Learner-Centered Teaching with Gamification in Practical Training of Optical Fiber Fusion Splicing for New Employees of State Grid

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Abstract. Optical fiber fusion splicing, a vital component in optical communication network construction and maintenance, significantly impacts communication quality and performance of power grid. The optical fiber fusion splicing practical training has been reformed for fresh personnel in communications-associated departments in State Grid of China Technology College in response to requirements for career training of State Grid Corporation of China. Nevertheless, traditional teaching strategies struggle to foster enthusiasm among learners, yielding unsatisfactory results. Thus, a learner-centered idea has been implemented, incorporating gamified teaching design into the Optical fiber fusion splicing training program. Elements like spinning wheels, points, rankings, rewards, competition, cooperation, and challenges facilitate active learning in areas covering optical fiber structures, transmission fundamentals, and splicing processes. Utilizing a task-oriented approach, learners can thoroughly grasp the importance of optical fiber splicing, its role in communication operations, network security, and even national defense. Learners can perfect their splicing techniques, share knowledge, and improved their skills through group work and contests. This gamified teaching design is to elevate the practical training quality through a more immersive and interactive learning environment by stimulating learners' interest, initiative, concentration, and overall engagement. It signifies a fresh development in innovative and efficient training methods for the power grid communication industry.

Keywords: Learner-Centered, Practical Training, Teaching Design, Gamified Teaching, Gamification.

1 Introduction

Electric power communication technology supports intelligence and automation of power grids, performing tasks including control, dispatch management, fault handling, and real-time monitoring [1]. The electric power communication network, critical for

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efficient information transmission, incorporates optical fiber fusion splicing. Thus, mastering this skill and cultivating competent teams are vital for the stability of communication systems. State Grid Corporation of China (SGCC) prioritizes technical and skilled talent development with an annual training program at State Grid of China Technology College (SGTC) for communication operation and maintenance personnel. The program includes optical cable splicing and testing to empower new staffs with these skills through practice, thereby bolstering their network management capabilities. However, traditional teaching methods often involve demonstration and imitation, which can provide basic knowledge but lack interest or initiative, resulting in low participation and limited skill enhancement.

In our technologically advanced era of developing educational philosophies, learner-centered teaching and gamification have emerged as crucial trends. It emphasizes adapting teaching plans to learners' traits and centralizing their learning through teaching activities [2]. Learner-centered teaching, compared to traditional teacher-centered methods, accentuated learners' initiative and creativity, thereby enhancing teaching efficacy. Gamification focuses on learners' involvement, integrating game design principles with education. By incorporating elements like rules, tasks, competition, and rewards, it created an engaging and challenging learning environment to keep learners' motivation level high, promoting knowledge acquisition, comprehension, and application [3]. Meta-analyses showed significant improvements in academic achievement, problem-solving abilities, and learning attitudes through learner-centered teaching [4]. Empirical studies found that it stimulated higher-order thinking, critical thinking, and problem-solving abilities, developing deep learning capabilities and lifelong learning habits [5]. Research on the effectiveness of learner-centered teaching indicated that it enhanced learners' collaborative learning awareness, fostering cooperation and communication, thereby improving overall learning outcomes [6]. As for gamification, comparative experiments and questionnaire surveys showed that it improved learners' participation and learning outcomes, thereby enhancing vocational training quality [7]. Qualitative research on information technology vocational training showed that gamification can stimulate learners' interest and enthusiasm, enhancing training effectiveness and satisfaction [8]. Questionnaire surveys indicated that gamified teaching improved learners' career readiness and employment abilities, laying a solid foundation for their future career development [9]. Evaluations of the effectiveness of teaching with gamification among retail industry employees showed that it enhanced their work performance and satisfaction, while reducing turnover rates [10].

However, gamified teaching in vocational training faces certain challenges, including designing game content aligned with vocational training objectives, striking a balance between entertainment and education, and assessing its effectiveness. Further exploration and research are needed to optimize gamification in vocational training outcomes. To rectify the discrepancies of traditional apprentice training in electric power communication operations and maintenance, the learner-centered teaching design with gamification was proposed in this work for optical fiber fusion splicing in the new employee training program of State Grid, in order to augment learners' participation fervor, learning drive, and training efficacy.

