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TRANSACTIVE MEMORY SYSTEMS: EXPLORING TASK, EXPERTISE AND PEOPLE (TEP) UNIT FORMATION IN VIRTUAL TEAMS: CONCEPTUALIZATION AND SCALE MEASUREMENT DEVELOPMENT

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Abstract

Transactive Memory Systems (TMS) are important cognitive constructs to share knowledge and control and coordinate interdependent tasks in teams. The construction of Transactive Memory Systems involves a number of key phases that lead up to the actual formation of a team's TMS. In particular, the development of Task-Expertise-People (TEP) units, form an essential part of the development of a team's Transactive Memory System. At this stage very little is known of how Task-Expertise-People units are formed in virtual teams. This paper addresses this problem by following an inductive, quantitative method to develop a measurement scale for TEP formation in virtual teams. TEP formation is a crucial step in developing a high-quality TMS and thus team performance. This is important because many organizations achieve contemporary work using virtual teams and we do not have a measurement scale for TEP formation in virtual teams. Findings from this study indicate that the measurement scale for a TEP unit yields 1) reliable constructs and 2) valid construct items to successfully measure TEP formation.

Keywords: Transactive Memory System (TMS), virtual team, scale development, construct measurement, Task Expertise People (TEP) unit.

1 INTRODUCTION

Since the introduction of Transactive Memory System (TMS) by Wegner et al. (1985), TMS has been used and adopted in a number of research programs that focus on teams and team process environments, especially those relating to knowledge management (Hollingshead 2001), information sharing (Liang et al. 1995) and information exchange (Moreland and Myaskovsky 2000). TMS is defined as a cognitive construct that relates to the awareness of 'who knows what in a team', and has been found to have positive effects on aspects such as a team's overall performance (Austin 2003; Choi et al. 2010; Moreland and Myaskovsky 2000; Ren and Argote 2011), the speed to market new product development (Akgun et al. 2005) and better performance in virtual teams (Kanawattanachai and Yoo 2007; Yoo and Kanawattanachai 2001). Recent work by a number of authors (Choi et al. 2010; Kanawattanachai and Yoo 2007; Yoo and Kanawattanachai 2001) has indicated that the TMS in virtual teams can help organizations to better use its team members' expertise towards team performance. Despite previous work and suggestions on the formation (see Kanawattanachai and Yoo 2007 and ; Lewis 2004) of TMS in virtual teams, there is a lack of unanimity in reported empirical research into the formation of TMS in virtual teams. Specifically, researchers have reported that it is difficult to form TMS in virtual teams (Lewis 2004). However, Kanawattanachai and Yoo (2007) found that the use of ICT such as email can help the form TMS in virtual teams. This is in contrast to Kayworth and Leidner (2000) where they found that it is difficult for virtual team members to communicate using email because it delays communication, suggesting that it is difficult to form TMS in virtual teams. Based on these inconsistencies, we have previously proposed a model explaining the formation of TMS in virtual teams (refer Ariff et al. 2011) that extends the model by Brandon and Hollingshead (2004).

Brandon and Hollingshead's model (2004), extends the concept of TMS by suggesting that the TMS is built by each team member developing a Task-Expertise-People (TEP) unit. A TEP unit is a mental model that represents the association between the Tasks (T), Expertise (E) and People (P) within a team. Brandon and Hollingshead (2004) also mentions that frequent communication among team members can help facilitate the development of the TEP unit thus leading to the formation of the TMS which then increases the overall team performance. However, empirical studies on TMS have not yet developed a measurement scale that can be used to measure the formation of one or more TEP units in a team. Hence, this paper reports on the development of a measurement scale for TEP unit formation developed by applying the rigorous scale measurement development procedures recommended by (Lewis et al. 2005; MacKenzie et al. 2011; Straub et al. 2004).

The paper is structured as follows: the next section starts with a brief explanation of Transactive Memory and Transactive Memory Systems followed by an explanation of the Task-Expertise-People unit. Section 3 highlights the research methodology employed in this study. The subsequent section introduces the key measurement items developed to represent the TEP unit. Section 4 describes the content adequacy assessment in assessing the key measurement items. Next, we present our results and discussions followed by a conclusion. Limitation and future works of this research are discussed in Section 7.

