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MONOGRAPH

Utilization of Team Process Framework to Improve Small-Group Learning in Medical Education

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Abstract The setting for medical practitioners typically involves collaborative and interdisciplinary teams. Medical schools have embraced many teaching methods that use a group of learners to facilitate learning. However, the actual learning benefits of these methods require additional inquiry in the areas of team cognition and team processes. There is limited research that evaluates the value of the team process behaviors in medical education to improve collaborative learning outcomes. This conceptual article provides a framework for team learning processes based on the theoretical foundation of social learning and the development of group shared mental models during team interactions that impact a student's performance.

Keywords Team cognition · Group learning · Cooperative learning · Medical education · Shared mental models

Introduction

In today's medical community, delivering the best possible clinical care to patients seldom depends on a clinician practicing in isolation; rather a team of skilled medical professionals working collaboratively provides optimal patient care. Working in teams has become an essential component in contemporary healthcare organizations, representing a useful strategy for providing successful medical practice [1]. Teams are expected to enable greater productivity, adaptability, and creativity compared to what an individual physician can offer [2]. Empirical research has provided ample evidence of the positive link between team behavior and group performance [3–5]. Well-functioning teams exhibit good communication and teamwork skills, which produce better clinical judgments, practices, and decision-making [6].

The accreditation standards by both the Liaison Committee on Medical Education (LCME) and the Commission on Osteopathic College Accreditation (COCA) require emphasis on communication skills and interprofessional collaborative team skills as part of the medical education curricula [7, 8]. Those standards recognize the need for interdisciplinary healthcare teams including physicians, nurses, and allied health professionals who work collaboratively to improve patient safety and to provide better patient care outcomes. Interprofessional education (IPE) was viewed to positively affect patient satisfaction, collaborative team behavior, and reduction of clinical errors rates for emergency department teams [9]. Recently, the American Association of Medical Colleges (AAMC) published new guidelines, The Core Entrustable Professional Activities (EPAs) for Entering Residency to provide expectations for medical students entering residency [10]. The Core EPAs require all medical graduates, regardless of their future career specialty, to be able to collaborate as a member of interprofessional team. As a result, medical school faculty is finding the need for innovative small-group collaborative learning activities, which will develop high-performance learning teams to increase understanding and application of medical knowledge, enhance critical thinking skills, and improve interpersonal skills. However, collaborative learning is not something that comes naturally to most medical students, since previous

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undergraduate learning experiences included a reward system that acknowledges individual accomplishments in a competitive environment [11]. That is, the interaction between students is characterized by negative goal interdependence, which reflects one person winning and the other losing. A shift is needed to create an environment that promotes positive goal interdependence for better development of team skills to enhance learning as well as foster the development of interpersonal communication skills.

Since the setting for medical practitioners typically involves collaborative and interdisciplinary teams, there has been a growing movement in medical education to improve small-group pedagogy and learning outcomes. As a consequence, teaching strategies such as problem-based learning [12, 13], team-based learning [14–16], and peer-teaching [17–20] have been introduced into medical school curricula to promote student-centered, active learning in a real world setting. These learning methods create circumstances in which students must work together cooperatively to solve clinical problems while applying their learning to real world practice situations. Medical schools have made major efforts over the past decade to reform their curricula with the focus of learning redirected towards the learners themselves working together in collaboration. Sultan and Hussain [21] affirmed effective learning to be an interactive process involving learners in different activities to achieve the learning outcomes. This innovative educational strategy relies on structured, student-centered activities that facilitate learning in an active, engaged manner versus passive learning [22]. Small-group learning has been adopted widely in medical education and research shows its benefits to include increased academic achievement, efficient use of instructional time, increased peer interaction, improved interpersonal relationships, transfer of skills, development of professional skills such as communication, teamwork, decision making, leadership, valuing other team members, student engagement, and satisfaction (e.g., positive feeling about the learning experience) [11, 16, 23–28].

