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The Translational Learning Ecosystem

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ABSTRACT

Aim/Purpose In this paper we propose an ecosystem for translational learning that combines core learning principles with a multilevel construct that embraces the tenets of translational research, namely, teaming, translating, and implementing. The goal of the paper is to argue that knowledge of learning sciences is essential at the individual, team, and organizational levels in the translational science enterprise.

Background The two decades that we can now call the translational era of health and medi-cine have not been without challenges. Many inroads have been made in navi-gating how scientific teaming, translating knowledge across the health spectrum, and implementing change to our health systems, policies, and interventions can serve our changing global environment. These changes to the traditional health science enterprise require new ways of understanding knowledge, forging rela-tionships, and managing this new tradition of science. Competency require-ments that have become important to the enterprise are dependent on a deep understanding about how people learn as individuals, in teams, and within or-ganizations and systems.

Methodology An individual, team, and organizational conceptual framework for learning in translational ecosystems is developed drawing on the learning science literature, a synthesis of 9 key learning principles and integrated with core competencies for translational science.

Contribution / Findings The translational learning ecosystem is a means by which to understand how translational science competencies can be reinforced by core learning principles as teaming, translating, and implementation intersect as part of the translational science enterprise.

Recommendations for Practitioners This paper connects learning science to tailored principles in a simplified way so that those working translational science with less knowledge of theories of learning and pedagogy may be able to access it in a clear and concise way.

Recommendations for Researchers This paper provides a framework for researchers who engage in the education of translational scientists as well as those who are charged with training new sci-entists in an emerging field critical to health and medicine.

Impact on Society This paper allows for greater inclusion of learning science as a critical aspect of the sciences that seek to help move discovery and research to policy and social impact.

Future Research The translational ecosystem described can serve to expand how teaching and learning impact scientific advances. In addition, it serves as a means in which to understand the impact of learning on micro, meso, and macro levels.

Keywords ecosystem, pedagogy, team science, implementation, translation, learning science

INTRODUCTION

Translational science grew out of the realization that important bench research was not efficiently making its way into clinical practice and thus not improving the health of individuals and populations as it could and should (Austin, 2018; Zerhouni, 2003). Scholars have commented on the fact that improving the translation process has proven far more complicated than initially conceived because, as Braithwaite et al. (2018) point out, "The health system is probabilistic and stochastic, not determinis-tic and causal" and depends at all stages on human systems distinguished by uncertainty, illogic, and unpredictability (p. 3). Translational research, thus, is a tricky enterprise, requiring the best and most nuanced science, conducted by interdisciplinary teams skilled at navigating complexity, engaging diverse perspectives, and thinking outside the box. Conducting and supporting such nuanced, bound-ary-defying research and application for downstream impact requires that those dedicated to clinical and translational science work where scientific exploration is accompanied by lifelong learning. This is where the learning sciences can significantly advance the success of discovery, application, and dissemination (Norman & Lotrecchiano, 2021).

Translational science requires a deep knowledge of how people, whether individually or in teams and organizations, learn and potentially change as they learn, unlearn, and relearn the traditional research enterprise (B. F. Jones et al., 2008; Wuchty et al., 2007). Decades of research on the mechanisms and conditions that promote deep, flexible, and effective learning have not made their way to the fore-front of the translational science movement. Instead, discussions about learning are often narrowly circumscribed, delegated primarily to the context of classroom teaching and training with little regard for the flexible and agile skills necessary to operate within the "the new youngest science, with boundless promise to transform science and medicine" (Austin, 2018, p. 456). We believe, however, that an understanding of the learning sciences has the potential not only to improve the training of the next generation of researchers and practitioners but also to significantly enhance the collabora-tive skills of individuals in teams and the organizational systems in which they work. After all, be-cause interdisciplinary researchers must constantly teach and learn from one another, teaching and learning infuse everything translational researchers do, from bench to bedside to storefront. An un-derstanding of learning research and its core principles should thus be central, not peripheral, to the work of translational researchers and practitioners (Seyhan, 2019).

The term 'learning sciences' refers to an interdisciplinary field of scholarship that explores the mechanisms by which learning occurs and identifies practices that facilitate learning (P. Brown et al., 2014; Sawyer, 2014; Sommerhoff et al., 2018). The learning sciences draw on a diverse set of disciplines, including cognitive and developmental psychology, neuroscience, computer science, sociology, and anthropology (Ambrose et al., 2010). In addition to challenging long-standing myths about teaching and learning (A. Brown & Kaminske, 2018; Nancekivell et al., 2020; Norman & Lotrecchiano, 2021; Riener & Willingham, 2010), the learning sciences distill research on learning into principles and strategies to enhance teaching. Not incidentally, the learning sciences have evolved over much the same timeframe as translational science, tackling the same problem (bringing research into practice) in a different sphere, and grappling with many of the same issues, e.g., promoting innovation within large and often hide-bound systems and creating inclusive and welcoming environments that foster intellectual risk-taking and interdisciplinary exchange. In a previous article (Norman & Lotrecchiano, 2021), we identify a set of key learning principles we believe are directly applicable in the educational roles of translational research. These principles synthesize half a century of research on how learn-ing works (Ambrose et al., 2010). They are not specific to any discipline or student level and, thus, apply across learning contexts

and modalities. Moreover, they are sufficiently broad enough to en-compass new discoveries and formulations. For simplicity, these principles can be organized into three categories: acquisition and integration of knowledge, social and emotional components of learning, and elements of skill-building. While we explore the principles themselves elsewhere (Nor-man & Lotrecchiano, 2021), our goal in this paper is to bring attention to the central role of learning across the translational enterprise and, thus, the critical role the learning sciences can play in our work, not just in traditional classroom and training settings but also on research teams and across or-ganizations. We outline the role of learning on the individual, team, and organizational levels within the translational learning ecosystem, demonstrate the relevance of learning principles as they apply to these three levels, and argue that learning science is foundational to the success of the translational science movement and is, in fact, the ultimate translational science.

THE TRANSLATIONAL LEARNING LANDSCAPE

Learners in the clinical translational setting are already sophisticated, highly trained individuals and are fully vetted in their own disciplines. These learners have a multitude of professional goals that are often complex and dependent on more than simply learning new tasks. Instructors come from a range of backgrounds from medicine to social work, from statistics to the humanities, and from clini-cal practice to philosophy. They themselves are typically trained in one area though they are often asked to supplement their own training with cross-disciplinary perspectives where they sometimes struggle. And unlike traditional education, these instructors possess a variety of roles from tenured faculty at universities, to clinical posts, to staff positions and community stakeholders, each providing their own brand of expertise. Duration and time variations range from full degree programs to short professional workshops, face-to-face, hybrid, and online sessions. These often target learning about praxis where theory and practice interface in clinical application, laboratory training and mentoring, technical and social skill training, disciplinary and cross-disciplinary studies, individual and team-taught modules. These different modalities all constitute a complex array of environments where the clinical and translational workforce are involved.

For individuals, the translational learning landscape requires a commitment to human intrapersonal and interpersonal competency-building with a predisposition to lifelong learning (Senge, 2006). The attitudes, behaviors, and cognitions are intentional alterations that allow one to be receptive to collaboration and change (Garvin et al., 2008). At times, individuals will be required to commit to learning about new ways of leading and managing, communicating, problem solving, and most importantly serving as a conduit for building trust into the translational science system (Uhl-Bien et al., 2007).

For teams, whether research teams or administrative units, they represent a microcosm of a learning organization and the working unit by which organizations learn and adapt (Lotrecchiano, 2011). Because the best and most nuanced translational science requires teams skilled at navigating complexity, engaging diverse perspectives, and thinking outside the box (Zerhouni, 2003), our goal should be fostering learning teams that are the direct product of learning organizations and thus are nurtured and supported by environments that see knowledge as the true mediator in translational science. In other words, groups perform both taskwork and teamwork to ensure that attitudes, behaviors, and cogni-tion are calibrated to ensure designed outcomes and goals are achieved (Garvin et al., 2008).

For organizations, the question of how to foster institutions that prioritize learning, adaptation, and agility has been addressed in the literature on complexity leadership and continues to be a concern in the

team science literature (G. Jones, 2000). It promotes a departure from the leader-centric notion of influence typical of the manufacturing economy with its emphasis on leader characteristics and relationship with workers to the adoption and management of emergent and non-linear environ-ments and systems that typify the knowledge and information economy that dominates the 21st cen-tury (Fiore, 2012; Fischer, 2000). Complex and distributed leadership models reorient organizations and teams around knowledge, learning, and flexibility (Fiore, 2012; Lotrecchiano et al., 2020; Yeo, 2020). Individuals, groups, and organizations serve as unique components of entire systems and thus leadership is more so the influence over processes rather than people and things (McHale et al., 2019).

First, we acknowledge that, as described, clinical translational efforts are intrinsically dependent on learning on the individual, team, and organizational levels. Thus, we need to consider different types of learning—applied, academic, scholarly, and social— as equal partners in the same ecosystem. In-stead of applying complex techniques to this 'new vision' for learning in the clinical translational landscape, we find it more appropriate to speak from the position of competence needed to accom-plish these goals. As such, we draw the basic competencies found in translational, team, and imple-mentation sciences as guiding foundational tenets as we describe how core learning principles are used within it (Achtenhagen et al., 2003; Northouse, 2007; Uhl-Bien et al., 2007). These, coupled with definitions and examples, are needed so that those less versed in learning science can embrace what is known from it while they equally apply their expertise to the scientific tasks at hand (Seyhan, 2019).

Second, to accomplish what we have stated in the last points, there is a need to simplify the otherwise complex tablature of educational theory and practice in the clinical translational setting. Teaching is a reflective practice requiring continual self-awareness, reflexivity with one's environment, and an acute recognition of how one's positionality to issues and problems affects their conscious and subcon-scious bias (Volberda, 1996). We have chosen to be specific and to highlight teaching and learning principles based on their applicability to Clinical and Translational Science (CTS) using enduring principles that can be applied to the micro, meso, and macro levels, backed up by self-reflection ques-tions for instructors and learners to utilize in their own contexts as they seek to apply the principles. These questions will allow those who generally do not embrace an evidence-based learning approach to adopt practices quickly and easily in their work that will contribute to better decision making about instructional content and the development of more inherently sound learning environments.

Third, we provide insight into how understanding the multilevel nature of clinical and translational learning environments provides insights into the unique character of a translational learning ecosys-tem. Learning principles are applicable to individual, team, and organizational functions. Change and adaptation are key when working across the sciences and across the multiple layers of an enterprise. Our approach addresses this multilevel environment, thus addressing how learning is central to all aspects of the translational science enterprise.

A learning ecosystem for translational research (Figure 1) recognizes the need for individuals, teams, and organizations to embrace the core processes of translation, teaming, and implementation, all of which require learning and change as part of their contribution to enhancing and affecting health and health systems (Schwandt & Gorman, 2004) and are higher order learning activities. These represent the functional and transformational elements that make translational science unique and support the goals of this "newest youngest science" charged with developing "new pathways" (Austin, 2018; Zerhouni, 2003). By the intersection of these contributing core disciplines, five grounding domains of competence

are key to successful engagement within the translational learning ecosystem that go beyond mere cognition but also include social and humanistic lifelong learning principles. These are facilitating team affect (or bonding), team communications, the management of research teams, collaborative problem solving, and leadership (Lotrecchiano et al., 2020).

Each of these domains has both individual, team, and organizational components and represents the catalysts for teaching and learning, namely, prior knowledge, the organization of knowledge, motivation, mas-tery, practice and feedback, cognitive load, climate, and metacognition (Figure 1). Critical to achieving the goals of this multilevel learning system requires a deep knowledge of these learning principles that, once understood, will assist in ensuring that the goals of the translational science community can be met using sound learning science. To extrapolate these principles, we provide an overview of these core principles, applications on the individual, team, and organizational levels, reflective questions about how one might apply each principle, and implications for the overall ecosystem.

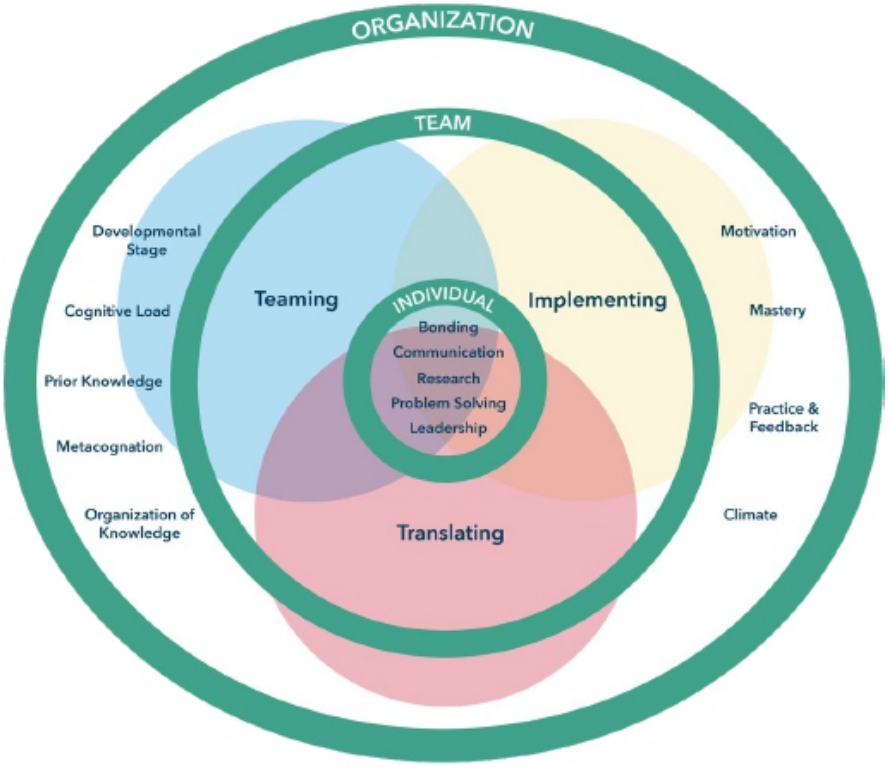

Figure 1. The Translational Learning EcoSystem

THE TRANSLATIONAL LEARNING ECOSYSTEM

We utilize the term ecosystem in a way that has been adopted not only in learning but also across several fields to describe the complex arrangement of efforts within translational science. "A learning ecosystem is a system of people, content, technology, culture, and strategy, existing both within and outside of an organization, all of which has an impact on both the formal and informal learning that goes on in that organization" (Eudy, 2018). Much emphasis has been placed on the psychological and cognitive properties of learning in individuals (Center for Leading Innovation & Collaboration, 2021); indeed, most conceptualize learning as an individual level vocation. However, other ap-proaches to learning have emerged that are more highly steeped in group and social learning, empha-sizing that learning requires social grounding and interactions within groups (Moore & Khan, 2020). Others have even

promoted that life-long learning has sensemaking properties that require one to constantly problem solve through the culmination of (a) cues or information from one's environ-ment that act as triggers or that signify that meaning is required; (b) a framework or knowledge struc-ture (Klein et al., 2020; Lotrecchiano et al., 2016; McAllister, 1995; Schön, 1987; Weick, 1995) that includes a set of elements, rules, or values that have served as a guide to understanding; and (c) a re-lationship, or script, that links the new information to the framework, all of which would suggest that learning in an interactive engagement with one's surroundings and the entire environment in which they interact on emotional, behavioral, cognitive, and humanistic levels (Schwandt, 2005). Un-like oversimplified constructions of learning, here, making 'sense' of the world and applying one's interpretation are matters of grounded identity, retrospection, awareness of one's environment, through social, ongoing, focused cues that are driven more by plausibility than accuracy (Jain et al., 2010). Table 1 serves as a means of organizing core learning principles as they apply to different lev-els of the translational environment, along with universal reflective questions for instructors and learners, as well as the implications of the principles to impact the overall ecosystem.

Table 1: Learning Principles, the Characteristics of Effective Learning at Individual, Team, and Organizational Levels, Reflective Questions, and Implications for Influencing the Ecosystem

Core Learning Principles	Individual level	Team level	Organizational level	Reflective Question	Implications for Influencing the Ecosystem
Acquisition and Integration of Knowledge					
Prior Knowledge: Learn- ers' prior knowledge can help or hinder learning	Successful Learners seek to connect new knowledge to existing knowledge, while identifying and ad- dressing gaps, misconcep- tions, and other prior knowledge problems.	Learning Teams create opportunities for mem- bers to share knowledge, recognizing and speak- ing to the knowledge gaps of team members from different domains.	Learning Organiza- tions nurture the ex- change of knowledge from multiple inputs.	*What do learners currently know or believe that I must address to effectively build new knowledge?*	Develop mechanisms and oppor- tunities in courses, on teams, and in organizations to discuss the knowledge that differently posi- tioned learners bring, as well as misconceptions and knowledge gaps that might impede progress. Use this information to collec- tively build more robust knowledge structures.
Organization of Knowledge: How learners organize knowledge influ- ences how they learn and apply what they know	Successful Learners de- velop effective and flexible ways to organize knowledge to meet varied goals.	Learning Teams com- bine different types of expertise and create op- portunities to explain contextualize how they organize knowledge within their respective domains	Learning Organiza- tions utilize agile mechanisms to organ- ize, share, and dissemi- nate different types of knowledge.	*What organizational frameworks do learners need to connect and use in- formation effectively, and how can I help them de- velop these frameworks?*	Allocate space and time in group settings to discuss various ways of organizing knowledge to reconcile cognitive frameworks and develop shared mental models.
Cognitive Load: The inten- tional connecting of seem- ingly unrelated or extrane- ous information	Successful learners will be skilled in how to integrate knowledge for the purpose of expressing thoughtful meaning.	Learning teams will em- phasize how constant emphasis on navigating similarities and differ- ences in collective exper- tise is necessary.	Learning organizations will develop structures so that integrate knowledge become an emphasized and nor- mative activity.	*What learning processes need to be developed so that learning is a foundational tenet while decreasing ex- traneous cognitive load?*	Emphasize how the task of trans- lation is to exchange, integrate and simplify the complexity associated with teaming, translating, and im- plementing.
Core Learning Principles	**Individual level**	**Team level**	**Organizational level**	**Reflective Question**	**Implications for Influencing the Ecosystem**
Metacognition: To become self-directed learners, learn- ers must monitor and adjust their approaches to learning.	Successful learners assess the demands of a task, evaluate their own strengths and weaknesses, devote time to planning, monitor their progress as they work, and take time after a project to reflect on their performance.	Learning Teams allocate time for task assessment and planning, designate opportunities mid-pro- ject to assess and modify processes, and take time after project completion to discuss and capture lessons learned.	Learning Organiza- tions designate oppor- tunities for collective reflection to identify and foster effective practices.	*How can I provide appro- priate opportunities for planning, monitoring, and reflection to promote meta- cognition?*	Build structured opportunities (during classes and trainings, at the mid- and endpoints of projects, and after major new institutional initiatives) to reflect and distill les- sons learned. Be deliberate about developing the habit of reflection. Establish mechanisms for preserv- ing and acting on the insights gen- erated as a normative throughput activity.

Social and Emotional Components of Learning					
Motivation: Learners' motivation determines, directs, and sustains what they do to learn.	Successful learners are aware of the important role of expectancy and value (including autonomy, mastery, relatedness, and purpose) in motivation, and leverage them to maintain motivation and persistence.	Learning teams identify the goals and motivations of team members and seek to align them to reach optimal performance.	Learning organizations provide recognition and rewards matched to the goals and ambitions of members, while minimizing obstacles to success.	*How can I help to build value and expectancy to spark and sustain motivation?*	Work to increase the factors that enhance motivation, whether in classrooms, on research teams, or among faculty and staff. Look to align individual goals with group goals, highlight the larger purpose of tasks and outcomes, reduce unnecessary obstacles, encourage independence, create opportunities to demonstrate mastery, and foster strong social connections.
Climate: Learners' current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning.	Successful learners attend to their own learning needs and seek out environments that support their intellectual growth	Learning Teams recognize the importance of trust and work to build an environment that promotes psychological safety.	Learning Organizations prioritize the development of an equitable and inclusive work environment.	*How can I foster and sustain an environment that provides learners the support and safety they need to thrive?*	Draw on the knowledge and expertise of learners. Be aware of how subtleties in tone and messaging affect climate and actively work to create inclusive team and organizational environments.
Core Learning Principles	**Individual level**	**Team level**	**Organizational level**	**Reflective Question**	**Implications for Influencing the Ecosystem**
Presence: The ability of learners to engage through social, cognitive, and teaching presence	Successful learners engage with others, content, and instructive influences equally to maximize learning outcomes	Learning Teams exercise engagement in multiple ways that include interpersonal, mental, and exploratory experiences.	Learning Organizations construct avenues and secure resources that ensure presence is a priority no matter the modality or context.	*How can one utilize learning opportunities to respond to the social, cognitive, and relational needs of learners?*	View learning opportunities as holistic experiences that tend to the social, cognitive and relational needs of all involved and utilize instructional design to satisfy these different needs.
Elements of Skill Building					
Mastery: To develop mastery, learners must acquire competent skills, practice integrating them, and know when to apply what they have learned.	Successful learners recognize that mastery is developmental and work to acquire key skills, seek opportunities to practice integrating them, and learn to use them appropriately in diverse contexts.	Learning Teams develop collective mastery by identifying and integrating members with necessary skill sets and working to utilize these skill sets effectively across contexts.	Learning Organizations identify desired areas of specialization and create opportunities for skill acquisition, integration and application.	*What are the domains of mastery I hope to develop, and how can I help learners acquire the relevant component skills, learn to integrate them, and apply them in appropriate contexts?*	Be aware of and work against expert blind spots in all contexts. Recognize that mastering complex skills requires time and patience. Provide opportunities, both for individuals and groups, to analyze complex tasks, break them into their component skills, practice these skills in isolation and then in combination, identify when and where these skills are applicable, and learn to apply them effectively to a range of problems.
Practice and Feedback: Goal-directed practice, coupled with targeted feedback enhances the quality of learning.	Successful learners identify skills they need to build, pursue opportunities for practice, and seek out feedback.	Learning Teams designate opportunities for members to learn and practice new skills and prioritize the sharing of feedback.	Learning Organizations create a culture in which regular sharing of feedback is normative.	*What specific skills do learners need to practice and what kinds of feedback can I provide to help them improve?*	Identify skills and subskills that individuals, teams, or organizations need and lack, and create opportunities for deliberate practice, allowing sufficient time for repetition. Create mechanisms and opportunities to provide constructive, timely feedback on individual and group performance.

DISCUSSION

Translational research, team science, and implementation science share a core reliance on ongoing, multi-dimensional, distributed learning. Moreover, the history of these pursuits and of education have moved on parallel tracks, shifting increasingly towards a team orientation, geographical distribution, technological mediation, attention to "soft" skills, and a mandate for diversity, equity, and inclusion. As such, these enterprises have much to learn from and teach one another. It is our contention that the principles of learning – rarely brought to the forefront of consideration in translational science discussions – underlie essential facets of learning at the individual, team, and organizational levels and in all aspects of translational research, team science, and implementation science. Moreover, as the individual competency domains necessary to ensure productive, satisfying teamwork and agile organizations become more clearly defined in the literature (Uhl-Bien et al., 2007), the mechanisms by which we acquire these competencies and teach them to others will become more salient.