2 Related Theories of Education

2.1 Learner-Centered Teaching

The learner-centered pedagogy stems from humanistic psychology and education ideologies. Carl Rogers, an eminent American humanistic psychologist and educator, views learner-centered learning as experiential learning for learners, accentuating the evolution of learners' personal experience as the focal point and utilizing learners' spontaneity and initiative as inspiration for learning. This ideology postulates that the aim of education is to nurture learners to learn, swiftly adapt to external fluctuations, and mold autonomous individuals who can fully exhibit their characteristics. Each learner is a distinct individual with diverse learning styles, interests, and needs. Hence, teaching should be learner-centered, concentrating on their learning journey and experience.

McCombs formulated a learner-centered model [11] (see Fig. 1.). This model positions the learner at the heart of the learning process, as effective learning and ultimate knowledge acquisition can only be realized by fulfilling the learner's inherent needs. Learners and learning, as key elements in knowledge acquisition, are shaped by cognition and metacognition, motivation and emotion, development and society, and individual differences [12]. Hence, comprehending the components of learning and supporting learners optimally can enable superior teaching decisions, foster positive teacher-student relationships, and enhance learner motivation and academic performance.

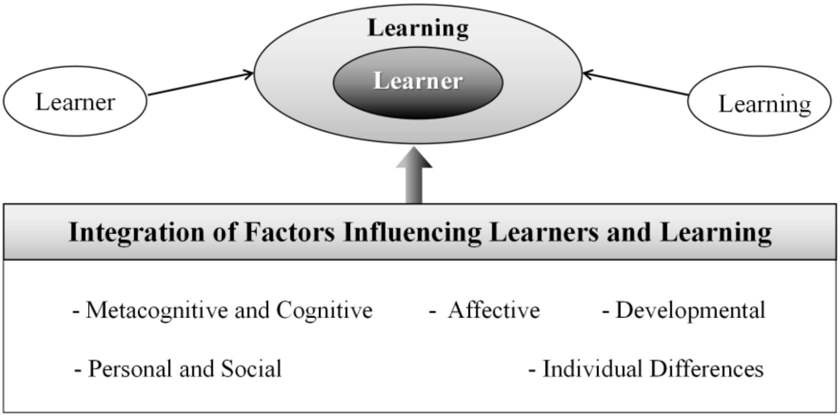

Fig. 1. Learner-centered model: a holistic perspective.

2.2 Game-Based Teaching

Game-based learning utilizes game components in non-gaming environments to captivate users and foster education and training [13]. This method transfigures a teacher-centered environment into a learner-focused one, promoting sophisticated cognition, with the instructor acting as a mentor and facilitator. The integration of these elements into the curriculum cultivates a dynamic and engaging educational setting, augmenting learner involvement and autonomy [14]. Game-based learning employs potent game elements such as challenges, badges, leaderboards, points, and levels to boost academic performance [15]. These mechanisms assist learners in recognizing strengths and weaknesses, stimulating enthusiasm and motivation, providing self-awareness feedback, and offering an immersive learning experience. Interactive and stimulating information delivery can mitigate monotony, and decision-making and challenge-resolution in games stimulate critical thinking. Moreover, collaborative problem-solving during game play nurtures teamwork spirit. A two-dimensional model matrix was developed with amalgamating teaching and game elements [16] (see Fig. 2.). The teaching elements encompass learning difficulties, psychological needs, critical thinking, exploration, challenge, participation, competition, practice, goal-setting, and motivation. The game elements encompass interaction, storytelling, interface, simulation, construction, feedback, literacy, communication, motor skills, memory, and outcome evaluation. Interactive and stimulating information delivery can mitigate monotony, and decision-making and challenge-resolution in games stimulate critical thinking. Moreover, collaborative problem-solving during game play nurtures teamwork and collaboration among learners. Rosemary Garris devised the Input-Process-Output model for educational gaming and learning [17] (see Fig. 3.). This model evaluates the educational relevance of games through the game cycle of learner judgment, behavior, and feedback, along with potential learning outcomes. By integrating educational content with specific game elements, the power of games can be harnessed to engage learners and achieve optimal teaching objectives.

Components	**Pedagogical**										**Game Design**											
Elements / **Models/ Frameworks**	Difficulty to learn	Psychological needs	Critical thinking	Exploration	Challenge	Engagement	Competition	Practice	Goal setting	Motivation	Interaction	Storytelling	Interface	Simulation	Construction	Feedback	Literacy	Communication	Motor skill	Memory	Outcome evaluation	**Total**
The Design Framework for Edutainment Environment	√	√			√					√	√	√	√								√	8
Adopted Interaction Cycle for Games									√	√	√					√			√		√	6
The Engaging Multimedia Design Model for Children						√			√		√			√	√	√					√	7
Game Object Model			√	√	√	√	√	√	√	√	√	√	√				√	√	√	√		15

Fig. 2. Summary matrix of game-based learning frameworks and models.