In the context of medical education, there is little empirical data with regard to the cognitive, affective, and social mechanisms underlying effective team performance. However, research on teams in the work setting has resulted in a number of constructs used to explain team cognitions, such as shared understanding, distributed cognition, shared knowledge, shared cognition, and team schema [29, 30]. Studies on effective team performance resulted in improved understanding about the teams' behaviors and have linked team cognition to many indicators and predictors of effective team performance [25, 31–34]. The overall goal of this conceptual article is to expand on previous work [35] that analyzes empirical research on team cognition while developing a conceptual framework, which can be used to improve the process of team learning in medical education.

Theoretical Foundations of Social Learning

In this section, we provide the theoretical foundation of learning teams. Social constructivist theory, situated learning theory, and the social interdependence theory are the primary theories to explain team cognition. All of these theories address the importance of the social aspect of learning and the importance of communication skills during group interactions or social activities.

The instructional strategies of cooperative learning, collaborative learning, and team-based learning have their roots well-grounded in learning theory; primarily, they emerged from the social and cognitive constructivist theories of social learning theory. In the constructivist theory [36], students take an active role in their own learning by constructing new ideas when utilizing previous and current knowledge. Bruner [36, 37] and Vygotsky [38, 39] included social aspects of learning as a primary source of cognitive development. Piaget [40] explored cognitive structures as they related to cognitive development and argued that cognitive structures were seen as patterns of physical or mental action that exist at a given stage of development. These cognitive structures changed through the processes of interpreting events in terms of existing cognitive structure. As students actively collaborate with one another and have productive communication, they develop social skills and two-way communication skills that help them learn to interact with each other [41]. Through active engagement socially with others, students embrace the responsibility for learning [42, 43]. As this social interaction takes place in groups and as programs adopt small-group learning, they have reported a marked increase in student attendance, student engagement, and staff satisfaction [24, 44, 45]. Active collaborative learning methods which help problem-solving and critical thinking skills provide a higher level of cognitive functioning, lead to a greater degree of understanding and retention [46].

The situated learning theory is another theory that provides explanation and insight into social learning and team cognition. The theory emphasizes that much of what is learned is specific to the situation or particular setting in which it is learned [47]. In situated learning, knowledge is presented in an authentic context, and for learning to occur, it requires social interactions. Situated learning involves people being full participants in groups and generating meaning from those interactions, and learning is in the relationships between people as well as in the conditions that bring people together and organize a point of contact that allows particular pieces of information to take on relevance [48, 49]. The social engagement represents the interaction between individuals in an effort to develop shared meaning and to form new knowledge. As this engagement of learning and conversations occur within situational contexts, there is the opportunity to create communities of practice. Wenger [50] defined a community of

practice as a group formed by people who engage in a process of collective learning in a shared domain of human engagement. Lave and Wenger [47] explain the community of practice as a place that learning occurs when learning outcomes are defined and engaged in together. The three basic dimensions that define a community of practice are (1) the domain of shared interest, (2) the community of members who interact and learn together, and (3) the shared practice (shared repertoire of resources).

Learning in small groups is a social activity in which social interaction is believed to be the driving force of developing team cognition. The social interdependence theory [51] explains the importance of all team members working toward a common goal and how that is affected by individual and group actions. Social interdependence occurs when the goal of individual is affected by the actions of others [52–54]. There are two types of social interdependence: (1) positive interdependence (cooperation) leading to positive correlation among individuals' goal achievement and (2) negative interdependence (competition) leading to negative correlation among individuals' goal achievement. During the group process, when the action of individual team members promotes the achievement of the group goals, it leads to positive interdependence, which results in positive group interactions [55].

The abovementioned theories are centered on the importance of social interactions in learning teams. In all teaching methods that involve small-group interactions, more efforts are needed to develop team-related skills [56] such as communication, professional behavior, appropriate peer evaluation, and emotional, social, and interpersonal skills. These skills are studied and better explained by the utilization of a team process framework leading to the development of shared mental models (SMMs) and the identification of the major factors that affect the performance of the team.