As demonstrated, there is much that learning science offers to translational research. This includes a deep understanding of the psychology of motivation, recognition of how new knowledge builds on prior knowledge, and strategies for shaping our work environments to foster inclusive learning. The learning sciences explain why the way we organize knowledge influences how we are equipped to use it, whether working alone or in teams, how feedback can be most effective, and how enlisting the cycle of metacognition more intentionally can make us more reflective and adaptive as learners. A deep understanding of the learning sciences and its explication of the core mechanisms of learning can

illuminate learning at all the levels – individual, team, and organization – explored here, helping us to become more effective teachers, mentors, team members, and administrators and positioning our students, teams, and organizations for the rapid evolution and innovation required of our fast-changing, complex world.

STUDY HIGHLIGHTS

In this paper, we have sought to connect the learning sciences with translational science. We have tried to tailor the principles we have extracted from voluminous scholarship in the learning sciences to fit the contexts in which translational learning occurs, and we have attempted to simplify those principles, paring them down to make them accessible and useful to people outside education. We have argued that, because learning is the ultimate translational science, learning sciences are tailor-made for the most essential goals of translational science, and it is time we made better use of this rich and relevant literature. The argument we make is based on the following key points.

- Learning is intrinsically linked to translation, teaming, and implementation in the clinical translational enterprise.
- The integration of learning science is critical to the success of the clinical translational enterprise.
- The clinical translational enterprise needs to give equal attention to learning on the individ- ual, team, and organizations level to maximize success.

CONCLUSION

We hope this article will consolidate the understanding of and provide a shared vocabulary for those already engaged in explicitly educational work and familiar with the learning sciences, while at the same time using the learning sciences to shed new light on the translational landscape, where learning constantly unfolds yet learning research has rarely been applied. We offer this as the beginning of what we hope will be a long and fruitful discussion about avenues to foster learning in all aspects of translational science.

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CONFLICTS OF INTERESTS

None.

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The Effect of Team Communication Behaviors and Processes on Interdisciplinary Teams' Research Productivity and Team Satisfaction

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ABSTRACT

Aim/Purpose There is ample evidence that team processes matter more than the characteris-tics of individual team members; unfortunately, very few empirical studies have examined communication process variables closely or tied them to team out-comes.

Background The University of Miami Laboratory for Integrated Knowledge (U-LINK) is a pilot funding mechanism that was developed and implemented based on empiri-cally-established best practices established in the literature on the Science of Team Science (SciTS). In addition to addressing grand societal challenges, teams engaged in processes designed to enhance the process of "teaming". This study uses the Inputs-Mediator-Outputs-Inputs (IMOI) model as a blueprint for an investigation into how team communication processes (shared communication, shared leadership, formal meetings, informal meetings) influence intermediary team processes (goal clarity, role ambiguity, process clarity, trust) and team out-comes (team satisfaction, team productivity).

Methodology Monte Carlo methodologies were used to explore both longitudinal self-report (survey of communication and team outcome variables) data and objective data on scholarly productivity, collected from seventy-eight members of eleven real-world intact interdisciplinary teams to explore how team communication pro-cesses affect team outcomes.

Contribution This study is among the few that centers communication practice and processes in the operationalization and measurement of its constructs and which provides a test of hypotheses centered on key questions identified in the literature.

Findings Communication practices are important to team processes and outcomes. Shared communication and informal meetings were associated with increased team satisfaction and increased research productivity. Shared leadership was as-sociated with increased research productivity, as well as improved process and goal clarity. Formal meetings were associated with increased goal clarity and de-creased role ambiguity.

Recommendations for Practitioners Team trainings should focus on communication practices that improve shared leadership and shared communication. Additionally, teaching best practices for formal (task-oriented) meetings can help improve goal clarity and decrease role ambiguity. Finally, the benefits of informal socializing should be recognized, and teams should be encouraged to meet informally (socially, without formal task agendas).

Recommendations for Researchers Studying intact interdisciplinary research teams requires innovative methods and clear specification of variables. Challenges associated with access to limited numbers of teams should not preclude engaging in research as each study con-tributes to our larger body of knowledge of the factors that influence the success of interdisciplinary research teams.

Impact on Society The success of interdisciplinary teams can be improved with trainings focused on communication skills. The success of these teams is critical to addressing so-cieties' most pressing challenges, and careful consideration of team processes is critical to that success.

Future Research Future research should examine different team formation and funding mecha-nisms and extend observation and data collection for longer periods of time.

Keywords communication, science of team science, team processes, shared leadership, shared communication, team outcomes

INTRODUCTION

Bennett and Gadlin (2012) claim that, "The only people more foolish than two people falling in love are scientists starting a collaboration. When passionate about an exciting scientific idea, scientists of-ten neglect to think realistically about the multiple tasks that will need to be accomplished to con-struct an effectively functioning scientific team" (2012, p. 773). However, while a new interdiscipli-nary team may want to focus foremost on how to conduct the proposed research, teams may want to first consider the process of collaboration itself. Although the literature on the science of team sci-ence (SciTS) has cited a wide variety of predictors of team success, it has yet to clearly delineate which specific team processes make a difference to teams' satisfaction and research productivity.

There is ample evidence that team processes matter more than the characteristics of individual team members (including team member intelligence, previous levels of productivity, or the number of dis-ciplines represented on a team) (Jeong & Choi, 2015; Pentland, 2012; Woolley et al., 2010); unfortu-nately, very few empirical studies have examined communication process variables closely or tied them to team outcomes. This is partly a result of the challenges involved with measuring both ante-cedent variables and outcomes as well as the nature of real-world research with intact interdiscipli-nary teams. The number of interdisciplinary teams operating under similar conditions which are available and willing to be studied is generally quite small. Additionally, there are few validated measures that correspond to many of the constructs that are of interest to researchers engaged in the science of team science (SciTS); even core constructs like "team success" are challenging to oper-ationalize. In this study, we describe a program to incubate innovative interdisciplinary research and describe processes that, based on the empirical literature, may help to explain differences in team out-comes, including satisfaction and research productivity. This work addresses an acute need to add to the empirical literature on the processes engaged in by real-world interdisciplinary teams and the out-comes that may result.

Specifically, this study argues that teams that engage in processes such as shared communication, shared leadership, formal (task-oriented) meetings, and informal (socially-oriented) meetings, are more likely to have higher levels of research productivity and report higher levels of satisfaction. These ultimate outcomes of productivity and satisfaction are preceded by intermediate states that in-clude behavioral indicators of trust, role ambiguity, process clarity, and goal clarity. Because shared communication, shared leadership, formal meetings, and informal gatherings represent behaviors that can be easily cultivated in teams, they represent potentially fruitful targets for both intervention and study.

Following the literature review, we describe our use of Monte Carlo methodologies to explore both self-report (survey) data and objective data on scholarly productivity, collected from real-world intact interdisciplinary teams who received pilot funding to advance innovative research on grand challenges to society. We conclude with a number of recommendations designed to advance the work of both SciTS researchers and practitioners who support interdisciplinary teams.

THEORETICAL FRAMEWORK

Interdisciplinary teams are those which "engage in a mode of research… which integrates information, data, techniques, tools, perspectives, concepts and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or field of research practice" (National Academies of Science, 2004, p. 26). The particular dynamics that govern interdisciplinary teams are of special interest to SciTS researchers, but this body of research draws from work done to describe teams in more general contexts. The IPO (Inputs – Processes – Outputs) framework (McGrath, 1964) dominates most empirical work on the practices used by successful teams. It posits that successful teams are associated with inputs and contextual features like team member goals and the pro-cesses teams use to share information. These inputs and processes result in outcomes that range from the depth and continuity of connections among group members, members' influence on each other's behaviors, and the quality of group outputs.

More recently, researchers have pressed for a more sophisticated approach, as represented by the In-puts – Mediators – Outputs – Inputs model (IMOI) (Ilgen et al., 2005; Mathieu et al., 2019), which acknowledges the dynamic nature of teams. This modified framework acknowledges a wider array of variables that constitute team processes and mediators (like communication) which are subsequently associated with a team's emerging states, including a shared mental model and a sense of psychological safety. However, methods and measures commonly used in empirical research have not yet caught up to theorizing in this area. While researchers appear to agree on the usefulness of the framework, there appears to be little consensus about causal constructs. For example, does trust between individ-uals predict the formation of a team? Or is trust an emergent state that is the product of other pro-cesses (or time spent working together)? Alternately, can trust be viewed as an outcome of the pro-cesses used by successful and productive teams? (The answer to all of these questions appears to be "yes".)

Thus, while Mathieu and colleagues (2019) have identified a constellation of variables that are associated with effective teams, additional research is required to establish clear causal pathways. The demand for more sophisticated methods and measurements may, ironically, preclude further identification of the directionality of the relationships between variables identified in a "grand model" of ef-fective teams. For example, while social network analysts can provide a sophisticated view of how researchers from diverse disciplines can contribute to discovery and innovation, it will be difficult for this approach to incorporate an assessment of the impact of goal clarity or shared communication practice. Similarly,

research employing natural language processing (NLP) analytic techniques can provide a valuable snapshot of specific dynamics within teams by linking complex, real-time commu-nication patterns to team outcomes. In other words, there is currently no one set of analytic tools or approach to research that can fully account for the variables specified in the larger theoretical ap-proach. For now, researchers must continue to assemble the complex pieces of the "team effective-ness" puzzle in discrete sections in hopes that knowledge generated in each area can be merged at a future point. Because it delineates the relationship between complex factors, we use the IMOI Model as a foundation for our examination of the impact of communication processes on outcomes associ-ated with team productivity and success.

Because it is difficult to employ methodologies that permit attention to all processes that are specified in the IMOI model, we have elected to focus on a subset of variables identified by this frame-work. A comprehensive review of meta analyses of team effectiveness research conducted by Mathieu and colleagues (2019) indicate that team outcomes (such as productivity, trust, and satisfac-tion) are predicted by processes like specifying goals and identifying strategies for attaining those goals. These processes result in emergent states such as shared leadership and a sense of psychologi-cal safety. Figure 1 represents a conceptual model of the relationship among the variables relevant to the present study rather than all dynamics specified in the IMOI framework.

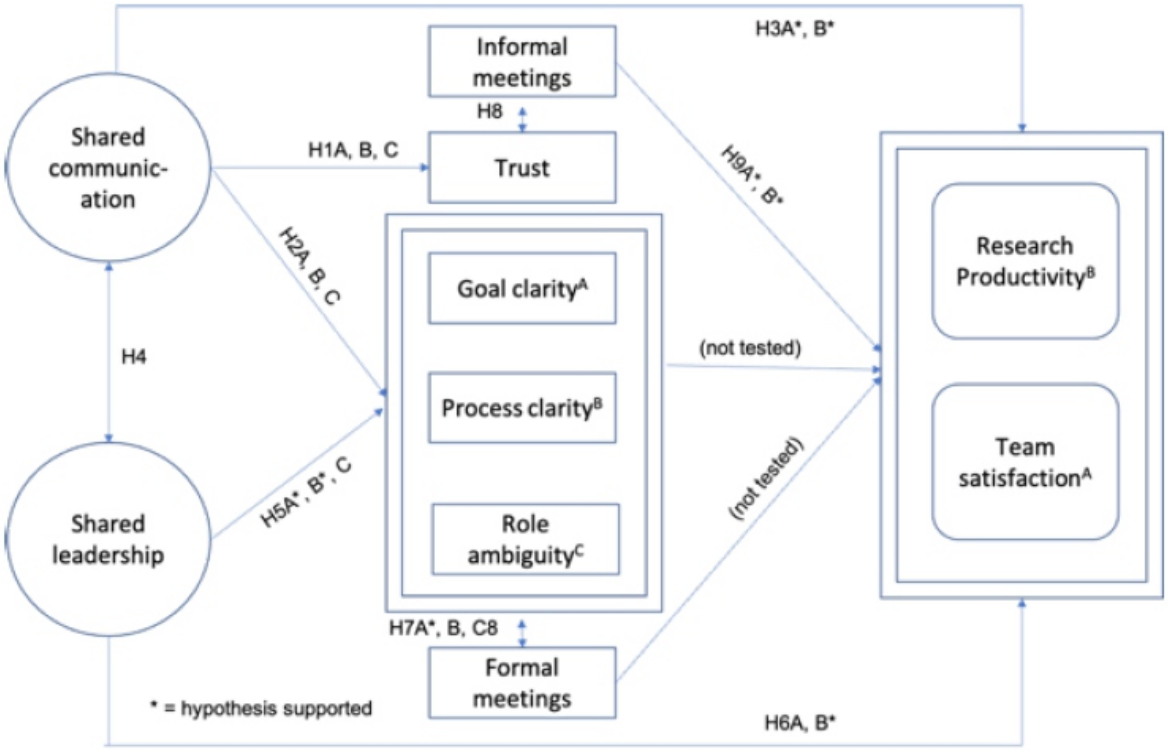

Figure 1. IMIO-Based Conceptual Framework: Process Variables and Effects on Team Success

TEAM PROCESSES

Researchers have identified a number of group communication processes and practices that support interdisciplinary team success (Fiore, 2008). Wooten et al. (2014) provide a comprehensive list that includes creating a shared vision, developing a team identity, creating a team charter, building consen-sus, holding regular, face-to-face meetings that are agenda-driven, soliciting and integrating contribu-tions from all team members, and exploring synergies among team members. Communication is, of course, central to all of these processes; consensus cannot be created and a vision for the team's work cannot emerge without the clear communication among a team's members.

The exchange of information is perhaps the most crucial work performed by a team, and yet re-searchers often treat this as a straightforward, instrumental task. Wittenbaum et al. (2004) add nuance to this approach by providing evidence that the transfer of knowledge across disciplines can be de-scribed as a process of motivated information sharing. This framework acknowledges that features of the organizational context and team member goals affect communication processes, including what information is shared, how it is shared, and with whom it is shared. These processes are linked to task-related outputs (like the quality of outcomes) and the relationships between members of the group.

While the motivated information sharing theoretical framework was originally designed to develop predictions for how information sharing guides group decisions, it is nonetheless useful for under-standing how communication processes can affect team outcomes. Unfortunately, there are few the-ory-based empirical investigations that examine processes in real-world interdisciplinary teams (rather than simulated teams created for the purpose of study). In this study, we use the IMIO approach as a foundation to focus on four specific communication-driven processes. These processes were selected because (1) they are measurable and (2) they represent behaviors that can be targeted for change in team training/development interventions. An important goal of our work is to identify a possible set of best practices that can be employed by interdisciplinary teams to enhance their success and to support a variety of important intermediate goals. These practices include (1) shared communication, (2) shared leadership, (3) formal, task-focused team meetings, and (4) informal (social) team gather-ings, all of which allow teams to engage in the processes that have been posited as being central to team success, including research productivity and team satisfaction (Wooten et al., 2014).

SHARED COMMUNICATION: VALUING ALL CONTRIBUTIONS

A number of researchers have argued that communication is not only key to the success of teams (Bennett et al., 2018; Hinrichs et al., 2016), but is at least as important as the soundness of the scien-tific rationale for a team's work (Hall et al., 2019). Communication is not just a tool required for the coordination of activities, or a discussion of the scientific merits of a question or the process to be pursued--it is also essential for the establishment, strengthening, and maintenance of team dynamics (Bennett & Gadlin, 2012). In other words, while it may be tempting to think of communication as a means for achieving knowledge integration among team members through regular discussions (to use one example), good team communication also helps to build personal and professional bonds among collaborators. Attending to both the instrumental and relational functions of communication within team processes ultimately predicts the success of teams (Marlow et al., 2018; Read et al., 2016). Re-searchers have argued that it is possible to understand why some teams work well and others do not simply by studying their communication behaviors (Eisenbeiss et al., 2008; Lehmann-Willenbrock et al., 2017; Pentland, 2012).

While researchers' calls for "good communication" rarely define a particular set of practices, shared communication entails specific behaviors that team members can implement. Shared communication involves a more-or-less even distribution of conversational turns, and an equal amount of speaking time allows each team member to be heard and (potentially) to feel valued (Cheruvelil et al., 2014; Duhigg, 2016; Pentland, 2012; Woolley et al., 2010). The amount of energy in a team is evidenced by the number of exchanges in a meeting and how well those exchanges are distributed among team members (Pentland, 2012). Additionally, Pentland (2012) argues that team members should com-municate with all other members and not just those in leadership roles, a recommendation echoed by Read and colleagues (2016).

Because turn-taking and the amount of talking time can be measured (albeit with the use of ad-vanced monitoring devices and sophisticated analytic techniques; see Pentland, 2012), these practices can be empirically tied to team outcomes. Shared communication is associated, not surprisingly, with greater knowledge exchange among members, as well as greater knowledge integration (i.e., knowing what others know and being able to make sense of it relative to the topic being researched) (Cooke et al., 2017; Kozlowski & Ilgen, 2006, Mumford et al., 2002; Okhuysen & Eisenhardt, 2002; Read et al., 2016; Waruszynski, 2017). Additionally, a study of 52 novel teams (i.e., those that had no previous experience working together) conducted by Salazar and Lant (2018) demonstrates the importance of communication in the process of attaining both goal and process clarity. Further, it is through shared communication, not the traits or accomplishments of individuals, that collective intelligence is cre-ated, allowing teams to effectively and efficiently solve problems (Woolley et al., 2010). Of course, shared communication implies openness and respect for individual members by their colleagues, and it is likely that it is through this willingness to learn about others' expertise that a sense of psycholog-ical safety and trust is established, allowing for greater creativity and risk-taking in the quest for inno-vative solutions (Stokols et al., 2008) as well as greater satisfaction with the experience of working with the team (Guenter et al., 2017), which serves as an important predictor of long-term success of teams (Kauffeld & Lehmann-Willenbrock, 2012).

There is broad agreement that knowledge integration is paramount to the effective functioning and eventual outcomes of an interdisciplinary team. In fact, a consensus report commissioned by the National Academies (National Research Council, 2015) details the processes that are central to effective team science, which include knowledge integration. While the mechanism of effect differs from that specified by theorizing around transactive memory (Wegner, 1986), this difference does not contra-dict the basic premise that it is important for teams to develop an understanding of "who knows what." In order to create new conceptual frameworks, theories, models, and applications, and achieve transdisciplinary outcomes (i.e., those that transcend disciplinary boundaries) all members of a team must communicate freely and frequently. Individuals must be willing to share what they know, know what others know, and be willing to express this knowledge in ways that allow people from other disciplines to understand. While the National Research Council terms this process "developing shared knowledge" (National Research Council, 2015, p. 14), this can be achieved only through a process of "shared communication." Indeed, the consensus report states that communication is "the essential building block of team cognition" (p. 65). Their recommendation that funding agencies require grant applicants to submit a plan for how deep knowledge integration will be accomplished across disci-plines points to the importance of signaling to interdisciplinary teams that shared communication processes should be valued and developed. Based on the empirical evidence presented in earlier re-search and the strength of recommendations by funding agencies and policy makers, we advance the following hypotheses related to shared communication:

H1: Shared communication is positively associated with behavioral trust.

H2: Shared communication is positively associated with goal clarity (H2a), and process clarity (H2b), as well as lower levels of role ambiguity (H2c).

H3: Shared communication is associated with team success, as evidenced by research productivity (H3a) and survey scores on team satisfaction (H3b).

SHARED LEADERSHIP: TRANSFORMING TRADITIONAL THOUGHT

Although shared communication is a process that supports the success of interdisciplinary teams, the equal distribution of conversational space should be accompanied by additional communication- based processes, particularly shared leadership. However, unlike communication best practices, there is no consensus in the "science of team science" literature on the most effective model of leadership. Instead, there appears to be a general assumption that there is, in fact, a leader or Principal Investiga-tor (PI) who sets priorities and directs the activities of the team, albeit one who can be encouraged to adopt a "flat structure" (Mumford et al., 2002) or an "authentic leadership style" (Guenter et al., 2017). What is agreed upon, though, is that (1) leaders have a powerful effect on outcomes (National Research Council, 2015) and (2) it is difficult to train effective leaders (Eisenbeiss et al., 2008; Wooten et al., 2015). Some researchers have come to distinguish traditional leaders from "transformative lead-ers" who stimulate team creativity and innovation by inspiring team members through the articula-tion of a compelling vision and by stimulating team members to think in new and exciting ways; this stands in counterpoint to more traditional styles of leadership which focus on the status quo and the completion of well-defined tasks according to set performance objectives (Eisenbeiss et al., 2008). However, identifying a cohort of transformative leaders sufficient to populate all teams within an in-stitution or organization would surely prove to be a daunting challenge.

There is also evidence that shared leadership fosters the development of shared mental models be-cause of improved team communication and knowledge exchange (Guenter et al., 2017). Shared leadership of interdisciplinary teams is characterized by mutual influence and distributed responsibil-ity which leads to a positive team climate (Guenter et al., 2017). Survey data from 142 research teams, collected by Guenter and colleagues (2017) demonstrated that shared leadership practices influence team effectiveness through enhanced team coordination, satisfaction with the team, and the develop-ment of shared mental models. The authors posit that transparency, open and authentic relationships among team members, and positive emotional contagion all contribute to the effectiveness of teams. These findings are consistent with studies finding that team structures that promote an abundance of communication and "open, dynamic contact" contribute to innovation (Mumford et al., 2002, p. 731). Wang et al.'s (2014) meta-analysis demonstrated that shared leadership of a team is associated with the development of a shared mental model as well as multiple measures of team effectiveness, including satisfaction, commitment, cooperation, cohesion, and team productivity.

The actual type of responsibilities that are shared among team members makes a difference to team outcomes, however. Traditional leadership models are associated with the successful initiation (and structure) of interdisciplinary projects, but teams appear to be more successful overall when they use a shared leadership model. Moreover, when team members collectively create an appealing vision of a future state and share a common mental model, researchers' intrinsic motivations are validated and ultimately, team members generate new individual and collective aspirations (Wang et al., 2014).

Frequency of communication may be a hallmark of shared leadership. Pentland (2012) argues that emerging leaders of groups not only communicate a lot with team members but connect team mem-bers with each other in a way that earns them the label of "charismatic connectors." Because people who lead teams well have an ability to communicate in ways that are inclusive and respectful of mem-bers, regardless of background or discipline and that empower members of a team to share their knowledge and act autonomously (Baldwin & Chang, 2007; Benoliel & Somech, 2014; Eisenbeiss et al., 2008; Salazar & Lant, 2018), they are, in essence, fostering shared leadership of the team's goals and activities.

There is evidence that individuals on teams that share leadership create a common vi-sion for their future work and develop a shared mental model for how to achieve their goals (Wang et al., 2014). A shared mental model is an "emergent state" of a team whereby members have a shared understanding of their goals and how they will accomplish them, enabling members to integrate their efforts and perform effectively (Benoliel & Somech, 2014). Of course, the need for a shared mental model is obviated in teams with a single leader who provides direction and vision for the team's work. While the published literature makes frequent mention of the importance of shared mental models, there have been few attempts to operationalize or measure this important outcome stem-ming from shared leadership. We believe that goal and process clarity (the degree to which the goals, purposes, objectives, and activities of the team are clearly defined; Bang et al., 2010) and reduced role ambiguity (the degree to which individuals understand what is expected of them and how their activi-ties will contribute to team goals; Tubre & Collins, 2000) serve as an indicators that a shared mental model has been achieved; further, we believe that teams that operate under a shared leadership model are more likely to experience these positive outcomes.