2 LITERATURE REVIEW

Transactive Memory is an individual team member's mental representation of information and knowledge possessed by other members in the team. Transactive Memory does not hold actual information or knowledge of others, it merely holds an individual team member's awareness of who is in the team and their expertise ('who knows what'). Transactive Memory is formed when a team member gets to know more about another team member's domains of expertise (Wegner 1987). The idea of a Transactive Memory System (TMS) was first conceptualized by Wegner (1987) who observed it between individuals who were in a close couple relationship setting. TMS is based on the idea that couples in a close relationship serve as an external memory aid to each other. The two individuals are able to benefit from each other's information and knowledge, provided they develop an understanding of what the other person knows or 'who knows what'.

The concept of TMS was later applied to teams with interdependent tasks (Liang et al. 1995; Moreland and Levine 1999). Task interdependence is define as the extent in which team members interact and exchange information in order to complete their tasks / projects (Akgun et al. 2005; Kanawattanachai and Yoo 2007; Lewis 2004). The team's task interdependence encourages the formation of TMS. This is because in teams with TMS, each team member will be able to serve as an external memory aid and share information and knowledge about expertise possessed by other members. It is expected that TMS can help team members to more efficiently accomplish their interdependent task.

Organizations use virtual teams to accomplish interdependent tasks (Griffith and Neale 2001; Griffith et al. 2003). Advancements in ICT allow for greater collaboration and networking between individuals without the need for a physical presence in a specific location(Lewis and Herndon 2011; Zenun et al. 2007). Examples of virtual team interdependent task operations that can be performed by dispersed individuals are: (1) product development, (2) strategic analysis and (3) customer analysis (Cannon-Bowers et al. 1993; Moreland and Levine 1999; Townsend et al. 1998).

Since the formation of TMS relates to task interdependence, previous research have already started to address the study of TMS in virtual teams (e.g. Kanawattanachai and Yoo 2007; Yoo and Kanawattanachai 2001). These studies have also indicated that TMS have a positive impact on the overall performance of virtual teams however none of these studies have explored the formation of individuals' TEP units.

2.1 Task-Expertise-People (TEP) unit

Brandon and Hollingshead (2004) extended the concept of TMS to include linking tasks with expertise and team members with the expertise by stating that team members "*must attend not only to who knows what but also to who does what*" (p. 635). Specifically, only by having high levels of accuracy, sharedness and validation of the links between tasks, expertise, and team members would the team have an optimal TMS. Further, each team member's mental representation of the link associating Tasks (T) with Expertise (E) and People (P) they called an individual's TEP unit.

When a TEP unit is constructed, it is easy for a team member to associate "who knows what and who does what". Previous studies have also indirectly shown support towards the development of TEP unit (Kanawattanachai and Yoo 2007). By recognizing each team member's expertise in completing tasks, team members can more fully understand the overall objectives, and in turn it ensures that every team member is working towards the same goal in completing the overall task (Blickensderfer et al. 2000). The need for recognizing the TEP unit also helps other members to better anticipate the information or knowledge other members may need (Rentsch and Hall 1994). TEP unit is important because if an unexpected problem occurs in a team, team members may act accordingly since they have already developed a mutual shared understanding among themselves (Orasanu 1990).

The development of a team member's TEP unit comprises three iterative cycles: *construction*, *evaluation*, and *utilization*. Each cycle is further explained in section 3.2. These iterative cycles occur through frequent communication among team members during which specific behaviour takes place (Mohr and Spekman 1994). This behaviour would then lead to each team member recognizing "who knows what and who does what". Recall that our study focuses on the measurement of TEP formation in virtual teams, a review of existing measurements was first conducted. This review showed that previously developed scales such as those developed by Faraj and Sproull (2000), Wu and Wang (2006) and Kanawattanachai and Yoo (2007) were either unsuitable for the specific focus of the current study or inadequate to capture the behavioural aspects of this research. To our knowledge, empirical research has not yet commenced on the development of TEP cycle measurements leading to the formation of TMS. Thus, in this study we address this gap by developing a set of measurement instruments that measure TEP units, which precedes TMS formation. The next section addresses the construct development methodology we employ in this research as proposed by Lewis et al. (2005) and MacKenzie et al. (2011).

3 RESEARCH METHODOLOGY

There are generally two common methods to measure a construct: (1) using existing measurement scales from previous studies and (2) creating a new measurement. Just as the use of existing, reliable and validated scales is recommended, the creation of newly validated measurement instruments is valued because such efforts "*represent a major contribution to scientific practice in the field*" (Straub et al. 2004, p.56). In developing a new measurement scale for a construct, a much more comprehensive and wider literature review is needed. The measurement scale development methodology in this research follows a two stage process (see Figure 1) that was adapted from guidelines in MacKenzie et al. (2011) and Lewis et al. (2005). The justification of combining the two guidelines is because the components of these guidelines that have been extensively utilized across a wide range of business and social science research topics and have been published in top rank journals (e.g. Tojib et al.(2008)).