Team Process Framework and the Development of SMMS

From a cognitive standpoint, a mental model is an explanation of how people organize material in structured, meaningful patterns that are stored in memory [57]. Team mental models are organized mental representations of knowledge about team's environment that are shared by team members [58]. The terms team mental model, shared mental model, teamwork schema, shared understanding, and shared cognition have been used interchangeably to explain team functioning [58]. As team members work with each other, they start to develop shared mental models about the team and the task. Understanding the shared mental model advances our understanding of teamwork and team decision-making that correlates with the achievement of the learning outcomes.

The term shared mental model (SMM) includes sharing of team knowledge (teamwork, how to accomplish the task), as well as task knowledge (taskwork, what needs to be accomplished). Cannon-Bowers et al. [57] defined team knowledge as the knowledge associated with the team members' preferences, attitudes, strengths, and tendencies, beside knowledge about team interactions, which describes teammates' roles and responsibilities, interaction patterns, communications channels, role interdependencies, and information resources. The task knowledge is a very specific knowledge that is needed to successfully perform the task in terms of understanding the technology/equipment functioning and procedure and share knowledge about task strategies, procedures, and environmental conditions [57]. A team mental model includes the knowledge, skills, behaviors, and attitudes needed for effective team performance [59]. Team knowledge significantly improves team performance and provides framework for the explanations of the quality of team interactions. Thereby, it provides guidance for the selection of effective strategies that promote SMMs developments.

The development of the SMM and how it relates to team performance is diagramed in Fig. 1. The initial team cognition represents teammates' SMMs about the team and tasks before joining the team. During the process of team interactions, through the process of communication and coordination, the team members continue to develop updated SMMs. Changes in SMMs during these interactions lead to the development of new knowledge about the team and the tasks that would positively influence team performance. An understanding of team process behaviors is an important step in evaluating learning outcomes. It is essential to evaluate team process behaviors during learning activities of different tasks as we assess learning outcomes. For example, more efficient and effective group learning is achieved with more complex learning tasks; otherwise, the communication and coordination process will impose an unnecessary cognitive load for a single individual who could easily process the less complex tasks [60, 61].

Many studies suggest a causal relationship between SMMs and team performance [31, 57, 62] outline the value of SMMs in explaining team processes and predicting team performance. Figure 2 summarizes the relationship between the factors contributing to the development of SMMs and team performance and outcomes. Five major factors that affect the development of SMMs have been identified including (1) team knowledge, (2) team skills, (3) team attitudes, (4) team dynamics, and (5) team environments [63]. These factors are important components of the interactions that occur among team members leading to the development of SMMs.

Team Knowledge

Team knowledge consists of knowledge related to the teammate and knowledge related to the task [57]. Task-related