H4: Shared leadership is positively associated with shared communication.

H5: Shared leadership is associated with greater goal clarity (H5a), improved process clarity (H5b), and lower levels of role ambiguity (H5c).

H6: Shared leadership is positively associated with team satisfaction (H6a) and research productivity (H6b).

RQ1: How does team collaboration over time affect perceptions of shared leadership, role ambiguity, goal clarity, process clarity, and the number of formal and informal meetings?

FORMAL MEETINGS: CREATING OPPORTUNITY FOR CREATIVITY

While few people will admit to liking spending time in meetings, the literature is quite clear on the importance of formal meetings for efficiently advancing the work of a collaborative scientific team. Formal meetings are those in which team members primarily focus on working toward the objectives of the team. While meetings tend not to be popular, they may constitute a case where "more is more" (at least up to a weekly schedule; more frequent meetings are very likely to yield diminishing returns) (Baldwin & Chang, 2007; Wang et al., 2014). A number of researchers have identified regular meetings as a key process that supports the success of teams (Bosque-Pérez et al., 2016; Cummings & Kiesler, 2005; Huang et al., 2020; Jeong & Choi, 2015; Wooten et al., 2015). Frequent meetings ap-pear to enhance the development of shared mental models (Wang et al., 2014), achievement of team consensus (Wooten et al., 2015), the accomplishment of knowledge sharing and integration (Kauf-feld & Lehmann-Willenbrock, 2012), and the cultivation of creative approaches to problems (Parker & Hackett, 2012), all of which enhance team effectiveness. It is primarily through face-to-face meet-ings that teams are able to identify problems and their potential solutions (Kauffeld & Lehmann-Willenbrock, 2012; Marlow et al., 2018). Meetings may also be important because they provide a venue for "knowledge demonstrability," which occurs when the group realizes the importance of what each individual team member knows; the more teams meet in person, the clearer it becomes that each person's knowledge is important for the accomplishment of team goals (Kane, 2010).

There is, of course, a "dark side" to meetings. Attendees often perceive meetings to be without a clear purpose and as a result, disengage (Kello, 2015). Virtual meetings, which increased dramatically during the Covid-19 pandemic and which are a necessity for geographically distributed teams, can make it more difficult for individuals to connect with each other (Allison et al., 2015; Jeong & Choi, 2015; Kello, 2015; Pentland, 2012; Waruszynski, 2017). The cohesion of geographically distributed teams can be enhanced with a concerted effort to have in-person team launch meetings and annual in-person retreats (Allison et al., 2015; Cheruvelil et al., 2014; Parker & Hackett, 2012). Team satisfac-tion is also enhanced when team meetings are perceived to be effective (Kello, 2015). Fortunately, there are clear sets of published best practices that can improve the effectiveness of meetings (Cich-omska et al., 2015; Kello, 2015). Additionally, it is imperative that, during scientific team meetings, members create a sense of psychological safety for all members of the group to enhance the team's willingness to advance their most creative and innovative ideas (Parker & Hackett, 2012; Salazar & Lant, 2018; Wooten et al., 2015). Thus, effective meetings are critical to the achievement of the con-fluence of thought required to generate productive outcomes, particularly when members of collab-orative teams have diverse disciplinary approaches to a set of scientific and real-world challenges.

H7: The number of formal meetings will be positively associated with goal clarity (H7a), and process clarity (H7b), and negatively associated with role ambiguity (H7c).

INFORMAL MEETINGS: AN ESSENTIAL FRIVOLITY?

Although the business world has always recognized the importance of informal interactions as supporting profitable deal-making, research-focused institutions appear to view having fun with collaborators as a frivolity that, at best, shouldn't be discussed openly. Researchers focusing on best practices to enhance team science, however, identify informal meetings as a vital process for team success (Baldwin & Chang, 2007; Cheruvelil et al., 2014; Parker & Hackett, 2012; Salazar et al., 2012; Stokols et al., 2008; Thompson 2009; Waruszynski, 2017). Informal meetings may be spontaneous or planned, but while the work of the team may be discussed, social bonding is the main objective. Dur-ing informal meetings, team members learn about each other and enjoy shared laughter and fun. "So-cial time turns out to be deeply critical to team performance, often accounting for more than 50% of positive changes in communication patterns," even in a setting as efficiency-focused as a call center (Pentland, 2012). Nobel Prize-winning collaborators Amos Tversky and Daniel Kahneman famously had fun while doing their ground-breaking work. Bennett and Gadlin (2012) quote Kahneman's de-scription of his experience:

> "[W]e met in Jerusalem to look at the results and write a paper. The experience was magical. I had enjoyed collaborative work before, but this was different. … [A]nd we were not just having fun. I quickly discovered that Amos had a remedy for everything I found difficult about writing. With him movement was always forward … [A]s we were writing our first pa-per, I was conscious of how much better it was than the more hesitant piece I would have written by myself."

Thus, the "power of socialization" (Baldwin & Chang, 2007) allows researchers to become more productive than they would have otherwise been.

Why are these social connections so important? Researchers have identified several mechanisms by which informal interactions produce greater team success. First, informal interactions create team co

hesion which in turn supports team effectiveness (Guenter et al., 2017; Stokols et al., 2008; Waruszynski, 2017). It appears that when people like each other and enjoy spending time together, the resulting interpersonal and group bonds can facilitate the accomplishment of the difficult scien-tific work being demanded of the team. Shared emotional bonds are created through ongoing com-munication and the resulting relationships support a sense of collective identity and scientific recep-tivity (Parker & Hackett, 2012; Stokols et al., 2008; Thompson, 2009). According to multiple meta-analyses, when team cohesion is increased, team effectiveness is enhanced, particularly for teams with high interdependence, which is characteristic of interdisciplinary teams with a mission to generate novel, high-impact outcomes (Beal et al., 2003; Gully et al., 1995).

Second, informal interactions improve collective communication competence within the group, which ultimately fosters the development of team trust. The development of a set of team norms for appropriate communication happens only over time and through experience (Thompson, 2009). The social exercise of "getting to know each other" allows team members to know how to interpret each other's communication behaviors, which means that conflict based on misunderstanding is more likely to be averted (Thompson, 2009). Improved communication competence facilitates the type of relationship development necessary for interdisciplinary collaboration through the creation of trust (Read et al., 2016). Increased trust is accomplished through shared laughter and shared experiences (Cheruvelil et al., 2014; Thompson, 2009). Trust, in turn, is predictive of team members' willingness to integrate knowledge in a way that creates a shared understanding of a problem and ultimately, gen-erates creative, innovative ideas (Benoliel & Somech, 2014).

Third, sharing aspirations and the inspirations for one's own work can facilitate the process of achieving a shared mental model for the work of the team as a whole. The experiences described by Cheruvelil and her colleagues (2014) are instructive. Their large, interdisciplinary team gathered regu-larly outside the workplace for informal team outings and teamwork exercises to build interpersonal skills and to renew group bonds. Through these activities, team members developed shared research goals, developed and affirmed standards for behavior, and created a shared vision for project man-agement. These are all prerequisites for effective team functioning and high-impact outcomes (Hin-richs et al., 2016).

Thus, it is through informal social processes that truly creative and innovative ideas can be advanced, according to Hargadon and Bechky (2006). Their ethnography of engineering, consulting, and design firms indicates that rather than identifying the most creative and intelligent people to be members of collaborative teams, we should work to create the right interaction environment. Indeed, if we accept that researchers aren't merely breathing machines executing designated tasks but are, in fact, wholly human, then we (i.e., administrators, leaders, and research development professionals) must also ac-cept that supporting and even facilitating relaxed and enjoyable get-togethers among team members is an essential part of outcome-driven team science. Because the relational development functions of communication that support a sense of psychological safety in a team can conflict with the need to move toward goal fulfillment (i.e., scientific tasks and team coordination) (Thompson, 2009), infor-mal meetings are arguably not a frivolous distraction for a team but instead, may enhance its produc-tivity and success.

H8: More frequent informal meetings are associated with greater behavioral trust.

H9: More frequent informal meetings are associated with greater team success, including satisfaction (H9a), and team productivity (H9b).

METHODS

INTERDISCIPLINARY RESEARCH FUNDING PROGRAM

U-LINK (University of Miami Laboratory for INtegrative Knowledge) is a unique interdisciplinary pilot research program designed to incorporate the empirical findings described in the literature on the science of team science. In partnership with the Clinical Translational Science Institute (CTSI), the Graduate School, and university Libraries, it awards (through a highly competitive process) a sig-nificant amount of funding in two phases to teams that plan to address any grand challenge to soci-ety. (Teams advance their own vision of a grand challenge – they are not specified by the university.) A diverse, interdisciplinary internal advisory board reviews all applications and makes funding deci-sions. Teams awarded Phase I funding receive $40K for an 8-month period intended to support the process of "teaming." During this phase, teams aim to integrate their knowledge and build relation-ships with key stakeholder groups in order to develop a full plan for their subsequent research activi-ties. At the conclusion of Phase I, teams compete for $150K in Phase II funding (renewable for a second year), which is designed to support the development, feasibility testing, and/or pilot data col-lection required for the team to successfully compete for external funding. Approximately half of Phase I teams are competitively awarded Phase II funding. Phase II teams are required to apply for external funding as a condition of their awards. Thus, one measure of program success is grant fund-ing as well as an important antecedent of funding, research publications.

Each year, awardees are required to attend a full-day team science training workshop that provides evidence for best practices for interdisciplinary team collaborations and a hands-on opportunity to develop key skills. (Additional details about the team science workshop content and the evaluation of its effectiveness are provided in Morgan et al., 2021). Additional professional development activities designed to enhance the knowledge and practice of interdisciplinary collaboration occur throughout the academic year. Further, each team works with a librarian who is embedded with the team. Details about the functions of the team librarian and outcomes of their work with interdisciplinary teams are provided in Miller et al. (2020). U-LINK funded its first teams in January 2018; the program contin-ues with some modifications in 2021.

PARTICIPANTS

Participants for this study were awardees of the U-LINK internal funding program in 2018, 2019 and 2020; the program is described below. Eleven teams had at least one person respond to the sur-vey; the total number of participants providing responses for all three time points was 78, with 40 participants identifying as female, 31 identifying as male, and 7 declining to identify. Participants were mostly faculty members (n = 64; 81%), but also included team librarians (n = 4; 6%). Faculty partici-pating in the survey were distributed in rank as follows: assistant professors (n = 18; 23.1 %); associ-ate professors (n = 22; 28.2%), full professors (n = 17; 21.8%), non-tenure track faculty including and clinical and research professors (n = 7; 8%), including senior lecturer (n = 1). Participants came from a number of different departments across STEM and non-STEM disciplines; please see Table 1 for a complete list.

Table 1. Team Compositions and Descriptive Statistics (n = 97)

Team Name	# Team Members	% Male	% non-STEM	# External Grants Applied	# External Grants Received	$ Awarded	# Peer-reviewed Publications	# Conference Papers	# White Papers
Team 1 (Facial Profiling)	4	50.0	75.0	1	1	$33,932	1	0	0
Team 2 (Brain Injury)	7	28.6	25.0	1	0	0	0	2	0
Team 3 (Hyperlocalism)	6	33.3	66.7	4	1	$50,000	1	12	7
Team 4 (Child Well-Being)	8	25.0	62.5	2	1	$150,000	0	1	0
Team 5 (Data Inclusion)	6	0.0	83.3	1	0	0	0	0	0
Team 6 (Next-Gen Coastal Structures)	9	66.7	62.5	3	0	0	3	11	0
Team 7 (Online Virality)	5	40.0	80.0	1	0	0	0	0	0
Team 8 (SCORE/ CONNECT)*	10	50.0	60.0	3	0	0	6	4	2
Team 9 (Coastal Resilience)	7	57.1	28.5	4	2	$3,016,814	1	6	0
Team 10 (HURAKAN)*	7	57.1	60.0	1	0	0	2	3	0
Team 11 (Ocean & Human Health)	9	22.2	55.5	2	2	$239,995	4	5	0

*After the analyses were performed, teams applied for and received a total of two grants totaling $2.4M in fed-eral funding from NSF and NOAA.

DATA COLLECTION PROCEDURES

Data for this study are drawn from two different sources. First, teams' annual progress reports pro-vide data on scholarly outcomes, including publications, conference presentations, grant proposals submitted, and grant applications that have been externally funded. Second, we collected (self-report) survey data from grant awardees. Using Qualtrics, we compiled the measures described below to cre-ate the survey, which was emailed to all awardees along with a follow-up reminder. No incentives were provided in exchange for completing the survey. This study was determined to be exempt from IRB review because it falls under "process improvement" rather than human subjects research. Data were collected three times (January 2019, February 2019, and July 2019) using identical survey questionnaires (with some deletion of items in time 2 to improve scale reliabilities). Measures described below reflect the final items used for all analyses. Data related to teams' productivity including num-ber of grants submitted, number of white-papers, peer-reviewed manuscripts, and conference papers were obtained from the institution's Office of Vice Provost for Research and were current as of June 2020.

MEASURES

Behavioral trust disclosure

Behavioral trust disclosure was measured using a five-item instrument that was developed by Gilles-pie (2003). Sample items include "Share your personal feelings with your team", "Confide in your team about personal issues that are affecting your work", and "Discuss how you honestly feel about your

work, even negative feel-ings and frustration." Items were rated on a 5-point Likert scale that ranged from "Not at all willing" (1) to "Completely willing" (5). A composite score was created by averaging responses on five items, with higher score indicating higher level of one's willingness to share personal feelings and issues re-lated to the work. The internal consistency measured by Cronbach's alpha was high ($\alpha = .90$ for time 2; $\alpha = .91$ for time 3).

Team Satisfaction

Team satisfaction was measured using three items that were revised from Hackman and Oldham's (1974) job satisfaction survey questionnaire. Sample items include "I enjoy the kind of work we do on this U-LINK team," "Working on this U-LINK team is an exercise in frustration" (reverse-coded), and "Generally speaking, I am very satisfied with this U-LINK team." Items were rated on a 5-point Likert scale that ranged from "Disagree" (1) to "Agree" (5). A composite score was created by averaging responses on three items, with higher score indicating higher level of satisfaction with U-LINK team. This meas-ure was included in the survey beginning at time 2; internal consistency measured by Cronbach's al-pha was acceptable ($\alpha = .82$ for time 2; $\alpha = .83$ for time 3).

Role ambiguity

This two-item measure was drawn from Peterson and colleagues' (1995) measurement of role ambiguity, conflict, and overload. The items are "I know exactly what is expected of me on my U-LINK team" and "I know what my responsibilities are on my U-LINK team." Items were rated on a 5-point Likert scale that ranged from "Disagree" (1) to "Agree" (5). A composite score was created by reverse-coding re-sponses on two items and then averaging them, with higher score indicating less certainty about one's role around U-LINK team. The internal consistency measured by Cronbach's alpha was high at times 1 ($\alpha = .90$) and 3 ($\alpha = .91$) and was acceptable at time 2 ($\alpha = .77$).

Goal clarity

This four-item measure was revised from Sawyer's (1992) measurement of goal and process clarity. Sample items include "I am clear about my responsibilities on this U-LINK team", "I am confident that I know what the goals are for my U-LINK team," and "I know how my work relates to the overall objectives of my U-LINK team." Items were rated on a 5-point Likert scale that ranged from "Disagree" (1) to "Agree" (5). A composite score was created by averaging responses on three items, with higher score indicat-ing higher level of goal clarity. The internal consistency measured by Cronbach's alpha was high at each time point ($\alpha = .90$ for time 1; $\alpha = .93$ for time 2; $\alpha = .89$ for time 3).

Process clarity

This three-item measure was revised from Sawyer's (1992) measurement of goal and process clarity. Sample items include "I know how to go about my work on my U-LINK team," "I know how my team will move forward with its work on our U-LINK project," and "I am confident that my U-LINK team is using the right pro-cesses to move forward with its work." Items were rated on a 5-point Likert scale that ranged from "Disa-gree" (1) to "Agree" (5). A composite score was created by averaging responses on three items, with higher score indicating higher level of goal clarity. The internal consistency measured by Cronbach's alpha was relatively low at time 1($\alpha = .56$ for time 1) but was acceptable at subsequent time points ($\alpha = .87$for time 2,$\alpha = .85$ for time 3)

Shared communication

This two-item measure was created for this study, following information contained in the National

Institutes of Health (NIH's) Collaboration and Team Science Field Guide (Bennett et al., 2018. Sam-ple items include "I think it's important for every member of our U-LINK team to speak during meetings" and "It's important for members of our U-LINK team to find ways to elicit equal participation from our team members during our meetings." Items were rated on a 5-point Likert scale that ranged from "Disagree" (1) to "Agree" (5). A composite score was created by averaging responses on two items, with higher scores indicating higher levels of shared communication. The internal consistency measured by Cronbach's alpha was low at time 1 and time 3 ($\alpha = .64$ for time 1; $\alpha = .54$ for time 3) but was good at time 2 ($\alpha = .83$).

Shared leadership

This two-item measure was created for this study, following information contained in the National Institutes of Health (NIH's) Collaboration and Team Science Field Guide (Bennett et al., 2018). Sam-ple items include "It's important for all of our U-LINK team members to share leadership responsibilities" and "All of our U-LINK team members have the potential to make equally important contributions to our project out-comes." Items were rated on a 5-point Likert scale that ranged from "Disagree" (1) to "Agree" (5). A composite score was created by averaging responses on two items, with higher level indicating higher perception of shared leadership. The internal consistency measured by Cronbach's alpha was rela-tively low at time 1 and time 2 ($\alpha = .53$ for time 1; $\alpha = .61$ for time 2; $\alpha = .79$ for time 3).

Formal meetings

Following the example of Chatman and Flynn (2001), we used a single-item measure for individuals to self-report the number of formal meetings they attended since receiving pilot funding.

Informal meetings

Following the example of Chatman and Flynn (2001), we used a single-item measure for individuals to self-report the number of informal meetings they attended since receiving pilot funding.

ANALYTIC STRATEGY

After aggregating the individual scores to each team, we used SPSS (IBM SPSS Statistics for Win-dows, 2017) to obtain descriptive statistics and frequencies that summarize team characteristics and team-level scores on all measures. Then, a series of repeated-measures Analysis of Variances (ANOVA) or paired t-tests were used to examine whether team scores significantly changed over time. For any team scores showing a significant difference over time, we performed a post-hoc analysis using Bonferroni adjustment (Gamst et al., 2008) to control for the family-wise type I error rate. This process identified the time points at which teams on average reported differently.

Our goal was also to empirically test the model shown in Figure 1, where teams' success (i.e., satisfac-tion survey scores and research productivity measured by numbers of publications and external grants being secured) is related to team-level processes. However, given that the number of teams that comprise the sample ($n = 11$) is too small to obtain sufficient statistical power to perform a path analysis, as an exploratory step, we conducted a series of Monte Carlo simulations in Mplus (Muthén & Muthén, 1998-2011) based on the estimated value in a path analysis using our team sample size of 11. In a Monte Carlo simulation, 50 teams' responses that were first generated from a multivariate normal distribution. A multivariate normal distribution was based on the estimated parameter values using a team sample size of 11. Then, these teams' simulated responses were used to run a series of path models, as shown in Figure 1. With 500 replications, the probability of detecting a significant relationship when it exists (as

known as an empirical statistical power = 1 - β, which is denoted as π in this study) was computed. Only those relationships (b) with π (an empirical statistical power) greater than 0.80 are considered to be meaningful (as by convention, 80% of statistical power is an acceptable in the field) and will be discussed. We also reported the average of estimated parameters and their standard errors from a simulation with 500 replications.

RESULTS

TEAM CHARACTERISTICS

Table 1 summarizes team characteristics by team size, member composition by gender, a profile of external grants (i.e., applied, received, and grant funds secured), and publication record. As shown in Table 1, the number of team members ranged from 4 to 10 (M = 7.09, SD = 1.81). The percentage of male team members varied from 0-67% (M = 42%, SD = 21%). Only 1 team had an equal num-ber of male and female members, with 6 teams composed of more females and 4 teams with fewer females. Years of U-LINK funding ranged from 1 to 3, with 2 teams in their third year of funding and 3 teams in their second year of funding. Although all 11 teams had applied for external grants (Min = 1, Max = 4), only 5 teams secured external funding, with 2 of those 5 receiving two grants each. The amount of external grant funding secured by those 5 teams ranged from $33,932 to $3,016,814, with a total sum of $3,490,741. These 11 teams published a total of 18 peer-reviewed manuscripts (Min = 0, Max = 6), presented at 44 conferences (Min = 0, Max = 12), and wrote 9 white papers (Min = 0, Max = 7).

TEAM-LEVEL PROCESSES AND OUTCOMES OVER TIME

To address RQ1, we examined change in process variables that past research has shown to impact team success. While the number of informal meetings did not change significantly over time, signifi-cant differences were found over time for the following variables: (1) shared leadership, (2) role ambi-guity, (3) goal clarity, (4) process clarity, and (5) number of formal meetings.

First, teams' shared leadership scores were significantly different across time, F(2,18) = 11.78, p = .001, partial η2 = .29. The partial eta-squared value indicates large effect size. Teams showed a signifi-cant increase in their shared leadership from time 1 (M = 4.01, SD = .50, n = 11) to time 2 (M = 4.62, SD = .29, n = 11), p = .01. As shown in Figure 2, this result suggests that the team's perceived level of shared leadership significantly increased and then remained steady over time.

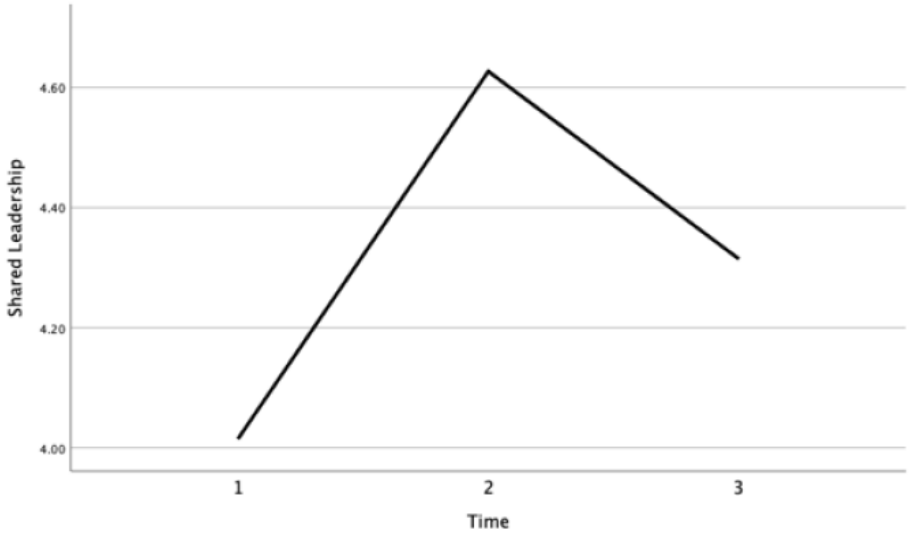

Figure 2. Comparison of Shared Leadership Over Time

Second, team-level role ambiguity scores were significantly different across the three-time periods, $F(2,18) = 19.11$, $p < .001$, partial $\eta 2 = .68$. The large effect size implies that there are important differences across time points. Post-hoc analysis showed (Figure 3) that teams significantly increased in role ambiguity from time 1 ($M = 4.02$, $SD = .33$, $n = 10$) to time 2 ($M = 4.48$, $SD = .39$, $n = 10$), $p = .004$; and time 1 to time 3 ($M = 4.65$, $SD = .45$, $n = 10$), $p < .01$.