Referring to figure 1, stage I concerns clarifying the conceptual foundations of the construct and comprises (1) premise identification – defining the purpose and/or the importance of the construct, (2) conceptual definition – describing the construct in general and (3) dimension identification – defining the elements or item measurements of the construct. Stage II ensures that the measurement items generated are comprehensive and represents the entirety of the construct. Firstly, measurement items were defined following an extensive review of the literature about TEP formation and by following the inductive method proposed by Webster and Watson (2002). Next, the items comprising measurement of the construct were screened by knowledge experts to further validate its reliability and validity. Finally we performed a content adequacy assessment on the measurement items.

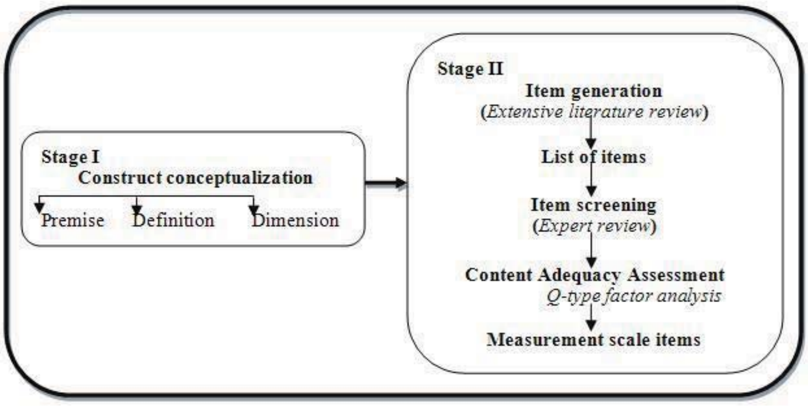

Figure 1. Two-stage process of the construct development methodology

In the following section we further describe the construct development methodology with a clear theoretical definition of the TEP unit, specifying its premise (purpose), and its dimension and measurement items. In order to adequately capture the relevant dimensions of the TEP unit, we followed the inductive method recommended by Webster and Watson (2002) whereby the literature guides the selection of dimensions which were conceptually relevant to the TEP unit. Instead of imposing our knowledge of the research topic, we reviewed the literature extensively and let the literature itself generate the most relevant dimensions. This was an iterative process until saturation was reached. Following this iterative process, we identified nine dimensions of the TEP unit (see table 1). The nine dimensions correspond to our focus, and the definition of TEP unit as highlighted by Brandon and Hollingshead (2004). To further ensure that the inductive process was sufficient enough to capture all the dimensions, the nine dimensions were also reviewed by knowledge experts. The knowledge experts' feedback indicated that the list of dimensions was comprehensive and no additional dimensions were required. The outcome of stage I (refer Figure 1), is presented in the domain specification table (see Table 1).

Premise (purpose of importance) of the construct	To measure the communication behaviour of the team members in helping them determine the team's overall task (T), the team's expertise (E) and the people / person (P) in the team. This measurement scale helps to establish the impact of the TEP construct towards the formation of the transactive memory systems (TMS)
Definition	<u>Construction</u> *the extent to which a team member communicates with other team members in getting to know their expertise and their task involvement in the team* <u>Evaluation</u> *the extent to which a team member communicates with other team members to evaluate the credibility of the previously created TEP unit* <u>Utilization</u> *the extent to which a team member communicates with other team members to utilize his / her TEP unit*
List of Dimension(s) (elements of the construct)	<u>Construction</u> (1) Past experience (2) Learning of unfamiliar concepts (3) Understanding the overall design of tasks (4) Establishment of a mutual relationship <u>Evaluation</u> (1) Clarifying previously performed tasks and current tasks (2) Elaborating previously performed tasks and current tasks <u>Utilization</u> (1) Task completion (2) Asking questions (3) Requesting specific information or knowledge

Table 1. TEP unit construct conceptualization adapted from Lewis et al. (2005)