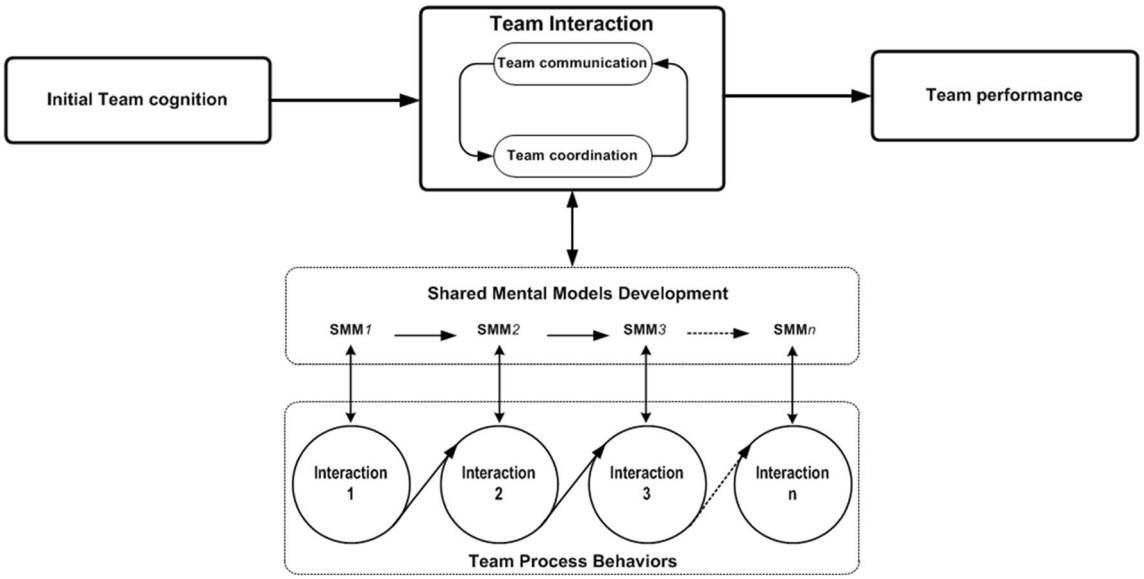

Fig. 1 Elaborated view of team cognition including team interactions and shared mental model (SMM) development

knowledge includes knowledge of task procedures, contingencies, environment, and equipment. Team-related knowledge includes team interactivity as well as the knowledge, skills, attitudes, preferences, and tendencies of the team members [57]. Team interactivity includes roles/responsibilities, information sources, interaction patterns, communication channels, role interdependencies, and information flow. Teams with developed SMMs better communicate and adapt to changes in task demands [57, 64]. High degrees of SMMs (e.g., degree of similarity) lead to greater team expectations which influence effective team behaviors [64]. A meta-analysis by DeChurch and Mesmer-Magnus [65] examined different measurements of SMMs in relation to team process and performance. All measurement methods: elicitation methods (e.g., similarity rating, concept maps), structure representation (e.g., pathfinder, multidimensional scaling), and representation of emergence (e.g., agreement, consistency) have indicated that SMMs were positively related to team performance. Teammates who have similar beliefs and knowledge structures are better able to anticipate their teammates' actions and information needs and respond effectively [57, 66–68]. However, team knowledge impacts team performance more than task knowledge [69]. This leads to more emphasis on teamwork rather than taskwork during team training [70].

Team Skills

Team skills refer to the ability needed to interact with other team members to perform a task. Team skills can be learned through participation in complex and challenging team assessment tasks. This means the instructor must design meaningful, complex activities that cannot be completed by an individual alone [71]. The major components of team skills refer to communications, team orientation, team leadership, monitoring skills, feedback, backup behavior, and coordination [72]. Communication skills, interpersonal skills, and leadership

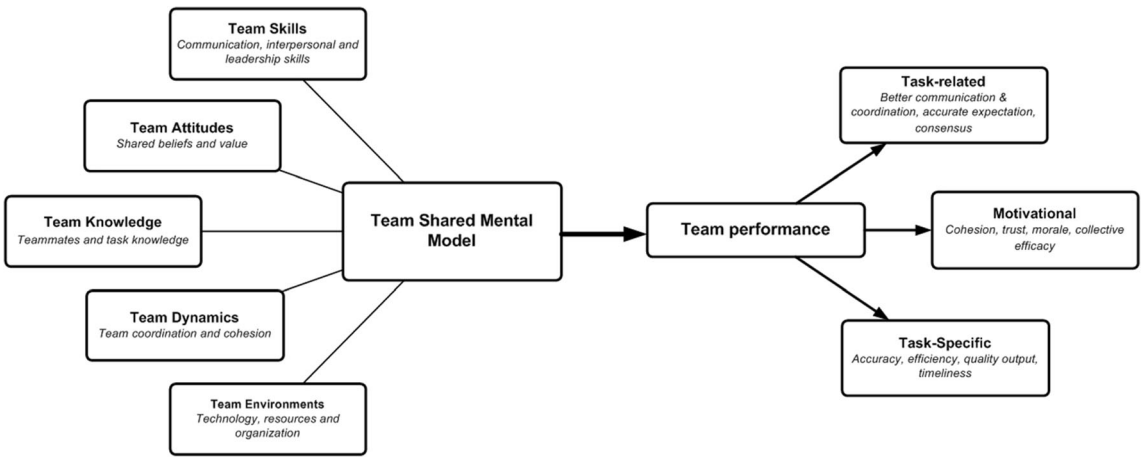

Fig. 2 Factors affecting the development of shared mental model (SMM) that impact team performance

skills are considered generic skills that are transferable to other teams [59]. Specific team interactions such as communication and coordination mediate the development of SMMs and influence team performance [69, 73, 74].