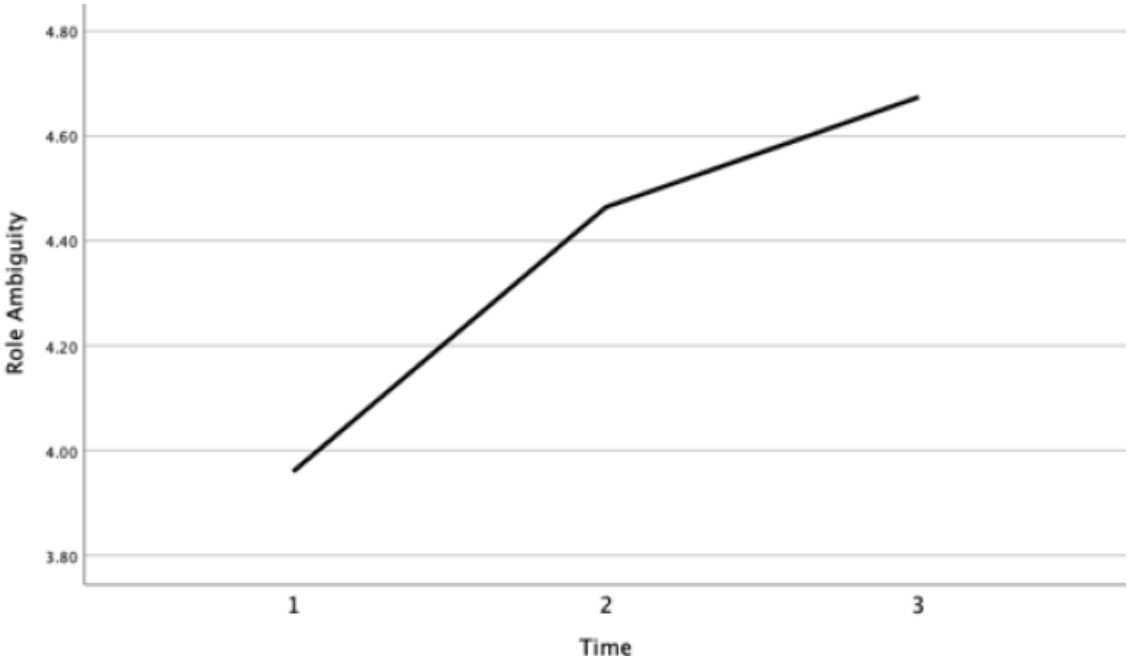

Figure 3. Comparison of Role Ambiguity Over Time

Third, team-level goal clarity scores were significantly different across the three-time periods, $F(2,18) = 9.90$, $p = .001$, partial $\eta 2 = .52$. The partial eta-squared value of .52 suggests a large mean differ-ence over time in team-level goal clarity scores. As shown in Figure 4, teams significantly increased their goal clarity scores over time ($M = 4.29$, $SD = .23$, $n = 10$ at time 1; $M = 4.62$, $SD = .32$, $n = 10$ at time 2; and $M = 4.66$, $SD = .36$, $n = 10$ at time 3).

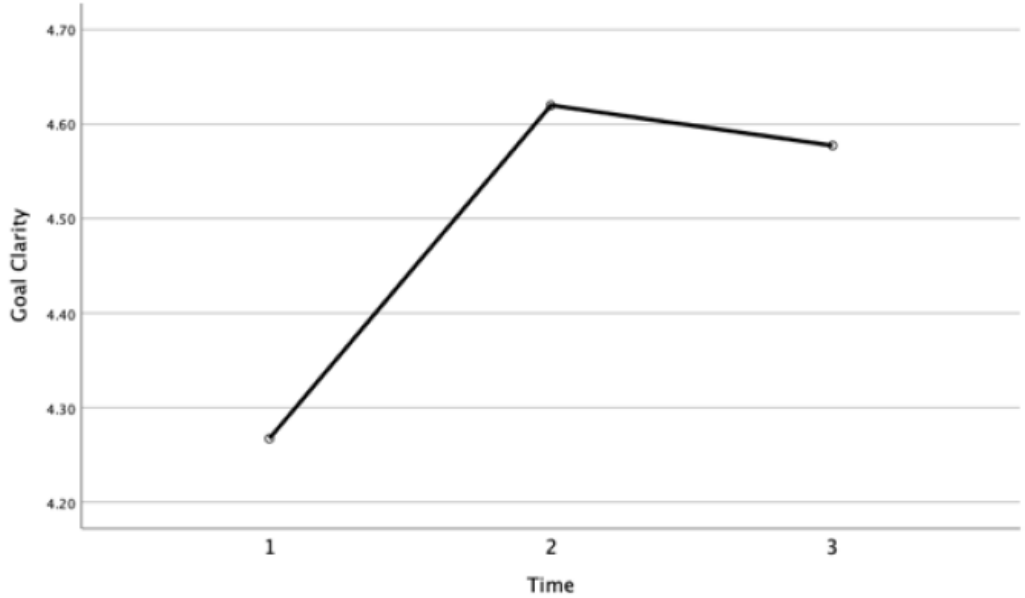

Figure 4. Comparison of Goal Clarity Overtime

Fourth, team-level process clarity scores were significantly different across time, $F(2,18) = 11.78$, $p = .001$, partial $\eta 2 = .57$. Teams showed a significant mean difference in their process clarity between time 1 ($M = 4.10$, $SD = .31$, $n = 10$) and time 2 ($M = 4.49$, $SD = .38$, $n = 10$), $p = .02$; time 1 and time 3 ($M = 4.57$, $SD = .31$, $n = 10$), $p = .003$. As shown in Figure 5, this result suggests that team-level process clarity scores were significantly increased and then remained steady over time.

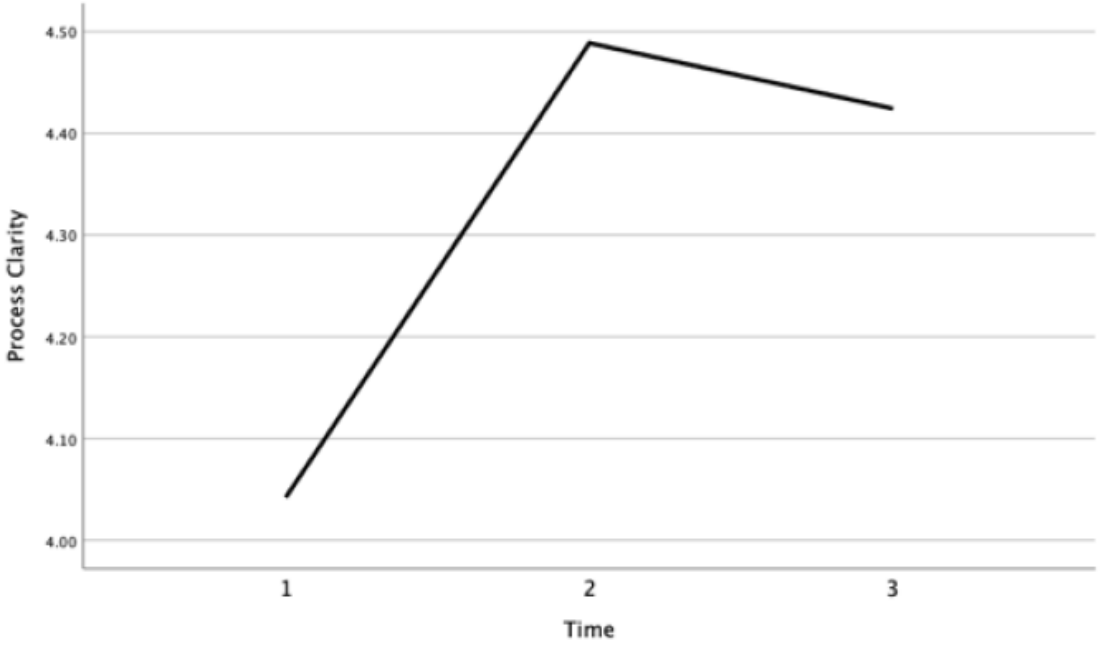

Figure 5. Comparison of Process Clarity Over Time

Lastly, on average, teams had held 4.63 meetings ($SD = 4.90$, $n = 11$) before time 1; 10.77 ($SD = 4.90$, $n = 11$) between times 1 and 2; and 21.25 between times 2 and 3 ($SD = 10.53$, $n = 11$). As shown in Figure 6, the number of times teams met formally significantly increased over the 3 time periods, $F(2,18) = 51.25$, $p < .001$, partial $\eta 2 = .84$. The effect size measure is extremely large, indicat-ing meaningful increases in the number of formal meetings over time.

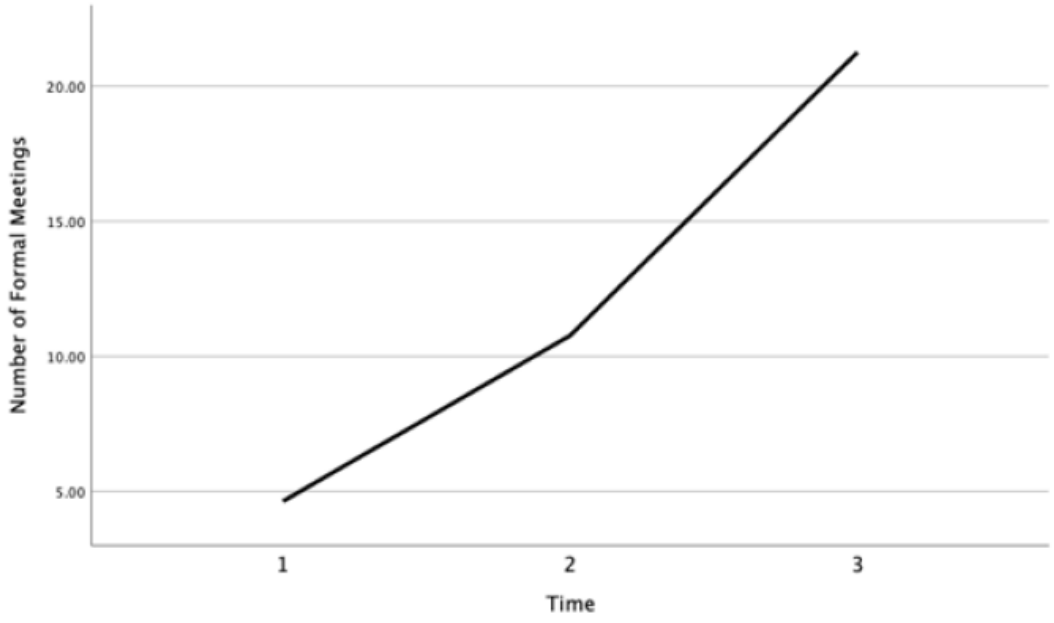

Figure 6. Comparison of Formal Meeting Frequency Over Time

RELATIONSHIPS BETWEEN TEAM-LEVEL PROCESSES AND TEAM-LEVEL OUTCOMES

Table 2 provides the parameters estimated from our sample that were used to generate the simulated data for 50 members in Monte Carlo simulations. The goal of conducting these Monte Carlo simula-tions is to provide insights about the relationships between team-level outcomes and team-level pro-cesses, if a sufficient number of sample size is collected to test the proposed model. These Monte Carlo simulations allowed us to test the hypotheses advanced in this study.

We had several hypotheses that focused on the role of shared communication. Our first hypothesis, which predicted that shared communication would be positively associated with behavioral trust, was not supported by the data. H2 predicted that shared communication would be associated with goal clarity (H2a), process clarity (H2b), and lower levels of role ambiguity (H2c). The data did not sup-port this set of hypotheses. Our third set of hypotheses predicted a positive relationship between shared communication and research productivity (H3a) and team satisfaction (H3b). Our analyses showed that shared communication did predict research productivity in the form of the number of grant proposals submitted, ($\bar{b}$ = -5.08, $\overline{SE}$ = 0.35, π = 1.00), as well as overall team satisfaction ($\bar{b}$ = -.20, $\overline{SE}$ = .04, π = .99), which is an important predictor of long-term team success. These findings support both H3a and H3b.

Table 2. Parameters used for Monte Carlo Simulations

	Satisfaction as an Outcome			N Grants as an Out-come			N of Publication as an Out-come		
	b	*se*	π	*b*	*se*	π	*b*	*se*	π
Satisfaction									
Role ambiguity	0.09	0.05	0.54	-5.83	0.17	1.00	-17.92	1.37	1.00
Process clarity	0.40	0.05	1.00	-3.04	0.31	1.00	-23.52	2.4	1.00
Goal clarity	-0.17	0.06	0.77	13.03	0.24	1.00	45.71	1.78	1.00
Communication	-0.2	0.04	0.99	-5.08	0.36	1.00	-14.34	1.85	1.00
Leadership	0.13	0.05	0.77	3.5	0.4	1.00	35.43	3.15	1.00
Informal meeting	0.04	0.005	1.00	-0.009	0.04	0.06	0.62	0.15	0.96
Role Ambiguity									
Communication	-0.01	0.11	0.07	-0.21	0.14	0.35	-0.19	0.14	0.29
Leadership	0.13	0.12	0.19	0.27	0.2	0.31	0.31	0.2	0.34
Formal meeting	0.02	0.01	0.50	0.06	0.01	1.00	0.06	0.01	0.99
Process Clarity									
Communication	0.05	0.11	0.09	0.21	0.09	0.64	0.23	0.09	0.71
Leadership	0.29	0.11	0.75	0.9	0.13	1.00	0.92	0.13	1.00
Formal meeting	0.02	0.01	0.33	0.01	0.008	0.29	0.008	0.008	0.21
Goal Clarity									
communication	-0.05	0.07	0.11	0.16	0.11	0.35	0.11	0.11	0.19
Leadership	0.08	0.08	0.20	0.19	0.16	0.22	0.14	0.16	0.14

Formal meeting	0.03	0.008	0.98	0.04	0.009	0.95	0.04	0.009	0.98
Communication									
Informal meeting	0.06	0.01	0.99	0.01	0.01	0.16	0.01	0.01	0.16
Trust									
Communication	0.18	0.07	0.78	0.1	0.09	0.2	0.1	0.09	0.22
Informal meeting	0.02	0.01	0.42	0.01	0.01	0.24	0.01	0.01	0.24
Leadership & communication	0.21	0.04	1.00	0.07	0.02	1.00	0.07	0.02	1.00

We also tested the associations between shared leadership with a number of important outcomes. Hypothesis 4 predicted a positive association between shared leadership and shared communication but this was not supported by the data. Our fifth set of hypotheses predicting that shared leadership would be associated with goal clarity (H5a), process clarity (H5b) and role ambiguity (H5c) was partially supported. Shared leadership predicted goal clarity ($\bar{b} = .90, \overline{SE} = .13, \pi = 1.00$), supporting H5a, and process clarity ($\bar{b} = .92, \overline{SE} = .13, \pi = 1.00$), supporting H5b. However, H5c was not supported. Our sixth set of hypotheses focused on the association between shared leadership and satisfaction (H6a), which was not supported, and research productivity (H6b) which was supported; teams reporting higher perceptions of shared leadership also had a higher number of publications ($\bar{b} = 35.43, \overline{SE} = 3.16, \pi = 1.00$) and a higher number of grant proposal submissions ($\bar{b} = 3.50, \overline{SE} = 0.40. \pi = 1.00$).

Hypotheses 7-9 examined the role of formal and informal meetings on team outcomes. H7 focused on the ways in which formal meetings could enhance goal clarity, process clarity, and role ambiguity. Our data indicate that formal meetings enhance goal clarity ($\bar{b} = .03, \overline{SE} = .009, \pi = .98$), supporting H7a; formal meetings also reduce role ambiguity ($\bar{b} = .04, \overline{SE} = .01, \pi = .95$), supporting H7c. However, formal meetings did not appear to have an impact on process clarity. Hypothesis 8 pre-dicted that informal meetings would have a positive effect on behavioral trust among team members, which was not supported by the data. Hypothesis 9 focused on the ways in which informal meetings support team success through enhanced satisfaction (H9a) and increased productivity (H9b). Informal meetings did appear to enhance team satisfaction ($\bar{b} = .04, \overline{SE} = .005, \pi = 1.00$), and was associated with a larger number of publication ($\bar{b} = .61, \overline{SE} = .15, \pi = 0.96$), which supports H9a and H9b.

DISCUSSION

The hypotheses advanced in this research were designed to evaluate the extent to which specific team processes affect the success of interdisciplinary scientific teams. The analyses of data were based on survey responses, and the teams' own annual reports of scholarly productivity. Consistent with the findings from empirical studies over the last decade, our study indicates that shared communication processes should be considered by interdisciplinary teams. While shared communication was not more likely to lead to a greater sense of trust or increased clarity about the team's goals, roles, and processes, it was positively associated with team satisfaction and greater research productivity. These findings, which are presented in a visual summary in Figure 7, are consistent with the literature (see Pentland, 2012). Shared communication, of course, is easier recommended than achieved. However, because communication is a skill, it can be taught and enhanced through practice, particularly if team members' awareness of individual behaviors can be heightened (perhaps through reviewing record-ings of team

meetings or by a presentation of summary statistics of the number of conversational turns taken and the amount of talking time each person had during a meeting). Pentland (2012) dis-cusses methodological advances made possible through the use of sociometric "badges" that record conversational turns and times, but such technology is fairly specialized and making sense of the re-sulting mountain of data collected across teams requires specific, advanced data analytic techniques. Nonetheless, this is a clear avenue for being able to measure the impact of training and development interventions designed to promote shared communication. For interdisciplinary team scientists, though, developing an awareness and appreciation of the importance of sharing conversational space may be enough to accomplish measurable changes in team functions and satisfaction.

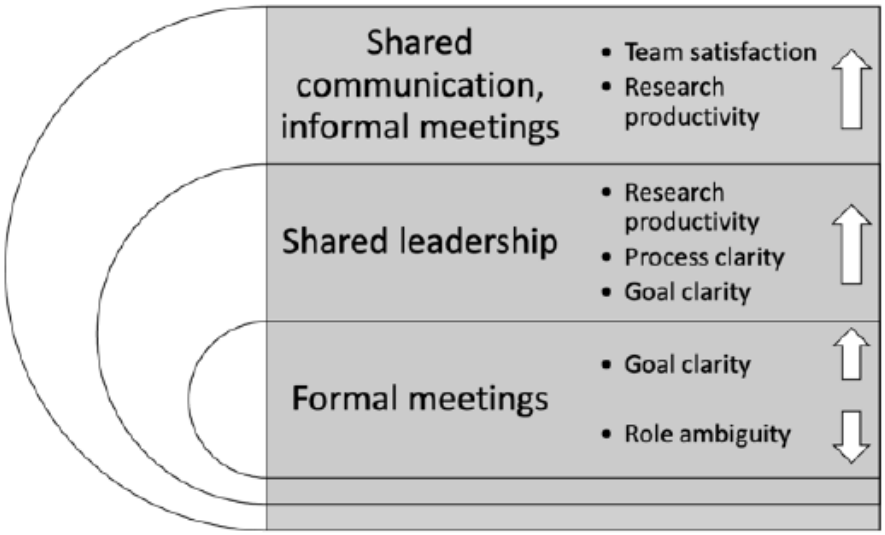

Figure 7. Visual Summary of Study Findings

Other findings related to team processes were mixed. Engaging in greater shared leadership of an in-terdisciplinary team created greater goal and process clarity, but role ambiguity was not improved. Nonetheless, stronger scores on shared leadership were significantly associated with greater research productivity, including publications and grant applications. While there is no clear consensus in the literature about the value of shared leadership relative to other, more traditional models of leadership (see Ziegert & Dust, 2020), this is likely because there are few opportunities to empirically test these principles. Further, it is difficult to assign some real-world teams to a shared model of leadership (which avoids labels like "Principal Investigator" in favor of "accountable lead") and other teams to a traditional model of team leadership in which one person generally directs the activities of other team members, making a clear comparison on outcomes very difficult. Future research should look at the evolution and longevity of teams employing different types of leadership models, including how team processes change over time. Most research on interdisciplinary teams provides a snapshot of one (or relatively few) point(s) in time; longitudinal research focusing on the evolution of dynamics of interdisciplinary teams would yield valuable insights for researchers as well as research develop-ment professionals.

Teams' meeting activities also had an impact on specific outcomes. For example, more frequent for-mal team meetings were predictive of an understanding of the team's goals and greater clarity about each individual's roles on the team. Moreover, teams that connected with each other through infor-mal gatherings were more likely to report greater satisfaction and to report a higher number of publi-cations stemming from the work of their teams. Curiously, informal meetings did not result in higher levels of behavioral trust.

Finally, the extent to which teams engaged in specific processes changed over time. Shared leadership, goal clarity, process clarity, role ambiguity, and the number of formal meetings all improved over time. Based on these findings, it does appear that with time and experience, teams become more highly functional. However, it should be recognized that an important part of the interdisciplinary initiative that provides funding for these teams is the mandatory participation in team training and development activities, which are described elsewhere (Morgan et al., 2021). This is a competing ex-planation for these improvements.

There are several important limitations to this study which we hope future research can address. First, the number of teams comprising the sample size is too low to empirically test a theoretical model using traditional analytic strategies. While certainly better than a case study of a single team in many respects, a limited number of teams presented us with data analytic challenges because the number of "subjects" is essentially the number of teams under study; just 11 teams is too small for traditional statistical approaches. Future research with a larger number of teams (or with a combina-tion of interview and/or ethnographic data) could address team dynamics over time in a way that our current study could not. Additionally, all of our teams were embedded within the same university and were subject to the same guidelines and requirements associated with the pilot funding program, which means that certain types of variance that might occur across universities (like the freedom to work within established teams rather than being required to assemble novel teams) are not generally possible with the program described here. Thus, future research studies should be developed in part-nership with additional universities with similar programs and goals for the support of interdiscipli-nary research teams. Finally, we experienced some issues with our measures. Some of the measures we used were found not to be sufficiently reliable, and there are key concepts in SciTS research, in-cluding shared communication, for which no measures currently exist. The process of measure de-velopment, testing, and refinement takes considerable time and energy, but we are hopeful that the research community will help move this work forward.