3.1 Item generation

This section refers to Stage II (see Figure 1). Stage II begins with a thorough review of the literature that relates to the definition of each cycle by reviewing papers "*that contain the name of construct in the title, keyword list, or abstract*" (Lewis et al. 2005, p. 391). The construct was created by Brandon and Hollingshead (2004). Thus, our literature review began by examining the publications of these authors and other publications that cite their work. The search was limited to scholarly journals from 1995 to 2011. At the time the search was conducted, 150 articles were found. We then selected those studies that operationalized the construct of interest (80 articles). All items in these studies were included in our initial item list. This list was further refined by eliminating obvious duplicates and refining the search using the condition outlined by MacKenzie et al. (2011). Further, we were interested in understanding the communication of team members in knowing *who knows what* and *who does what,* therefore we also removed items in our pool that were not focusing on these communication behaviours. The following three subsections respectively cover the three cycles of TEP unit - construction, evaluation, and utilization. Each proceeds by explaining the cycle and showing how the literature leads to the measurement items prior to expert review

3.2 TEP construction cycle

The construction cycle begins during the formative stages of a project lifecycle. In this cycle, individuals begin to start linking each person (P) and task (T) with their expertise (E) (Brandon and Hollingshead 2004). This begins using any means of communication (e.g. overhead communication) or documentation (e.g. office memos). This cycle is a dynamic process that takes time for an individual to recognize a person's expertise. An example of a TEP unit that associates People (P) with their related Expertise (E) and relevant Tasks (T) is shown in Table 2.

Task (T) = Creating dynamic webpage, Expertise (E) = Programming Expert, People (P) = Noreen

Table 2. Example of a TEP unit (Brandon and Hollingshead 2004)

When individuals start working on a project and communicate over a period of time, they learn more about each other's domains of expertise (Wegner 1987; Wegner et al. 1991). Synthesising Brandon and Hollingshead (2004) and Wegner (1987/1991), the TEP construction cycle is the extent to which a team member communicates with other members in getting to know their expertise and task involvement in a team. In the formative stages of a team, the main objective is interpersonal interaction among members to determine "what teams have to do-their task" (Kozlowski and Ilgen, p. 80). Furthermore during the formative stages of a virtual team, members are more inclined to communicate about (1) learning unfamiliar concepts and (2) understanding the overall design of tasks (Majchrzak et al. 2000). The formation of a team may comprise of members that have never met before, but need to work together in completing a given task (Jarvenpaa et al. 1998). Thus, there is a need to know each member's expertise, to better perform tasks. In order to know each team member's expertise, team members may communicate with each other by asking questions about past task related experience about previous performed projects or tasks (Bunderson 2003). Communication that takes place during the early stages of a virtual team can help team members establish a mutual relationship with one another in the team (Weinberger and Fischer 2006). This mutual relationship can be use to acquire other members' expertise. Based on these, we then propose a number of construction cycle measurement items as shown in Table 3. In the table we show the principle literature upon which each measurement item is based.

Past experience (PE)	**Key reference**
In the early stages of the project, how often did you request information from other team members about their past professional experiences?	Kozlowski and Ilgen (2006)
In the early stages of the project, how often did other team members request information from you about your past professional experiences?	Bunderson (2003) and Jarvenpaa et al.(1998)
In the early stages of the project, how often did you send messages to other team members asking about their past working experiences?	Majchrzak et al.(2000)
In the early stages of the project to what extent did other team members send you messages asking about your past work experiences?	Jarvenpaa et al. (1998)
In the early stages of the project, how many requests did you send to other team members asking about their past professional experiences?	Moreland et al. (1996)
In the early stages of the project, how many messages did you receive from other team members asking about your past professional experience?	Fowlkes et al. (2000)
In the early stages of the project, how many requests did you initiate on getting to know other team members' working experiences?	Moreland et al. (1996)
In the early stages of the project, how many messages did you receive from other team members asking about your working experiences?	Moreland et al. (1996)
Learning concepts (LEARNING)	
In the early stages of the project, how often did you communicate with other team members to understand aspects of the task/projects that were new to you?	Kozlowski and Ilgen (2006) and Bunderson (2003)
In the early stages of the project, how often did other team members communicate with you about aspects of the task/projects that they did not understand?	Jarvenpaa et al.(1998) and