Team Attitude

Team attitude is a state that effects an individual's decision and choices to act in a certain way under certain situations [59]. Teams with shared values and beliefs have compatible perceptions for effective decision-making [75]. That is, team members do not share identical mental models, but hold compatible mental models in terms of team expectations. For positive interdependence, which is considered essential to successful cooperative learning, the task of the group goal must be established so that completion of the activity can only be accomplished through the participation of all individuals within the group [13, 76]. The assumption is that if students value the success of the group, they will encourage and help one another achieve the intended goal. Other examples for developing positive interdependence besides establishing group goals are assigning individual roles, giving joint rewards, and using shared resources.

Team Dynamics

Team dynamics are teamwork processes that consist of information exchange, dynamic interaction, supporting behavior, and guidance [77]. Mark et al. [78] defined team process as "members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals, p. 357." The management of group dynamics is increasingly being recognized as crucial for the success of the small-group learning setting. Nonose et al. [79] examined the congruency between self and others' perceptions of the dynamics of team cooperation through a team situation awareness instrument. Their results highlighted an individual's need to know the team not just as personalities, but to know what all members are doing during the events of completing a task and blending one's own perceptions of one's own work with the perceptions of others. The development of group dynamics has been investigated in problem-based learning [56, 80], and studies found a low awareness of effective group dynamics among students and tutors as well as a discrepancy between self-reported behavior and observed behavior. Successful learning in a team setting requires team members to be aware of effective group processes that would be reflected in a better match of a member's self-perceptions and the actual observed behavior.

Specific types of student behavior in small-group learning settings have an impact on group dynamics. A study by De Grave et al. [81] highlighted the issue of dysfunctional groups that hinder the achievement of the objectives of small-group learning and the need for more and different research on all the underlying processes, including cognitive, motivational, and group processes that explain why tutorial groups are or become unproductive. Elgort et al. [82] also found that students appreciated group activities; however, significant numbers of students believed that they could complete assignments better on their own. Therefore, there is a need to train both instructors and students on how to guide the group behavior dynamics towards success [83].

Team Environment

Team environment factor includes knowledge about the resources used by the team to complete a task such as technology, as well as the knowledge about the environment in which the task is being completed. Team environment can include organizational factors such as organizational structure and culture. Cannon-Bowers et al. [57] included the team environment when describing task-related knowledge where team members shared understanding of team procedures, strategies, task contingencies, and environmental conditions.

Practical Implications of Using the Team Process Framework

The team process framework provides a structure that highlights several key factors involved in team performance and also provides insights into several applied issues related to group learning. By understanding this framework, medical educators who use any version of small-group collaborative learning will be able to better facilitate group interaction and provide effective feedback to students. That is, for better learning outcomes, educators should not only focus on content learning, but also consider a team process framework to facilitate group interaction strategies. The practical implication of using the team process framework is explained in improving the development of the SMM, team interaction strategies, and assessment of team processes.

Improvement in the Development of the Shared Mental Model

Learning in teams has been viewed as an effective learning strategy; however, issues related to team processes were also identified [16, 24, 25]. These issues are related to the fact that newly formed teams do not appreciate the importance of interactions that lead to the development of the SMM. Team members must be willing to engage in interactions conducive to the development of shared understanding about the team and the task. Therefore, early awareness of the benefits of working in teams and understanding team processes leading

to the development of efficient interaction strategies result in better team learning and performance [6]. Furthermore, collaborative decision-making was equated with SMM and was seen as a source of impairment to productivity, which results in social loafing, cognitive overload, or pressure to conform [84]. Additionally, understanding the framework of the SMM development helps in identifying team process factors to remedy non-functional teams.