Pragmatically, there are specific actions that interdisciplinary teams and research development profes-sionals/administrators can take that are warranted based on the findings from this study and the ex-tant literature in which our work is grounded. First, interdisciplinary teams should consider incorpo-rating behaviors that foster both shared communication and shared leadership by creating structures (such as a providing a period of time dedicated to the teaming process) that allow every member to share their knowledge about the research issue being addressed by the team. Second, teams should consider regular meetings (probably weekly, and likely not more) a vital part of their work; it is the means by which shared understanding of the team's work and its processes emerges. Our informal observation is that interdisciplinary teams that meet weekly are more productive than those that meet less often. Third, teams may benefit by incorporating informal gatherings into their "official" team activities. Such activities would provide an alternative pathway for members to get to know each other and establish trust in ways that support the processes that lead to more favorable research team outcomes.

Research development staff and high-level administrators must make important decisions about the design of funding programs designed to support interdisciplinary research. The empirical literature focused on the "science of team science", including the current study, point to a couple of key rec-ommendations. First, rather than assembling teams based on the productivity of individual research-ers (see Ahn et al., 2021, it would be more productive to provide training programs for communica-tion and collaboration skills for interdisciplinary scholars. Second, while we do not have direct data in support of this specific design feature, the U-LINK program provided 8 months of funded time for teams to engage

in the "teaming process;" that is, to learn about one another's disciplinary perspec-tive on a complex research topic and to develop an agreed-upon approach that transcends disciplines. This can happen only through extensive conversation and debate. This collective "visioning" also helps to build trust and satisfaction among team members, which should lead to greater research productivity, according to the existing literature. Empirical investigations of accuracy of these recom-mendations should certainly be conducted.

Indeed, what may be needed to both address the limitations of this study (and others like it) would be to collect data on interdisciplinary teams across institutions. A team of interdisciplinary investiga-tors representing a variety of academic institutions could collaborate to select and develop core con-structs for measurement and collect data from internally funded teams on a shared set of measures. While it is inevitable that features of internal funding programs would vary, these could be coded and statistically controlled if the number of participating institutions is adequate. This is certainly an am-bitious research agenda but one that could be highly fruitful for the SciTS field.

CONCLUSION

This study was conducted in response to multiple calls for research to investigate team processes and the factors that are antecedent to team success (National Research Council, 2015; Wooten et al., 2015). We looked at four specific processes (shared communication, shared leadership, formal meet-ings, and informal meetings) on intermediate outcomes of goal clarity, process clarity, and role ambi-guity, and their impact on two outcomes (research productivity and team satisfaction) using both self-report (survey) and objective (research output) data and found that teams that encourage all members to share conversational space, meet frequently, and share leadership responsibilities have the most fa-vorable team outcomes. Communication behaviors are central to all four of the processes we exam-ined; while almost all SciTS scholars have touted the importance of communication for the out-comes of scientific teams, this study is among the few that centers communication practice and pro-cesses in the operationalization and measurement of its constructs and which provides a test of hy-potheses centered on key questions identified in the literature.

While administrators generally can't (and probably shouldn't) control the process of team assembly (see Ahn et al., 2021, it is clear from previous empirical research that the specific composition of teams, particularly the level of accomplishment of individual team members, matters far less than the processes that teams engage in. The findings from this study reaffirm these assertions in the context of real-world interdisciplinary scientific teams with diverse memberships. While our sample size is small, our study benefits from the external validity afforded by the ability to study a group of 11 real-world teams.

Empirical evidence is urgently needed in order to develop strategies that are likely to work; a lot of money is wasted on pilot funding for teams that fail to "stick" or which do not generate meaningful outcomes. Based on our findings, we have offered a number of recommendations that are relatively straightforward for researchers and administrators to implement in real-world settings. These include reserving ample time for teams to engage in the process of "teaming," to hold frequent research team meetings, and to take time to get together in informal/social settings. Formal communication skills training and team development programs constitute investments that may be just as important as pilot funding that covers direct costs. Universities and other research-focused organizations have questioned how best to support teams charged with developing innovative approaches to grand chal-lenges facing society; offering effective team development initiatives that enhance team cohesion and individual

communication skills can help create positive, productive teams (Cheruvelil et al., 2014; Morgan et al., 2021).

Cheruvelil and colleagues (2014) recommend that "members of the scientific community… redefine research success to include collaborative outcomes, promote teamwork training for [researchers] at all career stages, and pay deliberate attention to and guide how teams are formed and maintained" (p. 37). Clearly, communication processes that are central to the formation and maintenance of teams that are both productive and satisfying should be deliberately and carefully cultivated as any other knowledge or skill that impacts scholarly outcomes.

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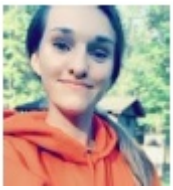

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Understanding of the Quality of Computer-mediated Communication Technology in the Context of Business Planning

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ABSTRACT

Aim/Purpose This study seeks to uncover the perceived quality factors of computer-mediated communication in business planning in which communication among team-mates is crucial for collaboration.

Background Computer-mediated communication has made communicating with teammates easier and more affordable than ever. What motivates people to use a particular CMC technology during business planning is a major concern in this research.

Methodology This study seeks to address the issues by applying the concept of Information Product Quality (IPQ). Based on 21 factors derived from an extensive literature review on Information Product Quality (IPQ), an experimental study was con-ducted to identify the factors that are perceived as most relevant.

Contribution The findings in this study will help developers find a more customer-oriented approach to developing CMC technology design, specifically useful in collabora-tive work, such as business planning.

Findings This study extracted the three specific quality factors to use CMC technology in business planning: informational, physical, and service.

Keywords computer-mediated communication, business planning, instant messaging, information product quality, information quality

INTRODUCTION

Computer-mediated Communication (CMC) is defined as any human communication utilizing the use of electronic devices (McQuail, 2005). CMC technologies include email, text messaging, instant messaging (IM), Social Network Services (SNS), chatting services, etc. (Ellison et al., 2007). CMC is one of the commonly used Information Products nowadays. An Information Product is a highly interdependent package of information that can be digitized and can be transmitted, and distributed in digital form (Shapiro & Varian, 1998). With the advent of the Internet and high-speed internet connection, CMC has been one of the most widely used communication tools and a keystone of com-puter-supported collaborative work. CMC technologies enable people to record/store information, reduce delays in communication, improve coordination of people remotely located, support reflec-tion and composition of information, and improve user capabilities in information processing (Baltes et al., 2002).

Due to the necessity of using information products as a gateway for collecting data that could be exploited for marketing purposes, the design of the CMC has recently been more directed toward the needs of the businesses. For example, digital companies, using the huge amount of customers' online activity data, use predictive analytics to create new business values/opportunities. They consider con-sumer data as the most important data asset. Sometimes, they use the assets without the consent of customers. Recently, there has been a concern that Facebook has been collecting customers' call rec-ords and SMS data for years. However, little is known about the desires of users in the use of CMC, as well as what their main concerns in the use of CMC are. The major focus directed towards the businesses of the digital company now should be directed more towards the desires of the users. To create a new value for customers, understanding how users perceive the quality of CMC is important.

Effective communication in the workplace is key to the long-term success of an organization, and CMC plays an integral part in collaboration at the workplace. For business planning, CMC plays a crucial role in helping coworkers to communicate effectively. A collaborative team may be presented with various CMC technologies (email, phone, instant messaging, applications, etc.) for the support of distributed collaborative work. The purpose of this study is to investigate what quality factors us-ers perceive important in using CMC in business collaboration. In this research, Nam (2014)'s infor-mation product quality model will be adopted as a theoretical framework. The framework will be used to find out which factors users perceive important in CMC use, especially in a business planning collaboration. The understanding of quality factors important in CMC use in business planning is ap-plicable in other collaboration work as well. The right choice of CMC technology may facilitate or delay collaborative work. CMC plays a crucial role in any collaboration work these days. Therefore, the understanding of the quality of CMC in collaboration may result in better design of CMC tech-nology.

The paper is organized in the following way: In the following section, the theoretical foundations of this research will be discussed, including a review of the features of CMC technologies and a brief introduction of the information product quality concept. In the methodology section, the research method, including instrument design and data collection, is discussed. The Data Analysis and Re-search Findings section will include data analysis, findings, and discussion on the findings to extend understanding to user's perception of CMC quality. Finally, I will summarize the research results and implications for researchers and practitioners and make a brief conclusion and directions for future research.

LITERATURE REVIEW

COMPUTER-MEDIATED COMMUNICATION

CMC technologies are becoming an important tool at the workplace. People use CMC for various reasons, for example, to reduce delays in communication, improve coordination, store/record information, to reflect and compose information, improve information processing, etc. (Baltes et al., 2002). CMC is defined as any human communication utilizing the use of electronic devices (McQuail, 2005). Therefore, technologies such as email, text messaging, instant messaging (IM), So-cial Network Services (SNS), chat rooms, and blogs can be considered as CMC technologies (Ellison et al., 2007; McQuail, 2005). Various software tools have been changing the way we communicate and collaborate at the workplace, ensuring that physical barriers are no longer problematic for communi-cating purposes. One innovative example is the Virtual Reality Conference, which combines 360 vid -eos and VR technology to create a VR teleconference system that gets as close as possible to actually being located in the same place.

As more and more companies continue to find ways to embrace more innovative communication tools, the possibilities for new and innovative solutions will continue to grow. According to 2005-2016 American Community Survey (US Census Bureau) data, regular work-at-home, among the non-self-employed population, has grown by 140% since 2005, nearly ten times faster than the rest of the workforce or the self-employed. Larger companies are most likely to offer telecommuting options to most of their employees. Fortune 1000 companies are entirely rearranging their space around the fact that employees are already mobile. Studies repeatedly show employees are not at their desks 50-60% of the time. All kinds of telecommuting tools are on the rise. One hundred three percent increase from 2005-2016 alone (Global Workplace Analytics, 2018).

In this study, CMC use in business planning is the focus. People may consider using various types of CMC technologies, such as email, text messaging, instant messaging (IM), Social Network Services (SNS), chat rooms, blogs, etc. Media richness theory (Daft & Lengel, 1986) classifies communication technology along a continuum of "Richness," Richness implies capabilities to carry visual social cues, provide rapid feedback, and convey personality. Therefore, each medium may show a different capability to communicate complex messages. Comparably, lean media are less effective for communicating complex issues than rich media. Some people may prefer to utilize the richer CMC technology for communication since it incorporates more cues to increase communication performance. Others may prefer to choose lean media for certain tasks, considering social influences and geographic distri-bution. For example, people may choose lean medium over rich medium to prevent embarrassment or to avoid upsetting others. Fulk et al. (1990) found that social influence (user's social work and so-cial circle, peer pressure, culture difference, and previously developed context-specific mental sche-mas) has a strong influence on CMC media use.

Instant Messaging, like Skype, iMessage, Telegram, Facebook Messenger, WhatsApp, etc., is getting popular as it shows multimedia functions, such as text, voice, video transmission, with a capability to be aware of the online presence status of their communication partners. The most popular IM in South Korea is KakaoTalk. Among various IM applications, 95% of the estimated 43 million smartphone users in South Korea mainly used KakaoTalk in 2017 (The Korea Herald, 2017). Ka-kaoTalk users can share photos, links, videos as well as free video/audio calls, group chats, and mes-sages. The app may automatically synchronize the user's contact list on their smartphones with the KakaoTalk contact list. Users can search for people by KakaoTalk ID without a phone. The app has a built-in browser, so users can open links and view websites while using the app. KakaoTalk has tar-geted countries in Southeast Asia as well, such as Malaysia, Indonesia, Philippines.

Email is mainly transmitting/receiving text and attachments. As an asynchronous CMC technology, it is not possible to check the online presence status of their partners. Social Networking Services (SNS) is a technology that enables users to share their interests, personal life, and stories with friends, acquaintances, and even with strangers. SNS allows users to upload text, pictures, audio, videos, news, and programs. Users can adjust privacy settings to select the audience before they share the content. SNS companies, such as Facebook, Twitter, Instagram, etc., are getting popular and driving a huge volume of traffic.

Researchers have examined the role of CMC technology in various organizational settings. Scheibe and Gupta (2017) found that computer-mediated socializing generates higher organizational creativity than low computer-mediated socializing when an organization has a rational culture. Rational culture is the of

organizational culture in which accomplishment/productivity/impact/profit is highly valued (Scheibe & Gupta, 2017). Sirait and Zellatifanny (2020) investigated the patterns and the effectiveness of computer-mediated communication and collaboration among government employees during the Covid-19 pandemic. The results show that most employees have used instant messaging, online meeting applications, email, and document shar-ing tools to collaborate remotely. Tate et al. (2019) measured dimensions of employee engagement among telecommuting knowledge workers in the US using the five subscales of the Computer-medi-ated Communication (CMC) competence model (i.e., expressiveness, attentiveness, efficacy, knowledge, & motivation). They found that the most significant predictor of engagement was atten-tiveness, followed by expressiveness and then motivation (Tate et al., 2019).

CMC allows individuals to interact and share ideas with each other regardless of their physical loca-tion, so it may play an important role in enhancing business planning outcomes. Even though litera-ture shows that there are various CMC technologies available and popularly used, and each CMC technology has different capabilities, functions, and different levels of Richness, there has been little research work in examining quality factors of CMC technology that may be perceived as important for collaborative work.

BUSINESS PLANNING

Entrepreneurship courses have become one of the essential courses in many business schools. Honig (2004) examined the 2004 college catalogs of all of the top 100 universities in the United States for courses that specifically referred to Entrepreneurship in their course description. He found 78 of the top 100 universities offered such courses. Entrepreneurial education programs have a positive effect on the perceptions of the desirability and feasibility of starting a business (Peterman & Kennedy, 2003). This process is driven by the expectation that the university can be an engine to stimulate local economic growth and social well-being, and university management seeks to expand the university funding base in accord with governmental policies and initiatives (R. Graham, 2014).

In entrepreneurship courses, students learn how to write a business plan. A business plan can be de-fined as a written document setting out a business's objectives and describing in detail, including business goals, an industry and competitor analysis, an examination of environmental trends/re-sources, the organizational and financial strategies, and detailed activities of marketing, operation, production, and management. As the course content includes case materials, simulations, and various "hands-on" approaches (Gorman et al., 1997), teaching how to write a business plan and monitoring of the production is identified as being the most important course feature of entrepreneurship courses (Hills, 1988). Business planning projects require a significant amount of collaborative effort among team members. Students typically work in groups to write a business plan. They present the business plan in the classroom to demonstrate the feasibility and quality of the plan. The instructors assess each team's achievement to see if each team effectively integrates course knowledge into the plan. To complete several weekly tasks to build a business planning, on-site or virtual meetings must take place. The management of the collaboration includes assembling, scheduling/coordinating meetings, monitoring of tasks completed, etc. If team members are distributed in different locations to collaborate towards a shared goal, CMC technologies play the role of a communication platform to accomplish a task. A proper communication tool decreases the risk of communication break-downs and increases the chances to build a shared context. The business planning project follows similar procedures of real-life business planning, as students are expected to generate a business plan at the end of the semester for grading.

Some limitations of this setting include lack of funding/re-sources/budget. For example, the subjects are students, so they prefer freeware to purchased soft-ware.

CONCEPTUAL MODEL OF INFORMATION PRODUCT QUALITY (IPQ)

An information product is an interdependent package of information that can be digitalized, transmitted, and distributed in digital form (Shapiro & Varian, 1998). An information product has quality when it is beneficial to information product recipients. Crosby (1980) defines quality as "conformance to requirements." Deming defined quality from the customer's point of view as "satisfying customer's requirements" (Deming, 1986). The Information Product Quality concept will be adopted to measure the perceived quality of CMC. Any information product consists of three components: in-formational, physical, and service components (Alter, 2002). As a kind of Information Product, a CMC technology also has three components: informational, physical, and service.

Eppler's concepts of content quality and media quality are used to explain information and physical components, and SERVQUAL explains the service component of information product quality. Information Product Quality consists of three components: informational, physical, and service components. Informational components include comprehensiveness, accuracy, clarity, applicability, conciseness, consistency, correctness, and currency. Physical components include convenience, timeliness, traceability, interactivity, accessibility, security, maintainability, and speed. Service components include reliability, responsiveness, assurance, empathy, and tangibility. Nam (2009, 2014) tested the Information Product Quality model in the use of different types of information products, which is a general web portal. In this research, a total of 21 quality factors will be considered to measure CMC quality in business planning (Table 1).

Table 1. Conceptual Model of IPQ

Information Product Quality (IPQ)	
Informational components	C1: Comprehensiveness C2: Accuracy C3: Clarity C4: Applicability C5: Conciseness C6: Consistency C7: Correctness C8: Currency
Physical components	C9: Convenience C10: Timeliness C11: Traceability C12: Interactivity C13: Accessibility C14: Security C15: Maintainability C16: Speed
Service components	C17: Reliability C18: Responsiveness C19: Assurance C20: Empathy C21: Tangibility

The quality of CMC also can be examined in three components. Physical components are the materi-als that hold data in a certain form or that allow data to flow. In this study, hardware or software that may hold, present, and deliver data in any form or that may allow data to flow is considered as a physical component. Information components are contents that users try to deliver. Service compo-nents are sets of actions that create values to users that do not include information nor physical com-ponents.

RESEARCH QUESTION

The most popular CMC technologies are Instant Messaging, email, and SNS (Ku et al., 2013). In this study, text messaging and telephone are also included. By adopting Nam (2009, 2014)'s information product quality model, this study investigates the following research question.

Research question: What quality factors are perceived as important in the use of CMC technologies in business planning?

In other words, given many factors that were discussed in the literature on information quality, which one would be pertinent to CMC use in business planning? In this study, the quality of CMC—as an information product—was examined from the perspective of end-users. Nam's Information Product quality model (2014) incorporated Eppler's (2003) information quality model and SERVQUAL. The definition of each quality factor in Nam's study was utilized in this study. A total of 21 quality dimensions are examined in this study. They are comprehensiveness, accuracy, clarity, applicability, conciseness, consistency, correctness, currency, convenience, timeliness, traceability, interactivity, accessibility, security, maintainability, speed, reliability, responsiveness, assurance, empathy, and tangibility. The list of dimensions appears in Table 2.

Table 2: Information Product Quality (IPQ) Attributes

Quality components	Quality attributes	Description
Informational components	Comprehensiveness	Is the scope of information adequate (not too much nor too little)
	Accuracy	Is the information precise enough and close enough to real-ity?
	Clarity	Is the information understandable or comprehensible to the target group?
	Applicability	Can the information be directly applied? Is it useful?
	Conciseness	Is the information to the point, void of unnecessary ele-ments?
	Consistency	Is the information free of contradictions or convention breaks?
	Correctness	Is the information free of distortion, bias, or error?
	Currency	Is the information up-to-date and not obsolete?

Quality components	Quality attributes	Description
Physical components	Convenience	Does the information provision correspond to the user's needs and habits?
	Timeliness	Is the information processed and delivered rapidly without delays?
	Traceability	Is the background of the information visible? (author, date, etc.)
	Interactivity	Can the information process be adapted by the information consumer?
	Accessibility	Is there a continuous and unobstructed way to get to the information?
	Security	Is the information protected against loss or unauthorized access?
	Maintainability	Can all of the information be organized and updated on an ongoing basis?
	Speed	Can the infrastructure match the user's working pace?
Service components	Reliability	Is the service able to perform its functionality accurately?
	Responsiveness	Is the service willing to help and provide its functionality in an immediate form to the users?
	Assurances	Is the service able to convey trust and confidence?
	Empathy	Is the service able to provide caring and individual attention?
	Tangibility:	Does the service contain all the software and hardware infrastructures needed according to its functionality?

SUBJECTS AND PROCEDURE

Entrepreneurship is one of the mandatory courses for an undergraduate student enrolled in Ulsan National Institute of Science and Technology, South Korea. In this study, data were collected from undergraduate students who are taking the mandatory entrepreneurship course at the UNIST. ParticiQualityofComputer-MediatedCommunication Technology pation in thisstudywas voluntary, and subjects wererewarded with extra course credits for their sur-veyparticipation.Theschool(Ulsan NationalInstituteofScienceandTechnology)requiredapproval by a Human Subjects College, and IRB approved thisstudy withEXEMPTfrom ongoingreview.

The participants evaluated the perceived quality of CMC and the actual choice of CMC. A self-administered survey was done right after taking the "Entrepreneurship and innovation" course at the end of the semester. Subjects were asked the choice of CMC used the most in business planning projects. Subjects also evaluated the quality of the CMC, which they chose for their business plan-ning collaboration. The scale in the Nam (2014)'s study was used with suitable modifications in a business planning project context to measure the perceived quality of CMC. To evaluate the quality of the CMC, the questionnaire also asked participants to rate the extent to which they agree on a seven-point scale (anchored by 1: extremely unlikely, and 7: extremely likely).

DATA ANALYSIS AND RESEARCH FINDINGS

DEMOGRAPHICS

Two hundred eighteen undergraduate students—162 males (74%) and 56 females (26%)—enrolled in MGT102 Entrepreneurship courses at the Ulsan National Institute of Science and Technology dur-ing either the Spring or Fall semester in 2018-2019 participated in the survey. The average age among participants was 23.1 years old, with the youngest being 19 and the oldest being 28 years of age. The age of the majority of participants (91%) ranged between 20 to 25 years old.

94% of the subjects had their own laptop, and 29.4% of the participants had their own Tablet PC. all participants possessed their own smartphone. As a favorite mobile device in business meetings, 39% of participants indicated laptop, 12.4% picked the mobile phone, and 33.5 % participants chose both laptop and mobile phone at the same time. Most of the participants (about 90%) have less than seven years of experience in mobile device use. The average year of mobile device use is 4.3 years, with a standard deviation of 7.2 years.

EXPLORATORY FACTOR ANALYSIS

To test and find the significant quality factors in CMC use, Exploratory Factor Analysis (EFA), using SPSS, was conducted with maximum likelihood extraction with iterations. Varimax rotation was specified to identify variables that might indicate potential constructs. Prior to performing the analysis, the accuracy of data entry, missing values, normality, and outliers was checked. This study conducted Exploratory Factor Analysis (EFA) in examining the validity of the instrument. EFA is usually conducted to identify and organize a large number of items of the questionnaire into the constructs un-der one specific variable (Chua, 2014).

Construct validity is the extent to which an empirical measure effectively tests the real meaning of concepts under consideration (Babbie, 1990). If the Kaiser-Meyer-Olkin (KMO) is greater than 0.6 and the Barletett's Test of Sphericity (BTS) is significant at $\alpha < .05$, then it is believed that the sam-pling is adequate to proceed for factor analysis (Hair et al., 2010; Tabachnick & Fidell, 2007).

Four factors with eigenvalues over one were obtained. The four factors explained 58.72 percent of the variance. The reliability estimation for each quality factor is .830, .820, .812, and .630. As Cronbach alpha values of 0.7 or higher indicate acceptable internal consistency, the fourth factor (Cronbach value is below 0.7) is dropped. The other three factors are named Physical, Information, and Service. The three factors explained 53.82 of the total variance. All of the values are statistically significant ($p<.05$). Each of Cronbach's alpha data analyzed is summarized in Table 3. Table 3 dis-plays the rotated loading for these factors. Data supports the original structure of the research model. KMO was 0.916, it is greater than 0.6, and BTS is significant at $\alpha = .000$, so it ensures the sampling adequacy for factor analysis.