In the early stages of the project how many requests did you send to other team members inquiring about the task/projects that were new to you?	Majchrzak et al.(2000)
In the early stages of the project how many messages did you receive from other team members inquiring about the task/projects that they did not understand?	Jarvenpaa et al. (1998)
Understand task (UNDER_TASK)	
In the early stages of the project, how often did you communicate with other team members to clarify the tasks you had to perform?	Bunderson (2003)
In the early stages of the project, how often did other team members communicate with you to clearly understand the part of the project that you were responsible for?	Bunderson (2003)
In the early stages of the project, how many requests did you send to other team members inquiring the tasks that they had to perform?	Majchrzak et al.(2000)
In the early stages of the project, how many messages did you receive from other team members inquiring the task you were performing?	Weinberger and Fischer (2006)
Mutual (MUTUAL)	
In the early stages of the project, how often did you communicate with other team members in order to get to know them personally?	Weinberger and Fischer (2006)
In the early stages of the project, how often did other team members communicate with you in order to get to know you personally?	Weinberger and Fischer (2006)
In the early stages of the project, how many requests did you initiate in order to get to know other team members personally?	Weinberger and Fischer (2006)
In the early stages of the project, how many messages did you receive from other team members in order to get to know you personally?	Weinberger and Fischer (2006)
	Weinberger and Fischer (2006)

Table 3. TEP unit construction cycle measurement items (links to the dimensions in Table 1)

3.3 TEP evaluation cycle

The evaluation cycle begins when members starts to evaluate their previously constructed TEP unit for its credibility (Brandon and Hollingshead 2004). They further say that accessing another team member's credibility is necessary if (1) a team member fails to complete a given task or the completion of that task results in an error or (2) there is more than one expert for the same given task. The evaluation cycle may also occur after a team member's TEP unit has been used to complete a task. For example, when a team member manages to upload a webpage (this means a task is completed), but some of the web-links fail to open, then there is a need for a team member to evaluate his/her TEP unit. When this happens, the team member will evaluate his/her previously constructed Task (T), Expertise (E), and People (P) for its credibility (Brandon and Hollingshead 2004). There can be a possibility that the prior TEP unit is incorrect. Examples for which there is a need to evaluate TEP units are presented in Table 4.

The Expertise (E) is correctly assigned to the right People (P) but, the expert is incorrectly assigned to an incorrect Task (T).
The Task (T) is correctly assigned to the right People (P) but, it is linked to the wrong Expert (E).
The Task (T) and Expertise (E) are properly identified but linked to the wrong People (P).
The Expertise (E) is properly identified but the People (P) does not know how to solve the task (T).
The People (P) is properly identified but the Expert (E) does not know how to solve the task.
The Task (T) is properly identified but the Expert (E) or People (P) does not know how to solve the task.

Table 4. Incorrect TEP units (Brandon and Hollingshead 2004)

Brandon and Hollingshead (2004, p. 637) mention that incorrect TEP units (refer Table 4) often occur because it takes time and effort to distinguish "*who is good at what*". They also mention that, it is only through frequent communication amongst members that it is possible to determine ‘who is good at what’. If there are incorrect TEP units a team member will need to re-evaluate and reconstruct his/her TEP units. However, through frequent communication, team members’ credibility in knowing who knows what can be enhanced, thus leading to high credibility. In a virtual team environment, where there is high degree of task interdependence among team members, the evaluation cycle is necessary to establish mutual credibility across the virtual team environment (Jarvenpaa and Leidner 1999; Maznevski and Chudoba 2000). Based on the explanations above, we define the evaluation cycle as the extent to which a team member communicates with other members to evaluate the credibility of his or her previously created TEP unit. Following this definition, in order to evaluate a team member’s credibility, Moreland et. al (1996) suggest that there is a need for constant elaboration, clarification and discussion among team members. Jarvenpaa and Leidner (1999) also suggest that in evaluating a team member’s credibility, members might need to seek more information from other team members. In the study by Fowlkes et al. (2000), they found that probing communication questions such as elaboration and clarification from a team member’s previous tasks or projects was important, as it impacts on a member’s credibility as seen by other team members. This leads to better team credibility and better sharing of information and knowledge among team members. Based of these, we then propose a number of measurement items for this cycle as shown in Table 5.

Clarify (CLARIFY)	**Key reference**
How often did you communicate with other team members to clarify your understanding about their expertise? How often did other team members communicate with you to clarify about their understanding of your expertise? How many requests did you initiate with other team members to clarify your understanding of their expertise? How many messages did you receive from other team members in clarifying their understanding of your expertise?	<u>Items1 to items 4:-</u> Fowlkes et al. (2000) and Moreland et al. (1996)
Elaborate (ELAB) How many requests did you initiate with other team members asking them to elaborate on their expertise? How often do other team members request you to elaborate about your expertise? How often did you communicate with other team members in requesting them to elaborate about their expertise? How many messages did you receive from other team members asking you to elaborate about your expertise?	<u>Items1 to items 4:-</u> Fowlkes et al. (2000) and Moreland et al. (1996)

Table 5. TEP unit evaluation cycle measurement items (links to the dimensions in Table 1)

3.4 TEP utilization cycle

The utilization cycle takes place when team members are able to use the ‘team’s knowledge’ in completing a project or given task (Akgun et al. 2005). Tan et al. (2008) also refers to this cycle as “*the amount of activities related*” in using the team’s overall knowledge (p. 918). Based on these explanations, we define this cycle as the extent to which a team member communicates with another team member to utilize his/her TEP unit. This is illustrated in an example presented below:

TEP Unit: Task (T) = Creating dynamic webpage, Expertise (E) = Programming Expert, People (P) = Noreen.