Developing SMMs in teams is important in supporting team performance. Intervention has been developed and validated that specifically improves SMMs [63, 85]. The degree of knowledge shardness agreement among team memebers is measured by simple instrument and used as an indicator of potential team success [85]. The instrument measures similarity of team members' SMMs of the following factors: task and team knowledge, general communication skills, attitude toward team and task, team dynamic and interactions, and team resources and working environment. Johnson et al. [86] discussed interventions used to improve SMMs through consensus building and improving planning interventions. Three key activities to build a SMM have been found to have an impact on team performance. The mechanism for building a SMM involves the following: (1) assessing the individual mental model, (2) sharing individual mental models and reaching agreement on sharedness through consensus building, and (3) providing individual justification and then identifying areas of weak sharedness and proposing ways to build sharedness. The following describes each step:

Step 1: Each individual team member completes an assessment instrument that measures how much they believe their team has knowledge and skills relate to the team task at hand. This individual assessment must be done prior to moving on to the second task. The assessment covers the following eight items rating each item from Strongly Agree to Strongly Disagree.

- Team understanding of tasks
- Team process for working on tasks
- Team member communication of information
- Team member attitude toward each other
- Team attitude toward tasks
- Team member interaction in general
- Team use of resources (e.g., notebooks, computers, etc.)
- Team realization of working environment constraints (e.g., time, resources, etc.)

Step 2: Once step 1 is completed by each team member individually, the team reviews together each of the individual team member responses and determines the best response for the team as a whole. Where there are disagreements, the team is expected to reach consensus. In the process, the team members explain and provide a rationale for their perspectives on each item.

Step 3: The team reviews their collective responses and identifies the weakest areas and then proposes ideas to improve these areas. Again the team works to reach consensus by discussing each team member's individual opinion and rationale.

Development of Effective Team Interaction Strategies

Educators using small-group learning strategies must learn how to facilitate and improve team interaction. This is not a short, quick process as it can take weeks for a group to develop into a mature, functioning team [87]. As a team develops, if it struggles with communication, the SMM development is hindered. The educator must then provide extra instruction to improve the interaction between team members. Some of the tools educators may use include feedback on setting up roles and responsibilities, communicating individual and team expectations, discussing the amount and type of individual and team communication, overcoming personality differences, and dealing with difficult problems. Improving these interaction processes will allow teams to develop effectively through the team development phases of forming, storming, norming, and finally performing [88]. As the team passes through each one of these phases, the instructor is providing feedback to the team on its performance. A study by Johnson et al. [89] demonstrates the importance of instructor feedback on how well the group used cooperative skills. The effective evaluation of the group process is required for successful cooperative learning [90]. As instructors learn to give this feedback constructively, the team learns to engage in interaction strategies that result in a SMM that improves team cognition [91].

There is evidence that communication and coordination of team interactions mediate team SMM development that then affects team performance [92]. As part of this research [92], an interaction strategy was developed that focused on team communication and coordination. The interaction strategy is comprised of the three following steps:

Step 1: Teams are provided with information and a rationale for developing an interaction strategy. It is important that the team members understand why having a team interaction strategy is key to team performance. An interaction strategy encompasses objectives, goals, and tools for all communications that include written, spoken, and electronic interactions with the team members. The following points are the main purpose of the strategy:

- Helps the team to more effectively interact and communicate with each other
- Reminds and encourages all of the team members to stay on schedule
- Provides a means for feedback and input about the product from the team members, thereby enhancing the quality of the product

Step 2: Teams are provided with guidelines (tasks) for creating an interaction plan. Instructions are provided to the team on what tasks are involved in the creation of an interaction plan (Table 1).

Step 3: In this step, the teams practice creating a communication strategy/plan. As a team, they discuss and write down their interaction plan. They are also instructed to reach consensus on all aspects of a communication plan.

