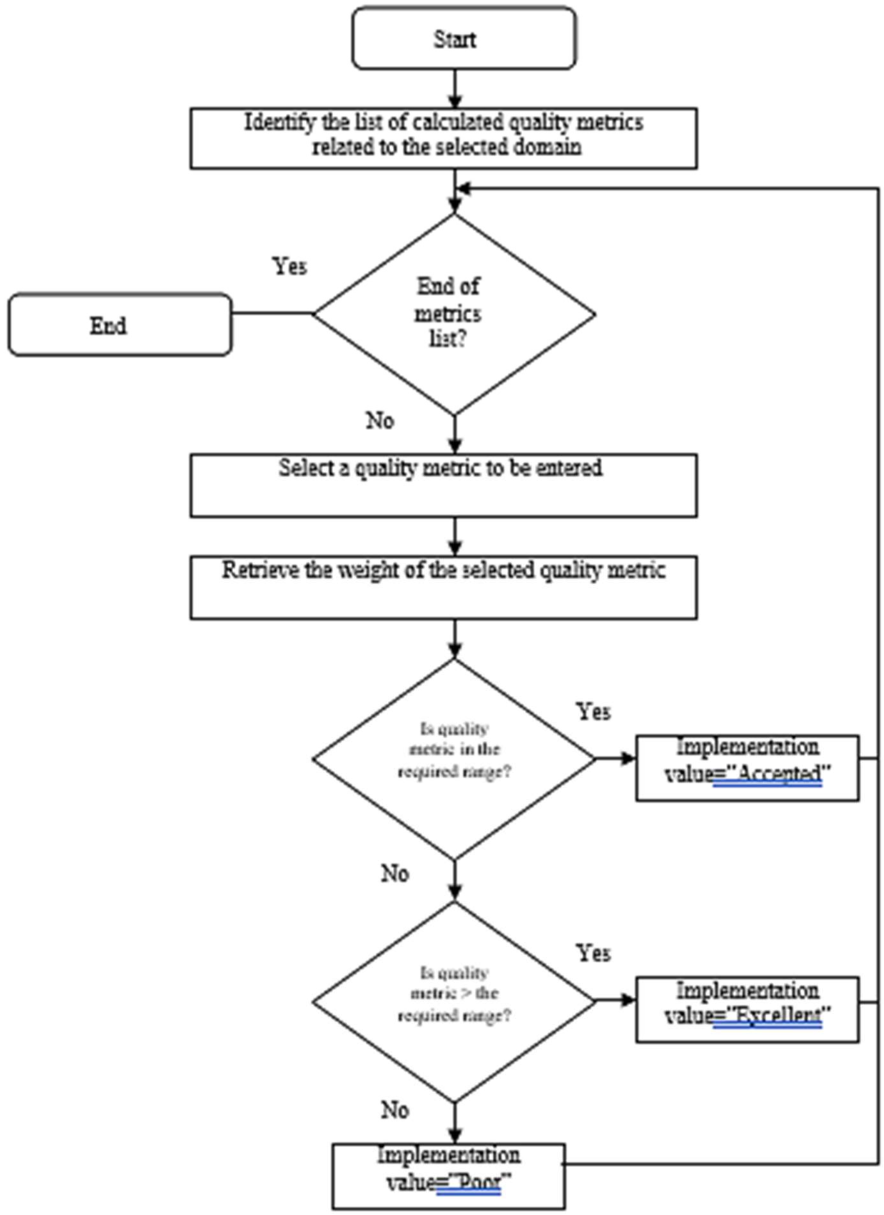

Figure (6): The Proposed Algorithm for Entering the Data of the Quality Metrics.

4-4 Calculate the Performance Indicator

The fourth procedure in the proposed model is calculating the performance indicator for a specific ISPM domain. Calculating the performance indicator is not an easy process because the performance indicator is a function of a set of quality metrics. The source of complexity is due to the different nature of the data types of the quality metrics. They may include ROI, PV, percentage, ratio, number of days, or/and numeric amounts. Table (3) and the following proposed model may facilitate this process. The performance indicator can be calculated using the weighted mean. The weighted mean is appropriate because it takes the weights into account during calculations [13]. The basic formula of the weighted mean is:

Weighted Mean= $(\sum Xi.Wi)/ \sum Wi$

Where:

Xi is the implementation value of the quality metric i

Xi may take the value 1, 2, or 3 according to the rating Poor, Accepted, or Excellent respectively.

Wi is the metric weight of each quality metric i. It may take the value 1, 2, or 3.

Based on to the rating scale that is used, the performance indicator value will range from 1 to 3. According to this algorithm, the performance indicator for the two domains in table (4) can be computed as follows:

Performance indicator of "project scope management" = (2x2 + 3x3 + 1x3 + 1x3 + 1x3 + 1x3 + 2x2+ 2x3 + 2x3 +2x3)/ (2 + 3 + 3 + 3 + 3 + 2 + 3 +3 + 3) = 1.76/3

Performance indicator of "project schedule management" = (3x3 + 2x3 + 1x3 + 1x3 + 1x3)/ (3 + 3 + 3 + 3 + 3) = 1.6/3

4-5 Interpret and Analyze the Performance Indicator

The fifth and final procedure in the proposed model is interpreting and analyzing the value of the performance indicator for a specific ISPM domain. The quality group should report their interpretation to their top management. If the performance indicator is not accepted, top management may take corrective actions or inform the project manager to take corrective actions. The acceptable value of the performance indicator for a specific ISPM domain depends on: ISPM domain itself, company, and the project nature. The quality group can determine a specific value in the range from 1 to 3 for judging and interpreting the quality value. For example: if we determined that the acceptable value of any performance indicator is 1.7. So, performance indicator of "project scope management" is acceptable, but performance indicator of "project schedule management" is not acceptable.

The value of performance indicator should be analyzed to discover the weakness and strength points of ISPM practices. The analysis may return to ISPM quality metrics to reveal which of them contribute to increase or decrease the value of the performance indicator. This analysis can be used to reduce or avoid many risks or obstacles that may be encountered in later phases in the same or next IS project.

5- Conclusion

Evaluating performance indicators for managing IS project is helpful for increasing capability level and productivity, improving quality, tracking project progress, and assessing project status. The main objective of this paper was proposing a model for evaluating the performance indicators of managing ISs projects. So, we presented a proposed list of quality metrics that are very important for evaluating performance indicators of ISPM domains. Depending on this list of quality metrics, we built a proposed model for evaluating the performance indicators. The proposed model includes five procedures: define ISPM quality metrics, calculate the quality metrics for an ISPM domain, input the data of the quality metrics, calculate the performance indicator, and interpret and analyze the performance indicator.

We conclude that the roles of quality group are very important in ISs projects. They can use the list of quality metrics and the proposed model to evaluate and track the performance of the IS project manager. Also, we conclude that the IS project manager can use the proposed quality metrics and the proposed model to evaluate, enhance, and correct his performance in managing an IS project.

Finally, we conclude that special emphasis must be given to performance indicators in ISs projects in a trial to reduce the failure rate of ISs projects.

6- Future Work

There are some hot topics in this domain and must be targeted, which are:

- Developing a software tool for evaluating the performance indicators of software project manager.
- Finding a relation between Capability Maturity Model (CMM) and the performance of software project manager.

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