When the above mentioned TEP unit is utilized by a team member, three possible outcomes may happen as presented in Table 6.

Outcome	Description
Outcome 1:	Noreen manages to create the dynamic webpage. Thus, the team member's TEP unit does not need to be evaluated or reconstructed.
Outcome 2:	Noreen does not create the dynamic webpage and mentions that she is an expert in creating static webpage instead of dynamic webpage. Thus, the team member's TEP unit needs to be reconstructed.
Outcome 3:	If Noreen mentions that she is good in creating webpage but she has not much experience in creating dynamic webpage, then the team member's TEP unit still needs to be evaluated and reconstructed. The Task (T) will need to be assigned to another People (P) or it can still be assigned to Noreen. If the Task (T) is assigned to Noreen, then the team member's TEP unit is evaluated as of low credibility.

Table 6. TEP unit utilization (Brandon and Hollingshead 2004)

Brandon and Hollingshead (2004) highlights that the utilization cycle begins when members start to communicate using their TEP unit for: (1) completing a task, (2) asking questions, (3) requesting specific information or knowledge from team members. In the study by Davenport and Prusak (1998), they find the utilization cycle is mainly used to solve task-related problems within a team. This is further supported by Lee et al. (2005) where the extent to which team members communicate amongst themselves helps to promote the utilization of each team member's knowledge and expertise in performing the tasks assigned to each team member. A team's knowledge utilization would also lead to better decisions or actions to complete tasks in a team (Holsapple and Wu 2006). Based of these, we then propose the utilization cycle measurement items as shown in Table 7.

Completing task (COMP_TASK)	**Key reference**
1) How often did you request other team members' expertise to solve problems in completing your tasks?	Brandon and Hollingshead (2004)
2) How often do other team members ask your expertise in enabling them to solve problems in completing their tasks?	Davenport and Prusak (1998)
3) How many messages did you receive from other team members requesting your expertise in enabling them to solve problems in completing their tasks?	Lee et al. (2005)
4) How many requests did you send to other team members in requesting their expertise in enabling you complete your tasks?	Holsapple and Wu (2006)
Asking Question (ASK_Q)	
1) How many messages did you send to other team members asking task related questions?	Brandon and Hollingshead (2004)
2) How often did other team members communicate with you to ask task related questions?	Davenport and Prusak (1998)
3) How often did you communicate with other team members to ask task related questions?	Lee et al. (2005)
4) How many messages did you receive from other team members asking task related question?	Holsapple and Wu (2006)
Request specific info or knowledge (REQ_SPEC)	
1) How often did you request specific task related information or knowledge from other team members?	Brandon and Hollingshead (2004)
2) How many messages did you receive from other team members requesting specific task related information or knowledge from you?	Davenport and Prusak (1998)
3) How many requests did you initiate with other team members requesting specific task related information or knowledge?	Lee et al. (2005)
4) How often did other team members communicate with you requesting specific task related information or knowledge	Kozlowski and Ilgen (2006)

Table 7. TEP unit utilization cycle measurement items (links to the dimensions in Table 1)

Referring back to section 3.2, 3.3 and 3.4, we have presented the explanation of each cycle that occurs during the TEP development cycle.

Brandon and Hollingshead (2004) suggests that the TEP unit facilitates the forming of a shared mental model. Shared mental model is defined as "the extent to which individual team members' mental models overlap-the extent to which team members share the same understanding of the task and the team"(Blickensderfer et al. 1997, p.252). They go on to further suggested that when team members have shared mental models, they are more likely to form a high quality TMS.

For the sake of brevity, the items presented in Tables 3, 5 and 7 are final items with reference to the literature and have been reviewed by experts from the information systems discipline. The expert review process is explained below (see Figure 1, stage II).