Development of Assessment Strategies of Team Process

Biggs and Tang [93] emphasize the focus on outcome-based learning by systematically aligning the teaching and learning activities as well as the assessment tasks with the intended learning outcomes. It is important to assess team behaviors in order to learn how to best facilitate team interaction. Due to the complexity of team interactions, different instruments have been developed to measure team behaviors [29, 72, 77, 86, 94–103]. The types of assessments, instruments used, and a brief description of each are provided in Table 2. These measures include observation, interview, questionnaire, concept mapping with secondary analysis, and the use of a team knowledge survey with follow-up analysis. These assessment instruments can be used to elicit individual knowledge and perceptions about task and team processes. The collected data can be used to provide medical educators with information related to team process as well as data needed to perform a provisional diagnosis of team behaviors. These activities allow educators to provide both corrective and reinforcing feedback to the learning teams. However, simpler measures can be developed and used as indicators of SMM development [63]. While it is time consuming for medical educators to collect and process data, Johnson et al. [86] developed a Team Assessment and Diagnostic Instrument (TADI) that can be used to easily capture, at specific points in time, the mental models of teammates. Using a simple calculation, they can determine the level of shared understanding for a particular group. While this is an indirect measure, there are two recent studies on SMMs that provide evidence for the reliability of this assessment measure. The first study [104] investigates how SMMs change over time in teams of students in a manufacturing engineering course. In this study, a complex, ill-structured project was given to each team. SMMs were measured and then analyzed to see if the SMM changed over time. The results indicated that SMMs do change over time and that similar SMMs are related to higher levels of team performance. In a second similar study, Johnson and Lee [105] examined the effects of SMMs on team and individual performance. The results indicated that each team's SMM changed significantly over time when subjects participated in team-based learning activities. The results also showed that

Table 1 Lists of tasks needed for teams to create an interaction plan

Tasks to create interaction plan	Detailed descriptions
Task 1: identify key roles and communication needs	- Identify the key roles for the team to be successful - Identify the communication needs between the key roles
Task 2: identify team goal	- Identify team goal and list key objectives related to that goal
Task 3: identify anticipated team challenges	- List potential challenges that might be problematic in reaching the team goal
Task 4: assign team roles and responsibilities	- Assign team roles with associated reponsibilities for each team member
Task 5: identify potential problems	- List key potential problems that might arise as the team performs their tasks
Task 6: determine solutions to potential problems	- Determine the causes/symptoms of the potential problems - Determine solutions to the potential problems with appropriate corrective measures
Task 7: identify and select communication channels	- Based on team needs and challenges, identify and select the most appropriate communication channels
Task 8: schedule communication frequencies	- To support team efficiencies, schedule communication frequency to be used by the team
Task 9: verify interaction tools	- Verify that the team has the tools to implement the interaction plan

Table 2 Types of assessment used to evaluate working in teams

Reference	Type of assessment	Instrument	Description
[72]	Teamwork and team performance	- Behavioral observation scale - Behavioral summary scale - Behavioral event scale	- Used to rate the occurrence of teamwork by a team and its members. - Used to rate the degree of teamwork displayed by a team and its member. - Designed according to the occurrence of critical events that are opportunities for teamwork (identified by experts).
[99]	Teamwork competencies	Teamwork KSA test (TWKSAT)	Teamwork knowledge, skills, attitudes test is a self-scoring inventory consists of 35 item based on the following competencies: (1) conflict resolution, (2) collaborative problem solving, (3) communication, (4) goal setting and performance management, and (5) planning and task coordination
[97]	Teamwork competencies	Teamwork competency test (TWCT)	TWCT is a four-point frequency scale consists of 36 item based on Stevens & Campion's model (TWKSAT). TWCT also includes the 14 sub-competencies by Stevens & Campion and uses observable behaviors statements
[98]	- Attitudes towards team communication - Attitudes, motivation, utility, and self-efficacy toward interprofessional team skills	- Teamwork attitudes questionnaire (TAQ) - Attitudes, motivation, utility, and self-efficacy (AMUSE)	- TAQ consists of 30 Likert-type items assessing attitudes towards team communication based on the five dimensions of Team STEPPS communications model (team structure, leadership, situational awareness, mutual support and communication) - AMUSE is 21 Likert-type items assessing attitudes, motivation, utility and self-efficacy toward interprofessional team skills
[103]	Students engagement	STROBE (5-min observation cycle)	It consists of 5-min observational cycles repeated continuously throughout the learning session. Observers record two types of micro-level observations, including the instructor's behavior and the behaviors of four randomly selected students.
[95]	Team performance	Team performance scale (TPS)	Use by students to evaluate team member based on their overall experience with their team during the course. The instrument is 18 items each item has 7-point scale
[29]	Team cognition and team coordination	Knowledge elicitation method, team metric and aggregation method	- Mapping of specific methods onto features of targeted team knowledge. - Measure of team knowledge including type, homogeneity vs. heterogeneity, and rate of knowledge change. - Analytical conclusions and empirical data support a connection between team knowledge and the measurement method.
[94]	Team learning	Six goal-criterion sets	- Developed and evaluated a model to assess team learning which required balanced representation amount multiple learning criteria arranged in six sets drawn from the literature on team learning. - Used to determine weaknesses in course design and methods of instruction in order to correct the deficiencies.
[77]	Team behaviors, mental model of teamwork	11 component team behavior assessment	- Analysis of performance ratings utilizing 11 behavioral components - Accuracy of an individual's mental model relative to effective teamwork.
[96]	Problem-based learning groups' function	- Qualitative approach based on a modified grounded theory technique using focus groups - Group interaction and activity - Questionnaire	- Series of statements to guide the students in determining the quantitative mark for each of the four domains presented in the guide (commitment, interpersonal relationships, problem-solving abilities, group interactions and activity) - Focus groups of nine students who just completed year 2, evening session to discuss experiences of PBL group work and assessment. A second focus group was conducted of 7 students regarding the dominant themes of the first group. - Qualitative themes were established and questions were designed.