Table 3: Factor Loading Results

Factors	Attributes
Factor1:Physical (Cronbach's alpha=.830)	C16: Speed (.719) C13: Accessibility (.717) C10: Timeliness (.701) C9: Convenience (.854) C12: Interactivity (.840) C19: Assurance (.586)
Factor2:Information (Cronbach's alpha=.820)	C5: Conciseness (.724) C1:Comprehensiveness (.709) C3: Clarity (686) C2: Accuracy (.656) C6: Consistency (.502)
Factor3:Service (Cronbach's alpha=.812)	C17: Reliability (.759) C20: Responsiveness (.743) C18: Assurance (.592) C21: Tangibility (.542)

CONFIRMATORY FACTOR ANALYSIS (CFA)

The three factors were confirmed through a measurement model in AMOS 26 graphics. This model was expected to provide factor validity in this study. The AMOS 26 Maximum Likelihood solution algorithm was used to estimate model parameters. $\chi 2(87)$ of the model was 181.655 (p=.000). In ad-dition, TLI=.898 (appropriate), CFI=.926 (appropriate), the Root Mean Square Error of Approxima-tion (RMSEA) = 0.071(good), 90 Percent Confidence Interval for RMSEA = (0.056; 0.085), and P-Value for Test of Close Fit (RMSEA < 0.05) = 0.000. AMOS 26 uses Maximum Likelihood for the analysis of missing data. Chi-square value (181.655) / df (87) < 5, so this model is appropriate.

When the standardized factor loading of each item is higher than statistically significant levels, then good convergent validity exists (Dunn et al., 1994; Anderson & Gerbing, 1988). In Figure 1, each var-iable exhibits significant loadings which support convergent validity.

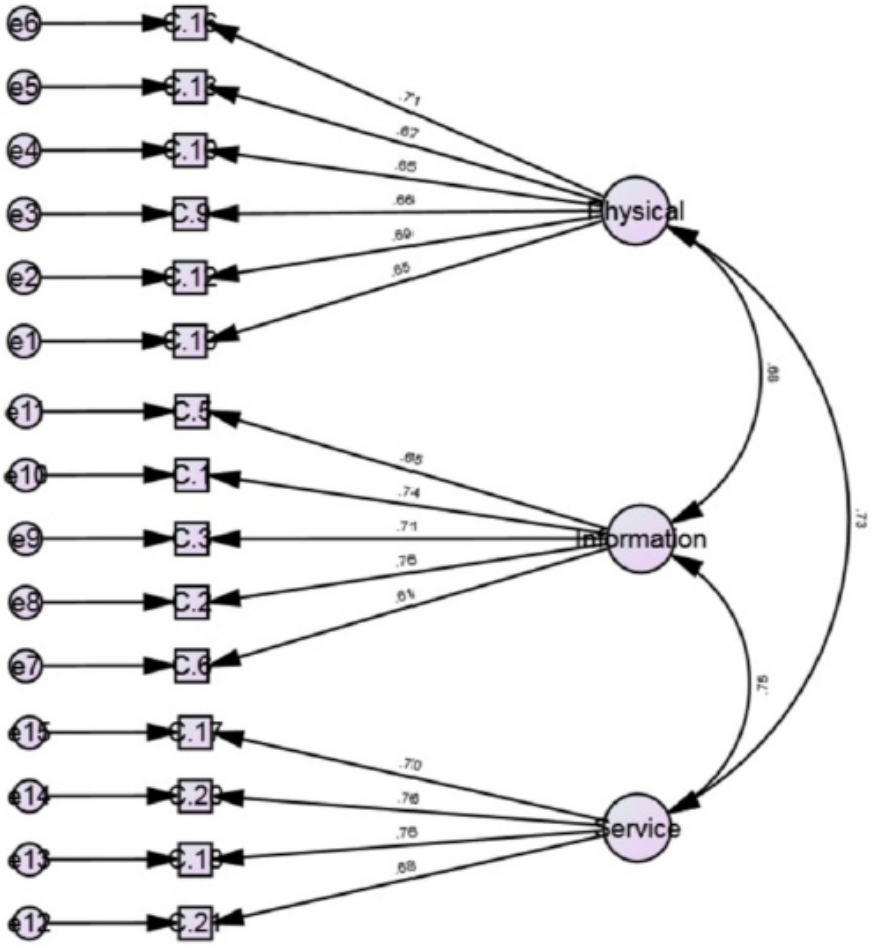

Figure 1: Standardized Factor Estimates

For discriminant validity, the estimated correlation parameter Φij between one pair of components was constrained to 1.0, and a $\chi 2$ difference test was conducted on the values obtained from the con-strained model and the unconstrained model. A chi-square difference test was conducted for each possible pair of the three factors at any given time (Anderson & Gerbing, 1988). The unconstrained model shows a significantly lower value of $\chi 2$ (($\chi 2(1)=10.83$, $p<.001$)) than all the constrained mod-els (see Table 4). Therefore, the factors possess discriminant validity.

Table 4: CMT Quality Factors

Factors con-strained to unity	X^2	df	p	ΔX^2	Δdf
unconstrained	181.7	87	0.000		
12	217.1	88	0.000	35.4	1
23	204.4	88	0.000	22.7	1
13	202.2	88	0.000	20.5	1

RESULTS & DISCUSSION

As a major CMC technology used in business planning collaboration, Instant Messaging was chosen by the participants (82.6%), with email (15.1%) and mobile phone (2.3%) ranked second and third, respectively. IM is a type of online service in which users can create a private chat room with other people to communicate in real-time. (Beal, 2019). IM is getting more popular at workplaces. IM is used to improve workflow, quality of workday, productivity, and interoffice cooperation. Shaw et al. (2007) said IM use influences positively on improving productivity in the workplace by a reduction in voice mail and phone tag, and improvement in checking if colleagues are available online to com-municate (Shaw et al., 2007). C. M. Graham and Jones's research (2019) supports the same position in the use of social network messaging apps for collaborative work. They said social network messag-ing apps could be helpful to share a sense of common ground between team members and to engage students better and improve learning in project teamwork.

However, there is also a concern about some distractions caused by IM as well. When asked whom they contact most often at work, 40% of IM users said that they use IM to communicate with coworkers and 33% with friends and family. Another pitfall is that IM may increase gossip/rumors, so it may create a stressful situation at a workplace (Pew Research Centre, 2004).

Although IM is based on text messages, the user may check if a counterpart on a private list is online and available for live chatting or not. This feature enables real-time telecommunication, and it makes IM distinct from other text messaging services. As a common feature of CMC, IM also allows users enough time to reflect on the situations and to respond accordingly.

This feature specifically appeals to the users who don't like any threatening/embarrassing situations caused by face-to-face communication. It may lead to better exploration, excitement, confidence, more engagement, and responsibility, as well as a better understanding of situations and discovery of new insight (Young, 2003).

This study is one of the few attempts to investigate student acceptance of CMC technology in busi-ness planning. In response to the call for a holistic model explaining CMC technology, we have tested a conceptual model of information product quality to explain student acceptance of CMC from an informational, physical, and service theoretical frame. This effort was successful in generating several new insights about the perceived quality nature as determinants of CMC use. Reliability of measure-ment items of each motivation and concern was ensured. Cronbach's alpha for each motivation and concern is >.70, and all of the values are statistically significant ($p < .05$). Factor analysis using SPSS was conducted with maximum likelihood extraction with iterations to test and validate the conceptu-ally developed three quality components. A factorial analysis has allowed the model to be rearranged. The three factors are labeled: (1) Physical, (2) Information, and (3) Service. This three-factor result supports Nam's Information Product Quality Model (2009, 2014). Different sets of quality attributes may be considered important in a different social, cultural, and situational context. Similar attempts integrating three components of quality for a holistic view of quality have been made by other re-searchers. Xu et al. (2013) proposed the 3Q model in the e-service context by including the Service Quality and its relationships with System Quality and Information Quality in website adoption. In their 3Q model, information quality includes four attributes (completeness, accuracy, format, cur-rency), System Quality includes four attributes (reliability, flexibility, Accessibility, & Timeliness). Ser-vice Quality includes five attributes (Tangibles, Responsiveness, Empathy, Service Reliability, and As-surance).

Kanwal and Rehman (2016) also paid attention to the three components of quality when they studied the user's satisfaction towards e-learning systems in Pakistan. They found that infor-mation quality, service quality, and system quality were the positive and significant indicators for user satisfaction. Wang and Lin (2017) also focused on these three components of quality when they in-vestigated the effect of perceived quality on their trust in location-based services. Location-based ser-vices are a type of app that detects the location where the device is located and can provide infor-mation such as routes, attractions, and traffic conditions. As there is a privacy concern in the use of location-based services, they examined how the perceived quality of the app affects user's trust in the app. They found that the information quality, system quality, and service quality of the app were positively related to the perceived trust.

In our research, among the three factors, (1) Physical factor appeared to be the most important be-cause it explained the largest portion (39.28%) of the total variance (Figure 2).

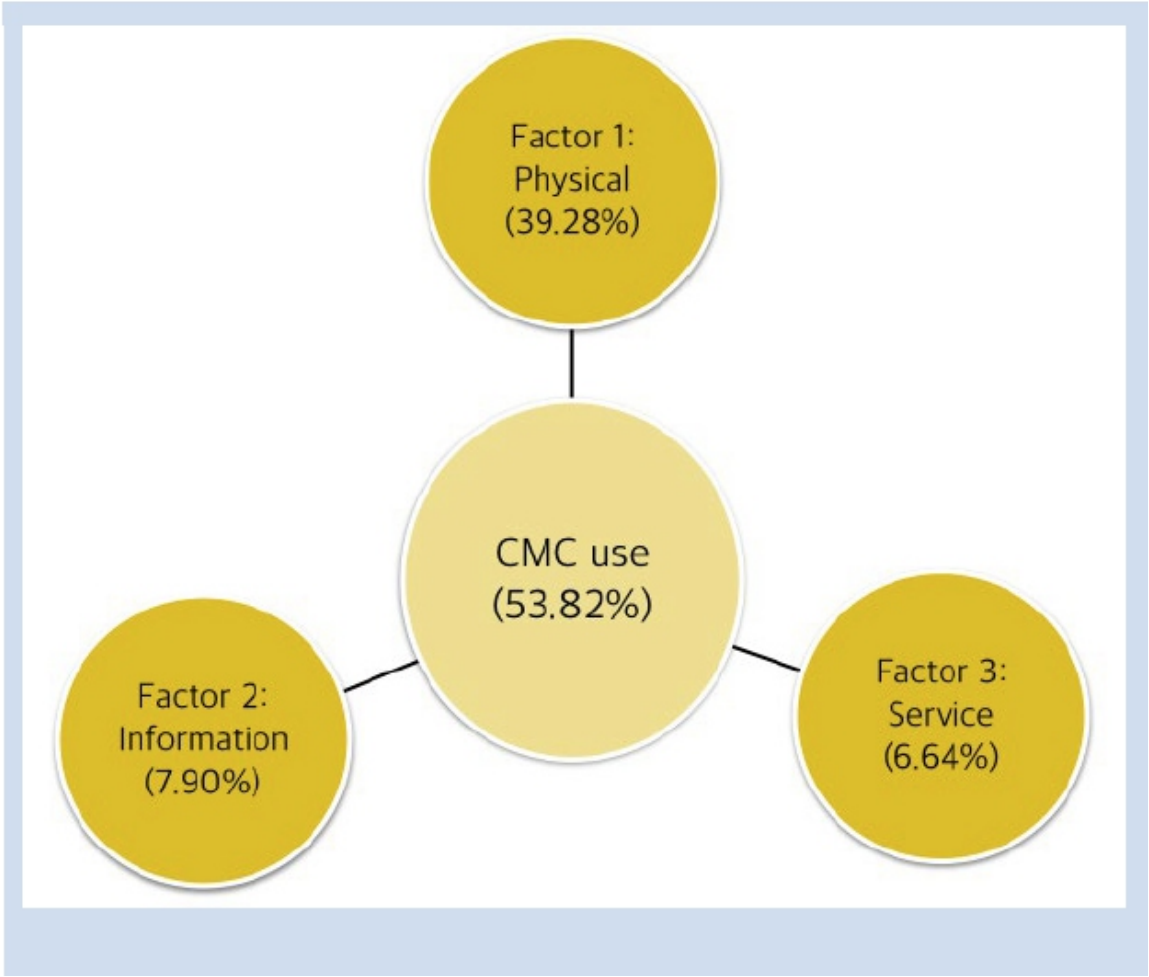

Figure 2: Rotated Loading Results

Physical factors were indicated by the attributes “Speed,” “Accessibility,” “Timeliness,” “Conven-ience,” “Interactivity,” and “Assurance.” “Convenience” is most highly correlated with a rotated load-ing score of .854 (Figure 3).

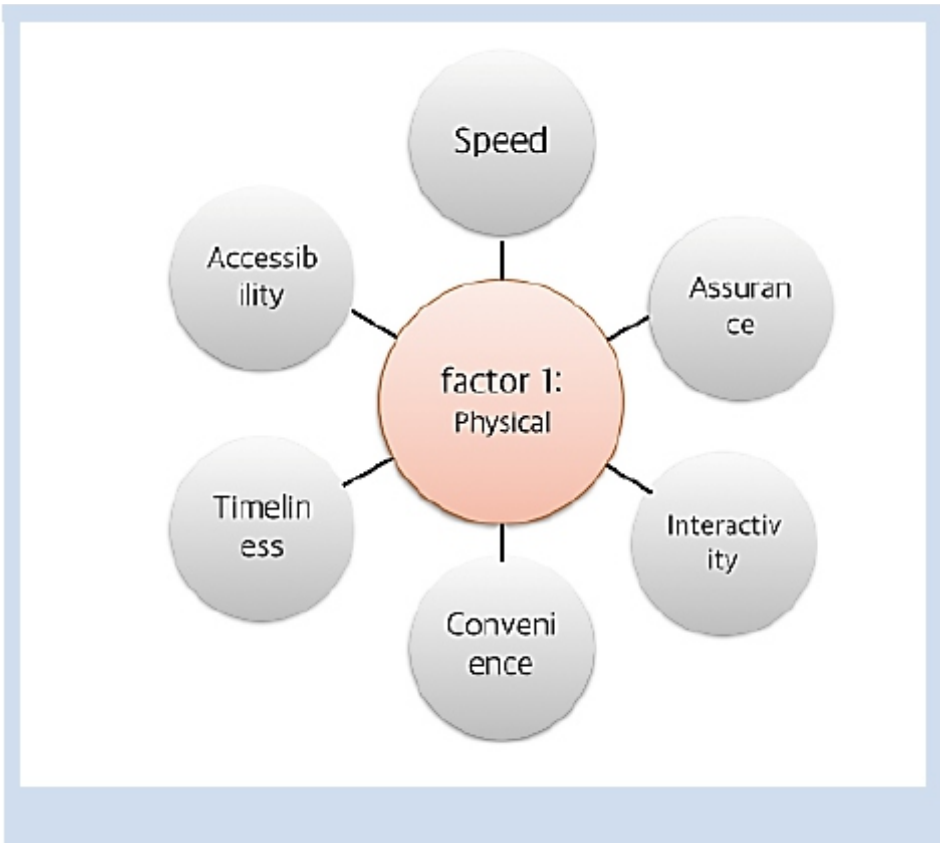

Figure 3: Factor 1 Physical

Information factors explained 7.9 % of the total variance. Information factor was indicated by the attributes "Conciseness", "Comprehensiveness", "Clarity", "Accuracy", "Consistency". "Conciseness" is correlated with the highest rotated score .724 (Figure 4).

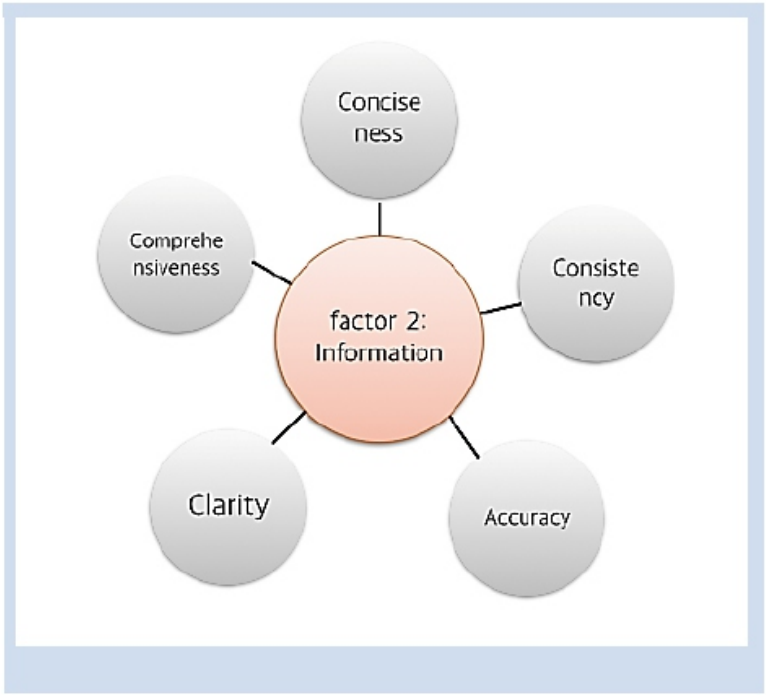

Figure 4: Factor 2 Information

The service factor explained 6.64% of the total variance. Service factor was indicated by the attrib-utes "Reliability," "Responsiveness," "Assurance," and "Tangibility." "Reliability" is correlated with the highest rotated score, .759 (Figure 5).

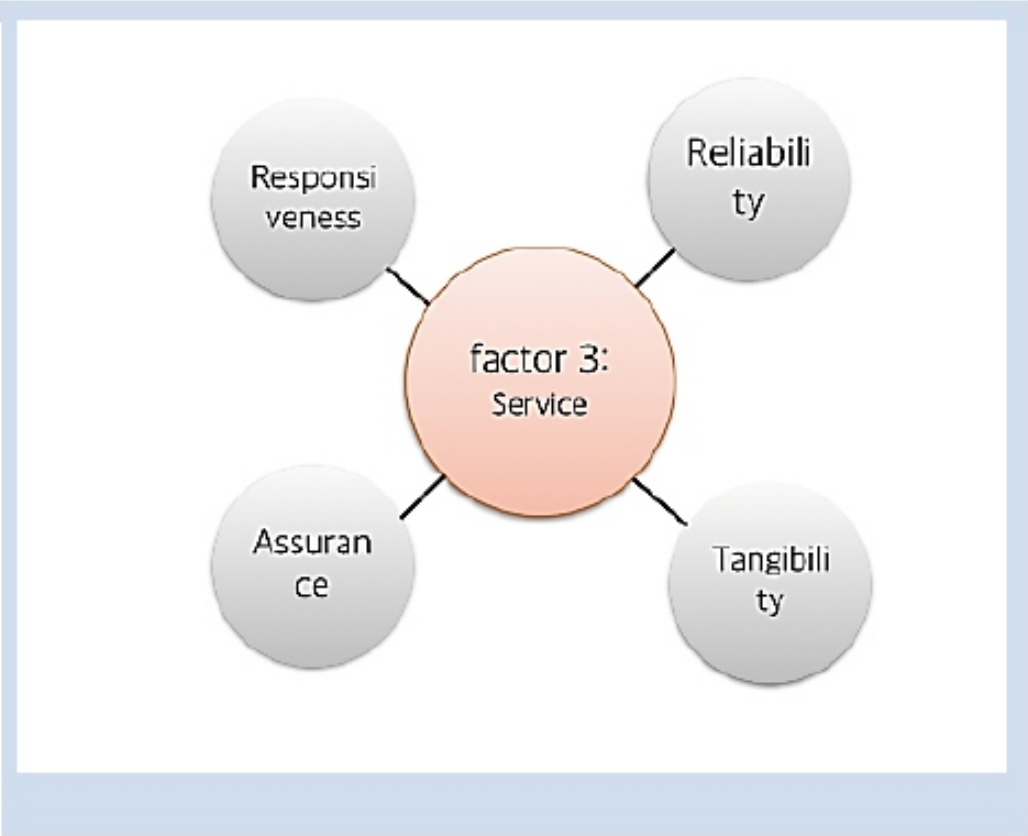

Figure 5: Factor 3 Service

It is remarkable that the physical component of quality appeared the most important in CMC use for business planning collaboration. Little is known regarding the importance of physical components of quality in the use of CMC. As a user nowadays carries his/her own portable devices to access various CMC technologies, convenience seems a very important attribute measuring the CMC perceived quality. Specifically, in the use of IM for real-time communication, 'Convenience' was pointed out as the most important attribute. Major concerns of quality research still remained only in the Infor-mation component of quality.

Information quality has been pointed out as an indicator of online e-commerce customer satisfaction (Lin, 2007). Muhammad et al., tested if information quality affects online customer's commitment, and they found that information quality positively influences e-satisfaction and e-trust (Muhammad et al., 2014). Ou and Davison (2016) examined how communication quality and mutual trust contrib-ute to the development of interpersonal relationships from working professionals in China. They found that synchronicity mediates the direct relationship between IM use and interpersonal relation-ship. They also found that communication quality mediates the direct relationship between IM use and trust. This finding suggests that even with the IM physically installed, employees' mutual trust cannot be achieved without quality communication. In their study, communication quality refers to the employee's perception of the quality of communication in terms of being timely, adequate, accu-rate, complete, interactive, and effective.

THEORETICAL AND PRACTICAL CONTRIBUTIONS

First, given the theoretical importance of integrating information, physical, and service components of information products (Nam, 2014; Nam, 2009), three factors were identified as the most im-portant component of CMC quality in business planning. By presenting a theory of quality on the use of CMC in business planning, our work contributes to research in multiple ways. First, our the-ory contributes to the literature discovering important quality factors in CMC use, specifically in busi-ness planning. Prior research has largely focused only on informational components of quality. In this study, we emphasize the importance of three components, Physical, Information, and Service components of quality, in explaining CMC use, specifically in business planning.

Second, the physical component was identified as the most important component in the use of CMC in business planning. Even though there are several attempts to integrate informational, physical, and service components of quality explaining media, major research domains remain in the focus of the information component only. This research highlights the importance of physical components in the use of CMC as 'convenience' is regarded as the key attribute in measuring users' perceived quality. Using mobile devices, people can access CMC technology in real-time. This finding points out the importance of physical quality components in the measuring quality of CMC.

Third, quality is recognized as an explanatory variable of the use of CMC in business planning. In theories based on the TAM model, the use of mandatory, work-related information systems has mostly been the focus. Therefore, the explanation has been limited in some senses. Although various quality attributes have been identified before, little is known about which quality factor is perceived as important in the use of CMC in business planning. This study shed light on quality research, specifi-cally in the use of CMC. As the focus of our study is on user-perceived quality, we offer a user-level understanding of the use of CMC about what quality factors drive the choice of a specific CMC for collaborative works.

With the growing role of CMC technologies nowadays, our study has practical implications for en-hancing CMC technology performance. This study informs the importance of 'Convenience' in CMC design to yield a higher value proposition to CMC users. The prominence of the Convenience attribute has important implications for app developers, particularly those who have tended to ignore physical factors. The significant quality attributes related to CMC use will provide insight to app de-velopers about which features they should consider in designing CMC. Our proposed quality model can be prescriptive to managers and designers on how to design a new CMC specifically for collabo-rative work. Articulation of these factors would help identify potential problems that may signifi-cantly promote or hinder use when web designers, managers, and users evaluate the quality of a CMC tool.