3.5 Expert review

According to Lewis et al. (2005), "the early and prudent use of experts in the design of philosophical elements can expedite scientific progress and make construct development project more efficient" (p. 390). Therefore, it was important that experts in the field to get involved before any empirical validation with potential survey respondents are performed. These items were reviewed by three experts from the information systems discipline to check each item, in the dimensions of the construct, for clarity of expression, conceptual clarity and appropriateness. The appropriateness of each item was checked using a set of four criteria (i.e., does item help fulfil the definition, is the item simple, avoid double-barrelled items and avoid any item clarification). The appropriateness was negotiated between the expert's reviewers and the researcher. This set of criteria by MacKenzie et al. (2011) was used in order to ensure the objectivity of each item across each proposed dimension in this research. An item was retained only if it fulfils all the four criteria. Based on these criteria, this screening process retained a total of 40 items that represent the domain of the concept of interest in this research (see Table 3, 5 and 7). In order to further empirically confirm the validity of the generated items, we then proceed to conduct a content adequacy assessment. The subsequent section will further describe this assessment.

4 CONTENT ADEQUACY ASSESSMENT

The purpose of a content adequacy assessment is to guarantee that the measurement items that will be used in the data collection stage are both valid and reliable. Although there are various content adequacy assessments, in this study we employ the content adequacy assessment procedure suggested by Schriesheim et al (1993) and Sharma et al. (2005) as recommended by MacKenzie et al. (2011) and Straub et al. (2004) to empirically check the classification of items under different dimensions. Details of this assessment procedure and analysis are described below.

The content adequacy assessment procedure begins by asking participants to select the most appropriate dimension for each of the items presented to them. Participants were graduate students at a large Australian university. Since we only ask participants to categorize each item, participants must simply have the intellectual ability to comprehend the definitions presented to them, and be able to follow simple instructions. Thus the use of graduate students is justifiable in this study. The use of graduate students is also supported by MacKenzie et al.(2011) and Schriesheim et al. (1993).

This survey was administered in an online format for the period of two weeks, and distributed through the university's email list to the graduate students ranging from economics, engineering, arts and commerce programs. Each respondent was placed in the running of a lucky draw. After two weeks 55 responses were received. After excluding uncompleted responses, a total of 50 responses with usable data were left.

Following Sharma et al. (2005) we first organized the data collected into a matrix form whereby N times M (N equals number of respondents and M equals the number of items). This resulted in a matrix of 2000 rows and 9 columns (8 for TEP unit and 1 for 'none of the above'). Following this, we computed the number of times each dimension was selected base on each of its item. Next, we performed a Q-type factor analysis by inverting the data matrix followed by a principal factor analysis.

The Q-type factor analysis was adopted in this study because it was recommended by Straub et al. (2004) when performing content adequacy assessment.

5 RESULTS

We used the decision rules as suggested by Hair et al. (2006) to identify the number of factors underlying each construct. Specifically, items with less than 0.45 loading and which cross-loaded on two or more factors at a 0.45 or higher were excluded from further analysis. Eigenvalue of '1' was used as the cut-off value for item extraction. The iterative sequence of factor analysis and item deletion was repeated, resulting in a final scale of 31 items belonging to eight distinct dimensions (TEP utilization cycle: ASK_Q dimension was dropped) associated with the TEP unit construct. We then further analysed other possible factor solutions but confirmed that the eight dimension is the most fitting solution, as it accounted for 99.21% of the variance (Hair et al. 2006). Appendix I summarizes the factor loadings for the condensed 31 items. The significant loading of all the items on multiple factors clearly indicates that the TEP unit is of a multidimensional construct as conceptualized in this research. The fact that no item had multiple cross loading was found to support the preliminary discriminant and convergent validity of the scale. The items also had high item loading for each of the construct. The items also showed high internal consistent reliability. This is demonstrated when the items have high factor loadings among its constructs (MacKenzie et al. 2011). The results of the factor analysis (see Appendix I) revealed that 31 distinct items cleanly loaded into eight dimensions, although in the conceptualization of the construct we proposed nine dimensions. These items refer back to the items shown in tables 3, 5, and 7 (e.g., item6 PE is item number six in the Past Experience dimension of the construct as shown in Table 3).

6 DISCUSSION

This study has conceptually defined the TEP unit construct and operationalized this construct into conceptually distinct measureable items. The measurement items developed in this study are critical in the development of the TEP unit construct since a sound scale measurement is a prerequisite for any theoretical advancement (Straub et al. 2004). Our analysis provides support for the propose measurement items base on each TEP unit cycle (see Table 3, 5 and 7). In this section we discuss: (1) dimensions that were dropped, (2) a 'none of the above' dimension that was added and (3) the generalizability of the sample size and (4) the practical contributions of this research.