Table 2 (continued)

Reference	Type of assessment	Instrument	Description
[100]	Teamwork	Kilpatrick's framework of training evaluation	- Surveys, situational judgment tests (SJT's), observations and patient chart reviews - The above assessments were used to determine the effectiveness of team training intervention.
[101]	Team workload, individual and team analysis	Empirical studies comparison	- Subjective measures, performance measures, and physiological measures, behavioral measures - Measure of task as individual workload measure, team workload measure and sensitivity to task difficulty
[26]	Team performance, team's shared cognition	Team assessment and diagnostic instrument (TADI)	- Assess the team process in order to give feedback on observed behaviors. - Peer assessment, feedback, quality of communication, latency of response, accuracy of information exchange, and accuracy of interim decisions can be developed and used as indicators or diagnostic tools. Guidelines to make sense of the assessment measures to diagnose strengths and weaknesses. - Degree of team-related knowledge in order to determine team-related knowledge sharedness.

the SMMs' sub-categories (team-related knowledge, skill, attitude, dynamicity, and environment) are strongly correlated on the team and individual performance.

Since team processes are closely linked to team performance and SMM measures are an indication of team performance, the use of a SMM assessment can provide an indirect measure for the quality of team process interactions. To assess the useful effects of team processes, medical educators can use a SMM measure to determine generally if the team interaction is productive in facilitating team processes to reach the targeted team learning outcomes.

Conclusion

To enhance the overall student's performance in a collaborative learning environment, it is necessary to promote team cognition during the learning process. The true test of team cognition is reflected when the team acquires and internalizes the knowledge and skills stated in the learning outcomes. Based on the available body of literature, SMMs are relevant to improving team performance. A better understanding of the group processes framework underlying the acquisition of team-related and task-related skills leads to the selection of effective strategies for the development of SMMs. Simple assessment instruments can be validated to measure the optimal time for a group to stay together based on monitoring the development of SMMs. In many cases, a student's performance could be improved by correcting group process deficiencies.

The SMM development is typically made known through examining external knowledge [106]; however, more research is needed to examine how group interaction impact individual cognitive processes which activate and develop the shared mental model. There is a strong need to expand on research protocols that measure team processes to understand the underlying mechanism of interactions in learning teams and to select appropriate team interventions for effective and efficient mechanisms to assess and diagnose team interactions. As medical students learn and embrace group strategies that produce effective teams and higher cognition, they benefit not only during their academic career but also in their interdisciplinary teamwork as a physician working with nurses and different allied health professionals.

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