LIMITATIONS AND FUTURE RESEARCH

The threat to external validity comes from the fact that it tested a limited number of subjects, tasks, and specific contextual situations. The student subjects may not represent a general population. Stu-dents' use of CMC technologies is tested to test CMC use in a work setting. Even if their use of CMC is for business planning as coursework, their student status may affect the choice or use of CMC. For another population, different motivational factors may appear significant. For example, the senior group of people may face more technical/physical challenges in the use of CMC (ex. opti-cal problems) compared to the student population (Chou et al., 2013). Their perceived quality of CMC may be different. Future research will shed more light on the generality of these findings. Fu-ture studies should be extended to other populations and contextual situations in the use of CMC.

CONCLUSION

The purpose of this study was to examine the user's perceived quality of CMC technology in busi-ness planning. The three components (Physical, Information, and Service) were found as significant quality factors. These findings contribute to a better understanding of the use of CMC in business planning. Future studies should be extended to other populations and contextual situations in the use of CMC.

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Research on the Tourism Decision- Making Mechanism: A Case Study of American Outbound Tourism

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ABSTRACT

Aim/Purpose This article takes 'tourism decision-making behavior' as an entry point, and deeply analyzes the factors influencing the travel decision-making of Chinese 'American Travel' tourists and their degree of influence, so as to provide a refer-ence for the development of Chinese outbound tourism.

Background With the development of China's economy and the improvement in people's level, the outbound tourism market of Chinese residents has developed rapidly. The United States has become an important tourism destination country for Chinese residents' outbound tourism, and China has also become one of the important tourist source countries of American tourism. However, the rapid development of 'American tourism' has also caused competition problems in China's tourism industry. For example, prices and tourism products have be-come a means of competition among tourism enterprises. As the main body of consumption, tourists' decision-making behavior will be affected by various fac-tors.

Methodology Drawing lessons from previous scholars' research results on tourism decision-making behavior, the influencing factors of tourism decision-making behavior are summarized. A theoretical model and index system of factors influencing tourism decision-making behavior of Chinese residents 'Travel in the United States' are established, research hypotheses are put forward, questionnaire data are collected, and SPSS and Amos are used to analyze and verify the theoretical model.

Contribution This research expands the literature on topics related to tourism decision-mak-ing in research and practice. It establishes a theoretical model and index system for the factors that influence the decision-making behavior of Chinese resi-dents' 'American Travel' tourism. In addition, we propose countermeasures for tourism products, enterprises, and the government.

Findings Prior knowledge and external information have a positive influence on tourism perception and value perception, and a negative influence on risk perception. Risk perception value perception has a positive and negative influence on tour-ism decision-making and tourism motivation, respectively. Tourism motivation has a positive influence on tourism decision-making and has a positive impact.

Recommendations for Practitioners According to the research conclusions of this article, the following counter-measures and suggestions are put forward from three aspects of tourism: prod-ucts, enterprises, and governments.

On the basis of existing tourism products, relevant operating companies should pay more attention to the upgrading and transformation of tourism, leisure and entertainment products in scenic spots to increase the willingness of tourists to travel.

When considering corporate marketing and promotion plans, tourism compa-nies operating related businesses should increase the weight of their marketing budgets in online marketing, increase investment in online marketing, and de-velop mobile applications that meet the preferences of Chinese residents in the United States.

Do a good job in the timely publication of safety reminders and local infor-mation. Safety is an important foundation for tourism development and the core concern of many tourists.

Future Research Due to the important research on the impact of tourism activities, the influenc-ing factors are many and complex, and the psychological process of tourism de-cision-making is carried out directly. There are still unconsidered factors that need to be studied in depth. In the future, it is possible to compare multiple re-source-featured themes, and increase the characteristics of potential tourists, and the factors affecting the selection behavior of regional cultural tourists, and so forth, in order to make the research more applicable and practical instructive significance.

Keywords tourism decision; influencing factors; structural equation

INTRODUCTION

For a long time, tourism has been regarded as a social phenomenon of economic nature, and has gradually become a very important field in tourism research (Wang et al., 2005). Tourism is one of the factors of long-term economic growth (Balaguer & Cantavella-Jorda, 2002), and its economic importance is reflected in various industries (Mayer & Vogt, 2016). But the essence of tourism is ontol-ogy-human research (Deng, 2019), and tourism decision-making is the key variable. At present, many experts and scholars lay the study emphasis of tourism and its influencing factors on the reaction of tourists after arriving at the destination, while ignoring the most significant link before tourism behavior – tourism decision-making (Yao, 2011). To this end, taking the Chinese 'U.S. Travel' tourists as an example, and 'tourism decision-making behavior' as an entry point, this article analyzes the factors affecting travel decision-making and their degree of influence in depth from five dimensions (Prior Knowledge, External Information, Risk Perception, Value Perception, Tourism Motivation) in order to deepen the understanding of the impact of travel decision-making.

LITERATURE REVIEW

Most models of tourism consumption are based on theoretical methods of psychology and econom-ics. Tourism behavior, as a research field rather than a subject, has adjusted the relevant theories of psychology and economics in a special way to adapt to the special situation of tourism behavior. Rugg (1973) took 'destination choice' as the dependent variable, and took 'product characteristics', 'consumption technology', and 'budget' as the main independent variables. Regression analysis was used for research. Its main contribution lies in the introduction of three previously ignored dimen-sions, namely, 'time constraint', 'transportation costs', and 'time costs'. Morley (1992) took the choice of 'tour itinerary' as the dependent variable, using 'country of destination' and 'individual characteris-tics' such as income, disposable time, and demographic variables. As an independent variable, the re-search was carried out in an experimental manner. It determined whether business trips, time alloca-tion, budget, and travel choices have an impact on the travel route.

Zalatan (1998) used 'tourism decisions' as the dependent variable and various tasks as independent variables, such as 'financing tasks' and 'pre-departure tasks.' Descriptive statistics and regression analysis were used. It was discovered that there are differences in gender in tourism decision-making. Jiang et al. (2000) also used 'tourism decision-making' as the dependent variable. They used factor analysis to determine that "tourism service", "social connection" and "goal orientation" are three di-mensions and take them as three main independent variables affecting tourism decision-making. Fi-nally, the cognition-based destination decision prediction scale was verified and expanded. McCabe et al. (2016) pointed out that microeconomics methods, motivational perspectives, behaviorist para-digms, cognitivism methods, and postmodern perspectives, are the five theoretical methods applied to the construction of tourism decision-making theories. It is through these theoretical methods that tourism decision-making models are empirically working in research.

With the rise of the Internet, the richness of information is different from the past. The Internet is an important carrier for marketing and promotion of travel agencies and tourist destinations. Tourist destinations have also begun to focus on image management. The importance of external infor-mation influencing tourists' individual travel decisions has risen. On the other hand, due to the devel-opment of the domestic economy, the tourism industry has risen rapidly, and the influence of per-sonal income and other material factors on tourism decision-making has declined compared with be-fore. At the same time, the importance of risk perception in tourism decision-making has gradually increased. In the era of underdeveloped information, tourism decision-making is less selective, and there are few famous tourist destinations, but relatively, the credibility of tourist destinations is greater. In the information-developed years, tourists cross-border travel. The possibility of tourism has increased, and the explosive increase of information about tourist destinations on the Internet, including false propaganda, has made tourists more cautious when making travel decisions, and fac-tors in risk perception have increased.

Based on the research methods and theoretical framework of experimental economics and behav-ioral economics, this article introduces tourism motivation and destination influencing variables into the study of tourist decision-making behavior, which helps to reveal the 'decision-making black box' of tourists.

RESEARCH MODELAND HYPOTHESIS

RESEARCH MODEL

This research is based on the tourism decision-making process model of Guo (2009), combining the tourism risk perception model of Sharifpour et al. (2013) and H. Zhang & Lu's (2005) research on tourism motivation, as well as the early research on tourism decision-making and recent research. The research model in Figure 1 is proposed.

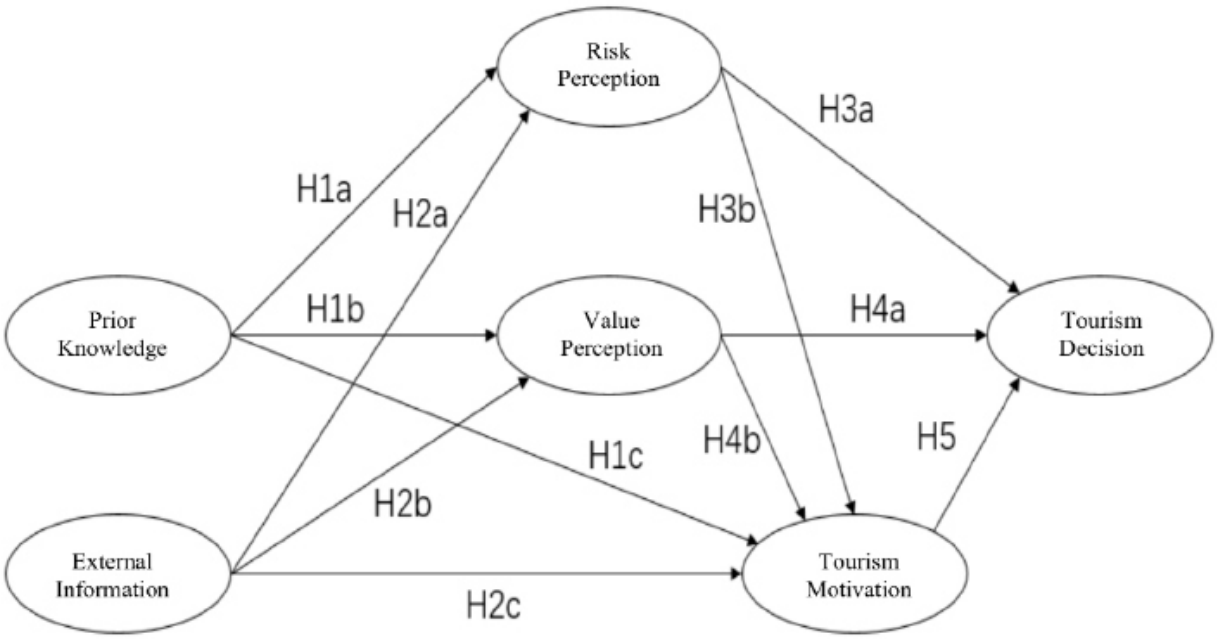

Figure 1. Research model

PRIOR KNOWLEDGE

Prior knowledge refers to the synthesis of the individual's past knowledge, which includes not only the individual's experience, but also the learner's attitude and knowledge (Sharifpour & Walters, 2014). In tourism decision-making, prior knowledge refers to the individual's past knowledge, experi-ence and attitudes related to the tourist destination. Tourism decision-making can be either the result of behavior, or a process. As a process, it may include a series of processes from problem identifica-tion, information collection, product evaluation and selection to purchase and post-purchase behav-ior (Q. Zhang et al., 2012). In this research, tourism decision-making mainly refers to the behavior tendency of individuals to decide whether to travel.

Prior knowledge, as the individual's previous knowledge, will give the individual a basic judgment, in-volving whether the travel is at risk; for example, a physical risk (such as traveling to dangerous areas or no-man's land), or a psychological risk (such as whether good enough scenery could be enjoyed). Additionally, prior knowledge is able to allow individuals to have a basic judgment on the value of the tourist destination. And, as the individual learns more about the destination, it will affect the indi-vidual's impulse to travel. Therefore, this research proposes the following hypotheses:

H1a: The individual's prior knowledge has a negative impact on their risk perception.

H1b: The individual's prior knowledge has a positive impact on their perception of value.

H1c: An individual's prior knowledge has a positive impact on his or her travel perception.

EXTERNAL INFORMATION

In the study of Sharifpour et al. (2014), the information is divided into three categories: information from oneself, information from others, and detailed information about external destinations. The in-formation derived from oneself can be considered as prior knowledge and belongs to the individual's past

knowledge, while the information derived from others, whether it is from family or friends or the propaganda of travel agencies, can be regarded as external information. At the same time, the de-tailed description of the destination, whether it comes from online travel notes, comments, or the destination's official websites, can also be viewed as external information. Therefore, in this study, drawing on the relevant research of public relations communication, external information is defined as different from the knowledge originally possessed by the individual, and belongs to the infor-mation that the individual later comes into contact with through certain media or individuals, includ-ing information from relatives and friends, networks, publicity information of travel agencies, and so forth (Feng, 2008).

On the basis of the individual's prior knowledge, the individual is also vulnerable to the outside world. Today is a networked information age, where online marketing is prevalent, and all kinds of information are bombarding consumers. At the same time, consumers may also communicate with relatives and friends to obtain certain travel-related information. This information will affect con-sumers' judgments on travel behavior, including risk considerations and value perception. In addition, external information tends to amplify information on tourist destinations, which easily evokes indi-vidual travel motives. Therefore, this research proposes the following hypotheses:

H2a: The external information received by the individual has a negative impact on the risk per-ception.

H2b: The external information received by an individual has a positive impact on its perception of value.

H2c: The external information received by the individual has a positive impact on their percep-tion of travel.

RISK PERCEPTION

Risk perception is an important research concept in many fields, mainly referring to the individual's perception and feeling of external risks (Meng et al., 2010). The original concept was extended from psychology, referring to the uncertainty of the results implicit in the purchase decision of customers (Derbaix, 1983). Some foreign scholars have also conducted in-depth research on the risks that new products will bring to customers: Jacoby and Kaplan (1972) divided customer perceived risks into fi-nancial risks, functional risks, physical risks, psychological risks, and social risks. Peter and Tarpey (1975) proposed that the sixth important risk is time risk; Stone and Grønhaug (1993), the study showed that the first five risks plus time risk can explain 88.8% of customer perceived risks.

In this study, it refers to the individual's perception of the risks that may be brought about by tour-ism behavior, including whether tourism services are value for money, whether there are physi-cal/ physiological dangers.

On the basis of the individual's prior knowledge, the individual is also easily influenced by the out-side world. Today is a networked information age, where online marketing is prevalent, and all kinds of information are bombarding consumers. At the same time, consumers may also communicate with relatives and friends to obtain certain travel-related information. This information will affect consumers' judgments on travel behavior, including risk considerations and value perception. In addi-tion, external information tends to amplify information on tourist destinations, which easily evokes individual travel motives. Therefore, this research proposes the following hypotheses:

H2a: The external information received by the individual has a negative impact on the risk per-ception.

H2b: The external information received by an individual has a positive impact on its perception of value.

H2c: The external information received by the individual has a positive impact on their percep-tion of travel.

The stronger the individual's perception of the risks of tourism, the more worried about the losses caused by tourism behavior, which will reduce their desire to travel. At the same time, risk, as a nega-tive factor, will also directly affect the individual's decision on tourism behavior. Therefore, this re-search proposes the following hypotheses:

H3a: An individual's perception of risk has a negative impact on their travel decisions.

H3b: An individual's perception of risk has a negative impact on his or her travel motivation.

VALUE PERCEPTION

Thaler (1985) proposed the concept of value perception. He understood value perception as the con-cept of difference in utility; that is, the difference between acquired utility and transaction utility. Among them, acquired utility refers to the comparison between people's subjective feelings of gain-ing benefits in the consumption process and actual monetary expenditures, while transaction utility refers to the comparison of the monetary price that consumers believe to purchase products should be paid with their real money.

Zeithaml (1988) defined the concept of value perception from the perspective of consumer psychol-ogy; that is, the overall effect that customers perceive after comprehensively evaluating and measur-ing the costs and benefits of the products and services they buy. It can be seen that his definition of customer value perception refers to the comprehensive evaluation made by customers after the over-all utility of the purchased goods, which is the result of comparing two perceptions of income per-ception and cost perception. This argument puts forward that not only the value can be obtained by the customer from the consumer experience, but also the customer will feel it in the consumer expe-rience, thus expanding the scope of understanding of the concept of value.

Best (2009) divides value perception into three levels: emotional benefit, economic benefit, and per-ceived benefit. In these three levels, perceived emotional benefits cannot be evaluated by money and have strong subjective perceived benefits. Perceived economic benefits are a value-creating product that can be measured by money. Perceived benefits can be measured from three angles: brands, ser-vices, and products quality. Park et al. (1986) further classified the benefits of brands from three per-spectives: experience value, symbolic value, and functional value. It can be seen from the above that different researchers have certain differences in their understanding of value perception, which are actually caused by the different starting points of the research scholars. They are essentially starting from the perspective of exchanging benefits to understand the concept of perceived value. In other words, they all believe that the value that customers can perceive is customer value, the most basic theoretical point of which is the produced comprehensive evaluation and subjective feeling as a result of perception and loss that consumers gain or lose when they have purchased or intend to purchase a certain product or service. Yu et al. (2010) believe that value perception refers to the subjective manifestation of the value con

tained in a product/service by customers, an overall evaluation of the perceived benefits, and the util-ity of the product or service. In this research, value perception is the individual's perception of the benefits (psychological enjoyment, social conversation, etc.) brought by travel behavior.

Value perception, as a positive influencing factor, can increase the possibility of individuals making travel decisions. When an individual feels that the scenery of a place is more beautiful and that travel-ing to that place can bring great enjoyment, the easier it is to make a travel decision. In the percep-tion of value, the first thing that improves is the individual's travel motivation. The greater the indi-vidual's perception of the benefits and value brought about by tourism, the greater the motivation generated.

Therefore, this research proposes the following hypotheses:

H4a: The individual's perception of value has a positive impact on their travel decisions.

H4b: An individual's perception of value has a positive impact on his or her travel motivation.

TRAVEL MOTIVATION

Motivation is the general driving force that guides consumers' behavior to reach their needs (Hennig-Thurau et al., 2003). Travel motivation is stimulated by people's travel needs, and when consumers have the demand, it will stimulate travel motivation (Xie, 2015). Travel motivation is the vaguely com-plicated psychological activity of people, which is regarded as a significant factor for tourists to de-cide to go to a tourist destination (Zhang et al., 2018).

Motivation, as the driving force of individual behavior, has always been the most significant and di-rect factor. When the individual's desires are stronger, the more naturally the individual cannot help making certain decisions or behaviors. Therefore, this research proposes the following hypothesis:

H5: An individual's travel motivation has a positive influence on that individual's travel decision.

RESEARCH PROCESS

SAMPLE SELECTION

The distribution of the questionnaire in this study was mainly completed by the staff of a travel agency. The main process is: first, issue paper questionnaires to customers who have consulted about travel in the United States; second, issue online questionnaires to past customers through instant messaging software; and third, further spread them to relatives and friends through customers. The advantage of distributing the questionnaire in this way was to ensure that the questionnaire could be sent to groups with travel experience or planning to travel, and accurately connect with the target group of the research.

QUESTIONNAIRE FORMALLY ADMINISTERED

The questionnaire was officially issued from June 2019 to October 2019. The author conducted a large-scale distribution of paper and online questionnaires through travel agency staff. A total of 346 questionnaires were distributed. After recovery, invalid questionnaires (the same option or omission in the questionnaire) were removed, and 287 valid questionnaires remained. The effective rate of the questionnaire was 82.9%. (The questionnaire is in the appendix.)

COMMON METHOD DEVIATION TEST

The data in this study is based on the participants' self-reporting methods, so there may be a com-mon method bias effect (Zhou & Long, 2004). In order to avoid this kind of influence, this study carried out strict control during the survey process, including the use of anonymous actual measure-ment and random sampling. In addition, after data collection, Harman's single factor test was used to determine whether the deviation of the commonly used method is serious. The factor analysis in SPSS shows that there are 5 principal components with characteristic roots greater than 1. The first principal component characteristic root is 6.132, and the explained variation is 34.07%, which is lower than the critical standard of 40%, indicating no serious common method bias effect in the study, and subsequent data analysis can be carried out.

Questionnaire data analysis generally uses Cronbach's alpha (Cronbach's α) internal consistency coef-ficient as the reliability standard, and uses Construct Validity as a data analysis standard to evaluate the validity of the questionnaire. In this study, SPSS 23.0 and AMOS 23.0 were used to verify them.

Using SPSS 23.0 to test the internal consistency of each dimension, the Cronbach's α value of each dimension is as follows. The results show that the α value of each dimension is greater than the standard of 0.7 (Hair, 2009), indicating that the internal consistency of each dimension is good and suitable for subsequent analysis (Table 1).

Table 1. Cronbach's α internal consistency reliability of each dimension

Dimension	Item	Cronbach's α
Prior Knowledge	Q1	0.796
	Q2	
	Q3	
External Information	Q4	0.863
	Q5	
	Q6	
Risk Perception	Q7	0.841
	Q8	
	Q9	
Value Perception	Q10	0.786
	Q11	
	Q12	
Travel Motivation	Q13	0.825
	Q14	
	Q15	
Tourism Decision	Q16	0.843
	Q17	
	Q18	

CONFIRMATORY FACTOR ANALYSIS

Using AMOS 23.0 to perform Confirmatory Factor Analysis (CFA) analysis on all dimensions, the results are shown in Table 2 and Figure 2. The fitting indicators are: $\chi 2/df=281.144/120=2.343$, RMSEA=0.069, CFI=0.935, TLI=0.917, GFI=0.901, SRMR=0.049. All fitting indicators of the model have reached the ideal standard and have an ideal degree of fit, indicating that the measure-ment model selected in this study can fit the structure of the empirical data.