While the results of this study were conceptually different from what was proposed (see Table 1), the fact that only one dimension that was dropped (*TEP utilization cycle: ASK_Q*) is reasonable as respondents may have perceived these items do not cohere with the suggested dimension definition. We speculate two possible causes: (1) the proposed items overlap into more than one dimension, (2) and (2) the dimension definitions were not sufficiently clear.

In the 'none of the above' category, it shed some light towards the thought process of the respondents. This category is recommended by Sharma et al. (2005) to be put in place if: (1) the dimension definitions are too simple or (2) if items can be categorized in more than one dimensions. The categorization of items in this dimension suggests that respondents followed the directions and gave careful thought towards their ratings of each item. We did not find any evidence of an additional dimension, however given the exploratory nature of this research it is possible that additional dimensions exist.

The appropriate sample size is a key issue in most research (Hair et al. 2006; Tabachnick and Fidell 2007). However base on the method employed in this research, it should be noted that we are interested in the assessment of the items in relation to the theoretically defined dimensions. In doing so, we are not attempting to generalize the empirical relationship base on the sample size and population but we are interested about the theoretical relationships among the items and the dimension it represents. In doing so, the only requirement for the participants to be considered adequate for this task is that they posses sufficient intellectual ability to perform the item rating task.

The analysis in this study was done base on correlation matrix (refer Section4). This correlation matrix reflects the relationship among the items and dimensions and, as such we do not need large number of samples. Previous studies from Sharma et al. (2005) and Schriesheim et al. (1993) also indicates that participants ranging between 30-50 are adequate to produce constant results.

The study also makes practical contributions for researchers. Because the newly developed TEP unit measurement item in this research depends on the team tasks, the items could be used to evaluate virtual teams over time and in a range of different task settings. This study may also contribute to and stimulate further interest in the study of TEP and TMS within other team settings such as:(1) new product development teams (Akgun et al. 2005), (2) emergent response team (Majchrzak et al. 2007), and (4) enforcement teams (Jarvenpaa and Majchrzak 2008).

7 LIMITATIONS

Although the resulting scale has been subjected to rigorous scale development and validation procedures, the study is not without limitations. Firstly, the participating respondents for this study were predominantly from one Australia university. While the unit of analysis is the individuals of working teams, the generalizability of the findings remains yet to be determined. Future research should test TEP unit measurement items with new data sets in other settings. For instance, researchers could perform cross- cultural studies using different larger samples from industries for greater generalization of the scale. Test-retest reliability investigation should also be considered in order to examine the stability of the construct over time. Secondly, the participants for this study are students. Although we have provided proper justification for the use of students, we recognize that other researchers might take exception to our justification. Finally, although a rigorous scale measurement approach has been adopted in this research, there still a need for continued refinement and validation of the measurement items.

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8 APPENDIX I

Factor loading for the 31 items

Factor	Item (see Table 3, 5 and 7)	Factor loading
Past Experience (PE)	item2_PE	.939
	item1_PE	.933
	item6_PE	.916
	item5_PE	.896
Learning unfamiliar concepts (LEARNING)	item1_LEARNING	.971
	item3_LEARNING	.951
	item2_LEARNING	.841
	item4_LEARNING	.838
Understanding overall design of tasks (UNDER_TASK)	item1_UNDER_TASK	.931
	item2_UNDER_TASK	.918
	item3_UNDER_TASK	.912
Establishment of a mutual relationship (MUTUAL)	item1_MUTUAL	.969
	item2_MUTUAL	.953
	item3_MUTUAL	.939
	item4_MUTUAL	.871
Clarifying prior expertise (CLARIFY)	item1_CLARIFY	.942
	item2_CLARIFY	.939
	item3_CLARIFY	.905
	item4_CLARIFY	.865
Elaborating team member expertise (ELAB)	item1_ELAB	.974
	item2_ELAB	.973
	item3_ELAB	.926
	item4_ELAB	.891
Task completion (COMP_TASK)	item1_COMP_TASK	.961
	item2_COMP_TASK	.895
	item3_COMP_TASK	.888
	item4_COMP_TASK	.849
Requesting specific task related information of knowledge (REQ_SPEC)	item1_REQ_SPEC	.982
	item2_REQ_SPEC	.963
	item3_REQ_SPEC	.962
	item4_REQ_SPEC	.962