Table 2. CFA fitting index

Inspection index	χ^2/df	RMSEA	GFI	CFI	TLI	SRMR
Evaluation standard	<3.00	<0.10	>0.90	>0.90	>0.90	<0.08
Model results	281.144/120=2.343	0.069	0.901	0.935	0.917	0.049

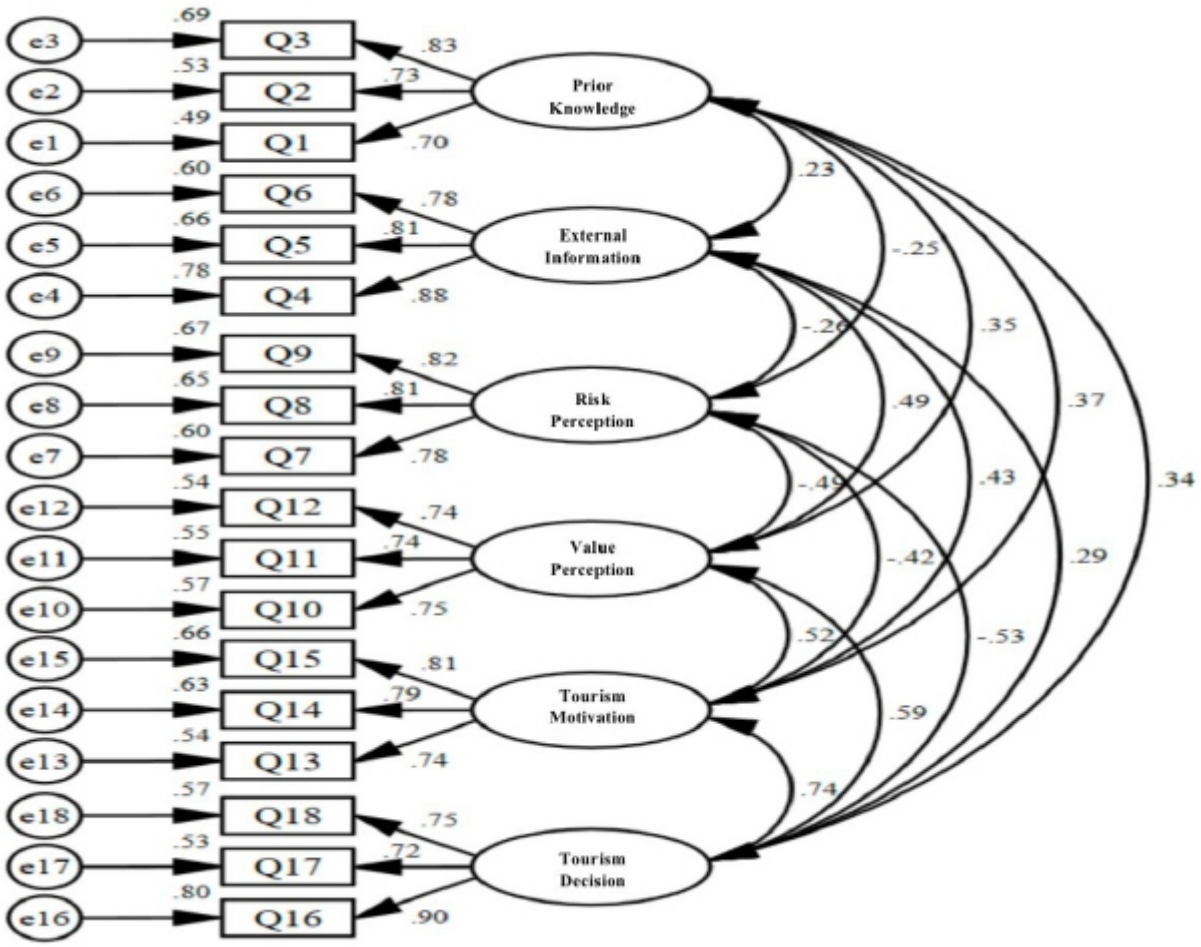

Figure 2. Confirmatory factor analysis (standardized)

Result validity is mainly reflected by convergent validity and discriminant validity. In the case of good model fitting indicators, further check the significance level of factor loading of each item, and calcu-late the combined reliability (Composite Reliability, CR) and average variance extraction (Average Variance Extracted, AVE) according to the standardized factor loading. The results are shown in Ta-ble

3. As shown in the table, the combined reliability of all dimensions is greater than 0.7, and the average variance extraction is greater than 0.5, indicating that the items measured on the same dimen-sion have good aggregation validity (Hair, 2009). (The CR in Table 1 stands for critical ratio.)

Table 3. Confirmatory factor analysis results

Dimension	Item	Non-standardized Regression coefficients	Standard error SE	Critical ratio CR	P	Standardization Regression coefficients	Convergent validity CR	Convergent validity AVE
Prior Knowledge	Q1	1.000				0.703	0.799	0.571
	Q2	1.093	0.106	10.283	***	0.725		
	Q3	1.237	0.117	10.572	***	0.833		
External Information	Q4	1.000				0.881	0.863	0.678
	Q5	0.931	0.061	15.192	***	0.811		
	Q6	0.894	0.062	14.498	***	0.775		
Dimension	Item	Non-standardized Regression coefficients	Standard error SE	Critical ratio CR	P	Standardization Regression coefficients	Convergent validity CR	Convergent validity AVE
Risk Perception	Q7	1.000				0.776	0.842	0.640
	Q8	1.156	0.089	13.028	***	0.807		
	Q9	1.035	0.079	13.119	***	0.817		
Value Perception	Q10	1.000				0.753	0.787	0.552
	Q11	1.043	0.095	10.968	***	0.740		
	Q12	1.115	0.102	10.925	***	0.736		
Travel Motivation	Q13	1.000				0.736	0.824	0.610
	Q14	1.123	0.091	12.320	***	0.793		
	Q15	1.227	0.098	12.538	***	0.812		
Tourism Decision	Q16	1.000				0.897	0.836	0.632
	Q17	0.739	0.054	13.653	***	0.725		
	Q18	0.759	0.053	14.328	***	0.752		

Note: *p<0.05, **p<0.01, ***p<0.001, both are bilateral, the same below.

On the basis of the convergent validity of the measurement model, the discriminant validity is further tested. The value of the root sign of the dimension AVE is compared with the correlation coefficients of this dimension and other dimensions, and the results are shown in Table 4. The correlation coefficient between any two dimensions is less than the square root of the AVE of each dimension itself (the numbers in bold on the diagonal line), indicating that there is sufficient effectiveness in distinguishing between different dimensions.

Table 4. Discrimination validity test table

Dimension	Mean	Standard deviation	1	2	3	4	5	6
1.P K	4.79	1.28	**0.76**					
2.E I	4.35	1.31	0.23	**0.82**				
3.R P	3.41	1.33	-0.25	-0.26	**0.80**			
4.V P	4.59	1.17	0.35	0.49	-0.49	**0.74**		
5.T M	4.95	1.22	0.37	0.43	-0.43	0.52	**0.78**	
6.T D	4.65	1.15	0.34	0.29	-0.53	0.59	0.74	**0.79**

Note: The bolded numbers on the diagonal of the table are the square ($\sqrt{AVE}$), of the average variance extraction of the corresponding dimensions, and the off-diagonal numbers are the correlation coefficients between dimensions.

MODEL FITTING AND HYPOTHESIS TESTING

On the basis of the above reliability and validity tests, this study conducted a preliminary statistical test on the research hypothesis of the relationship between the fit of the overall model and the potential dimensions. The analysis results of the structural model are shown in Table 5 and Figure 3.

Table 5. Fitting indexes of structural model

Inspection index	χ^2/df	RMSEA	GFI	CFI	TLI	SRMR
Evaluation standard	<3.00	<0.10	>0.90	>0.90	>0.90	<0.08
Model results	313.924/123=2.552	0.074	0.889	0.923	0.904	0.070

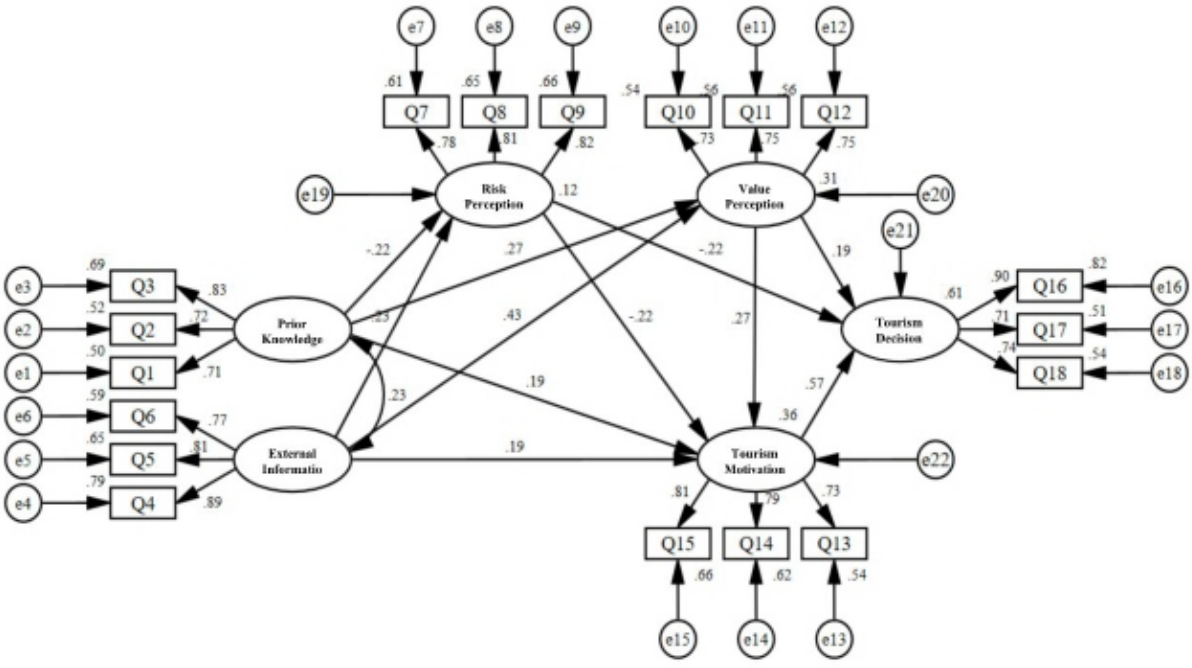

Figure 3. Preliminarily established structural equation model (standardized)

According to Table 5, most of the fitting indicators of the model meet the ideal standard, but the GFI is lower than 0.9. It is further found that the revised index of item Q15 and item Q16 is as high as 39.431. Therefore, the model was revised, and the residual correlation between Q15 and Q16 was released, and the analysis was performed again.

The revised model was analysed, and the results are shown in Table 6 and Figure 4.

Table 6. Fitting indexes of the revised structural model

Inspection index	χ^2/df	RMSEA	GFI	CFI	TLI	SRMR
Evaluation standard	<3.00	<0.10	>0.90	>0.90	>0.90	<0.08
Model results	266.754/122=2.187	0.064	0.903	0.941	0.927	0.068

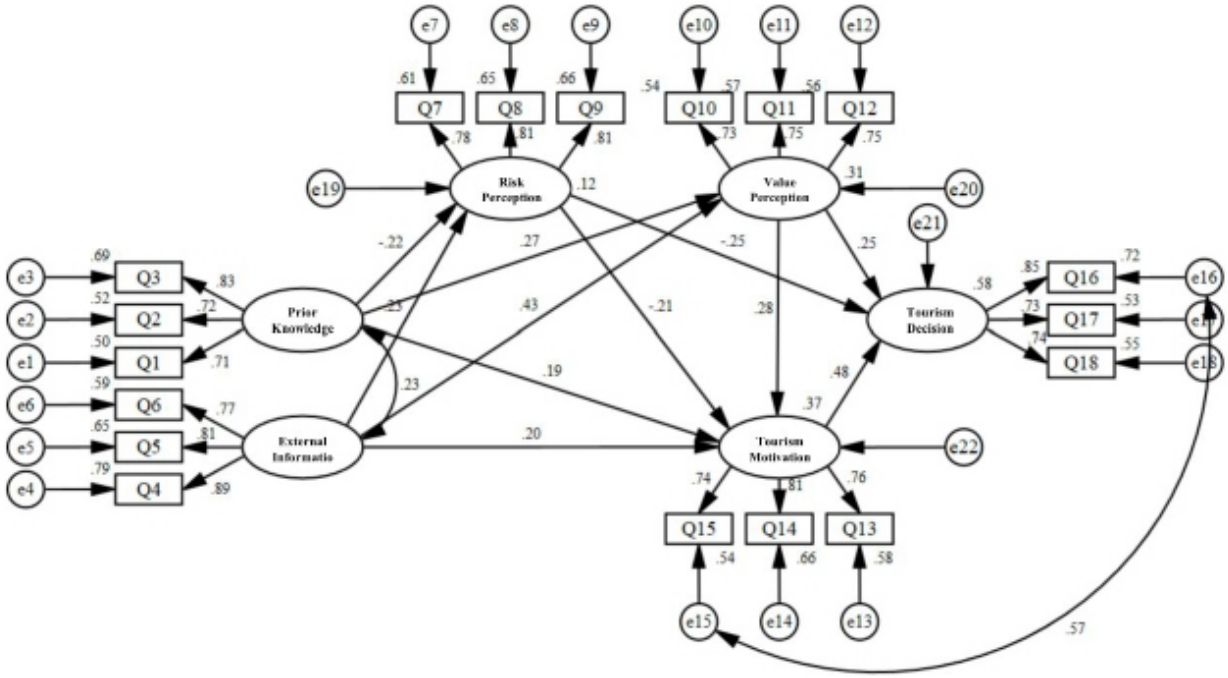

Figure 4. The revised structural equation model (standardized)

According to Table 6, all the fitting indexes of the revised structural equation model have reached the ideal standard, indicating that the actual data fits well with the hypothetical model. The significance of its path coefficient was further tested, as shown in Table 7 and Figure 5.

Table 7. Significance test of path coefficient

Path	Non-standardized Regression coefficients	Standard error SE	Critical ratio CR	P	Standard-ization Regression coefficients	Hypo-thesis	Test
PK → RP	-0.240	0.081	-2.983	0.003	-0.217	H1a	√
PK → VP	0.247	0.066	3.750	***	0.269	H1b	√
PK → TM	0.182	0.070	2.582	0.010	0.186	H1c	√
EI → RP	-0.203	0.061	-3.300	***	-0.229	H2a	√

EI → VP	0.314	0.052	5.988	***	0.427	H2b	√
EI → TM	0.156	0.058	2.670	0.008	0.200	H2c	√
RP → TD	-0.242	0.056	-4.291	***	-0.247	H3a	√
RP → TM	-0.183	0.059	-3.080	0.002	-0.207	H3b	√
VP → TD	0.299	0.077	3.857	***	0.252	H4a	√
VP → TM	0.297	0.088	3.361	***	0.280	H4b	√
TM → TD	0.534	0.086	6.242	***	0.479	H5	√

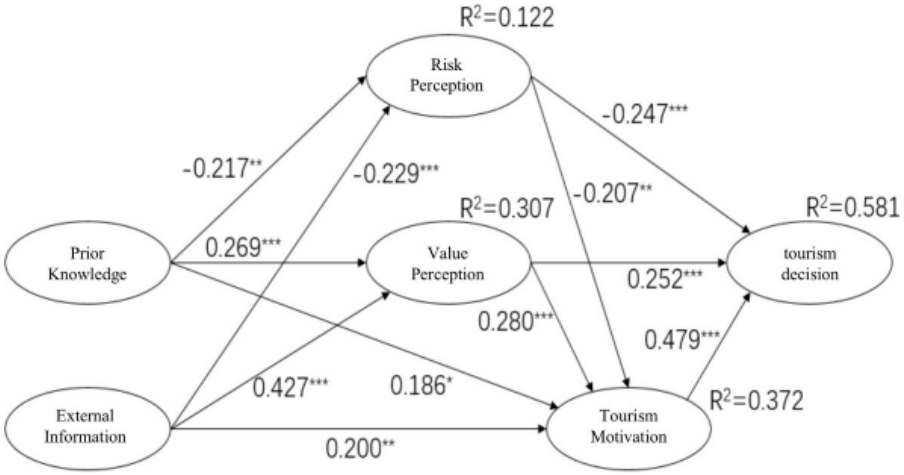

Figure 5. Simplified model diagram path factors and significance (standard)

According to the analysis results, all paths have reached the significance level of p=0.05, indicating that all the hypotheses put forward by the premise have been verified by empirical data. Among the many paths, prior knowledge⟶risk perception (β=-0.217, p=0.003), prior knowledge⟶tourism motivation (β=0.186, p=0.01), external information⟶tourism motivation (β=0.2, p= 0.008) ⟶tourism motivation (β=-0.201, p=0.002),the four paths of risk perception are less significant. R2 of risk perception = 0.122, indicating that prior knowledge and external information explain 12.2% of the reasons for risk perception; R2 of value perception = 0.307, indicating that prior knowledge and external information together explain 30.7% of the reasons for value perception; and tourism motivation R2=0.372, which means that 37.2% of the reasons for tourism motivation are explained by risk perception, value perception and external information; finally, R2=0.581 for tourism decision-making, which means that this model can explain 58.1% of the reasons for tourism decision-making.

The direct effects, indirect effects and total effects of model standardization are shown in Table 8.

Table 8. The direct effect, indirect effect and total effect of the model (standardized)

Dimension	VP			RP			TM			TD		
	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE
EI	0.427	NA	0.427	-0.229	NA	-0.229	0.200	0.167	0.367	NA	0.340	0.340
PK	0.269	NA	0.269	-0.217	NA	-0.217	0.186	0.120	0.306	NA	0.268	0.268
VP							0.280	NA	0.280	0.252	0.134	0.387
RP							-0.207	NA	-0.207	-0.247	-0.099	-0.346
TM										0.479	NA	0.479

Note: DE=Direct Effect, which means direct effect; IE=Indirect Effect, indirect (intermediary effect); TE=Total Effect, which means total effect; NA=None Affect, which means there is no such effect.

According to Table 8, in the model of this study, tourism motivation has the greatest influence on tourism decision-making, and the total effect value is 0.479. Among the remote factors, value percep-tion has the greatest impact on tourism decision-making, with a total effect of 0.387.

FINDINGS

According to the aforementioned theoretical assumptions and structural equation model analysis, prior knowledge and external information have a positive impact on tourism perception and value perception, and a negative impact on risk perception (Table 9). Risk perception value perception has positive and negative effects on tourism decision-making and tourism motivation, respectively; tour-ism motivation has a positive influence on tourism decision-making.

Table 9. Assumption verification result

Path	Hypothesis	Test
P K→R P	H1a: The individual's prior knowledge has a negative impact on their risk perception.	√
P K→V P	H1b: The individual's prior knowledge has a positive impact on their perception of value.	√
P K→T M	H1c: An individual's prior knowledge has a positive impact on his or her travel perception.	√
E I→R P	H2a: The external information received by the individual has a negative impact on the risk perception.	√
E I→V P	H2b: The external information received by an individual has a positive impact on its perception of value.	√
E I→T M	H2c: The external information received by the individual has a positive impact on their perception of travel.	√
R P→T D	H3a: An individual's perception of risk has a negative impact on their travel decisions.	√
V P→T D	H3b: An individual's perception of risk has a negative impact on his or her travel motivation.	√
R P→T M	H4a: The individual's perception of value has a positive impact on their travel decisions.	√
V P→T M	H4b: An individual's perception of value has a positive impact on his or her travel motivation.	√
T M→T D	H5: An individual's travel motivation has a positive influence on his travel decision.	√

The familiarity of tourists with prior knowledge will strongly influence whether tourists participate (Prayag et al., 2020), whether tourists think this tour is worth participating, and whether there will be a sense of entertainment after participating. The degree of understanding of tourist destinations has the greatest impact on risk perception (Sharifpour et al., 2014). Understanding of tourist destinations through different channels can alleviate the tension of risk. The higher the risk perception of the destination, the greater the possibility of consumption avoiding visiting foreign destinations (Reisinger & Mavondo, 2005; Roehl & Fesenmaier, 1992).

DISCUSSION

THEORETICAL CONTRIBUTION

This study combines choice motivation theory, perceived value theory, and tourism decision-making theory to construct a tourist decision-making model for destinations in the United States, aiming to study which factors affect the tourist's decision-making behavior on destinations. It then explores which factors can have an effect, and the influence relationship between these factors.

The decision-making model for traveling to the United States was constructed and verified. This pa-per combines rational behavior theory, customer value theory, tourism decision-making process the-ory, and approach destination chain theory to construct a multidimensional model of the effect mechanism of destination choice intention influencing factors, revealing the relationship between po-tential tourists' destination choice intention and influencing factors relation. Previous studies have mostly selected research variables from a single theory to analyze the relationship between a certain factor and behavioral intentions, and have verified the relationship between perceived value and choice intention. However, this choice of a single theory or variable to analyze behavioral intentions is not well explained.

PRACTICAL SIGNIFICANCE

This article analyzes the current situation of Chinese residents' tourism from the perspective of 'tourism decision-making mechanism'. The index system constructed is a collection of influencing factors in outbound tourism decision-making, and the structural model is a summary of the mecha-nism of tourism decision-making influencing factors, the quality of factors and changes in the mech-anism of action that will affect the exit decision of tourists. According to the research conclusions of this article, the following countermeasures and suggestions are proposed from three aspects: tourism products, enterprises, and governments.

Suggestions for the development of tourism products

On the basis of existing tourism products, relevant operating companies should pay more attention to the upgrading and transformation of tourism, leisure and entertainment prod-ucts in scenic spots to increase the willingness of tourists to travel.

Recommendations for marketing channels

With the rapid development of Internet technology, online marketing will replace the tradi-tional marketing model and become the main form of distribution of tourism products. For Internet and mobile applications, such as Wechat, WeChat Mini Programs, Weibo, Mobile App, and so forth, they have become the main channels for tourists to collect relevant travel information when they learn about and choose to travel to their destinations. Therefore, when considering corporate marketing and promotion plans, tourism companies operating related businesses should increase the weight of their marketing budgets in online marketing, increase investment in online marketing, and develop mobile applications that meet the pref-erences of Chinese residents in the United States.

Suggestions for relevant functional departments of the destination government

It is important to do a good job in the timely publication of safety reminders and local infor-mation. Safety is an important foundation for tourism development and the core concern of many tourists.

This research is mainly an empirical study on the impact of domestic tourists' travel decision-making behaviors. However, due to the many and complex influencing factors, it is difficult to directly ob-serve the psychological process of travel decision-making. There are still some factors that have not been taken into consideration and need to be studied in depth. In addition, tourism decision-making is not only one influencing factor, but the result of the comprehensive effect of multiple variables. In addition to the factors such as gender, age, income level, and tourism experience of the tourist, it is also affected by the social group to which the tourist belongs, residential culture, and other factors, so the research and its results need to be deepened and perfected. In addition, this research only selects the United States as a potential tourist destination for research. In the future, we can select several destinations with large differences in resource characteristics for comparison, increase the personality characteristics of potential tourists, regional social culture and other tourist choices, as well as the re-search dimension of behavior influencing factors, in order to make the research results more univer-sal and practical guiding significance.

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APPENDIX: CONCEPT MEASUREMENT AND SOURCE

Dimension	Item	Question content	Reference source
Prior Knowledge	Q1	I know the United States very well.	Flynn and Goldsmith (1999)
	Q2	In my circle of friends, I am more familiar with the United States.	
	Q3	I know a lot about the United States.	
External Information	Q4	I will inquire about United States related information from others.	Gursoy and McCleary (2004)
	Q5	I have access to news about the United States.	
	Q6	Travel agency or relatives and friends will tell me something about the United States.	
Risk Perception	Q7	I am a little worried about traveling to the United States.	Jin (2007)
	Q8	In general, the situation in the United States is not very optimistic for tourists.	
	Q9	Some unexpected situations may happen when traveling to the United State.	
Value Perception	Q10	Compared with other places, traveling to the United States is more worthwhile.	Chen and Zheng (2016)
	Q11	Traveling to the United States is more valuable to me.	
	Q12	In general, it is worthwhile to travel to the United States.	
Travel Motivation	Q13	I want to travel to the United States.	Tierney et al. (2006)
	Q14	I like the feeling of playing in the United States.	
	Q15	I think it's a good choice to go shopping in the United States.	
Tourism Decision	Q16	I am willing to pay for a trip to the United States.	Kim and Han (2010)
	Q17	I have a plan to travel to the United States.	
	Q18	I'm likely to travel to the United States next	

Note: The measurement of variables in the questionnaire refers to previous studies, using a 7-point Likert scale, ranging from 1-7 to strongly disagree to strongly agree

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