The objective of vocational training is to furnish trainees with industry-specific skills and knowledge. Game-based learning simulates authentic work scenarios, enabling trainees to comprehend work processes through simulated operations in a digital environment. Complex concepts are often involved in vocational training. The incorporation of game elements such as competition, challenges, and rewards invigorates trainees' interest and drive. Concrete learning objectives and rewards inspire trainees to complete tasks, augmenting their enthusiasm and sense of accomplishment. Multiplayer collaborative tasks cultivate teamwork ethos and communication competencies, which assists trainees in adapting to potential team collaboration scenarios in their professional careers. Moreover, game-based learning provides timely assessments, enabling trainees to evaluate their learning progression and effectiveness. Instant feedback from the game empowers trainees to analyze their performance, mistakes, and shortcomings, enabling them to recalibrate their learning methods and strategies, amplify their comprehension and memory, and enhance training efficacy.

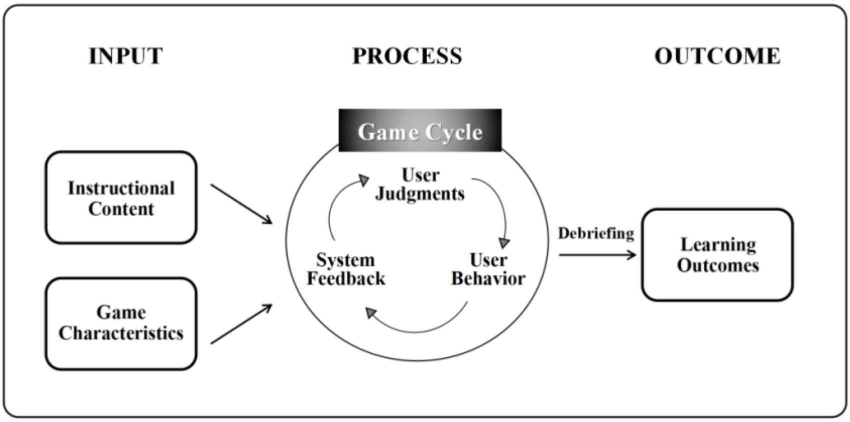

Fig. 3. Input-process-output game model.

3 Improved Teaching Design and Implementation of Optical Fiber Fusion Splicing

Learner-centered instruction prioritizes learners, cultivating autonomous learning, fostering inquiry skills, critical thinking, and problem-solving capabilities. Gamification employs its inherent engagement and motivation to enhance the learning process. Incorporating both methodologies can yield substantial synergistic benefits for educators and learners alike. In learner-centered and gamified integration, learners are invited to actively engage in learning, investigate concepts, and proactively resolve problems. This methodology develops innovative thinking, collaboration, and originality, providing immediate progress feedback.

3.1 Learning Situation Analysis for Trainees of State Grid

Centralized induction training serves as a cornerstone of strategy of State Grid for recent university graduates. Research and assessments elucidated the attributes of students specializing in communication operation and maintenance. Typically aged 21-26, these graduates demonstrate robust theoretical comprehension of communication, superior learning capacities, proactive approach, and inquisitiveness. However, their practical experience is limited, lacking proficiency in optical fiber fusion splicing, and impaired in optical cable fault diagnosis, as well as lack of familiarity with instrument operation.

3.2 Practical Training Objectives and Teaching Content

Knowledge Objectives. Mastering fundamentals and architectural features of the optical fiber, acquiring standard processes and vital techniques for optical fiber fusion splicing, and comprehending methods for evaluating splicing quality.

Skill Objectives. Proficiently operate machinery and specialized tools for optical fiber fusion splicing, execute the operations precisely within set timelines, accurately evaluate the splicing quality, and resolve anomalies within the work environment.

Attitude Objectives. Amplifying safety awareness and accountability, enforcing a rigorous and dedicated academic approach, promoting collaboration and mutual support, stimulating critical thinking, and instilling a commitment to craftsmanship.

3.3 Teaching Content

Tailored to meet the competence criteria for communication operation and maintenance roles, the training content caters to new staff from communication departments of State Grid. It places emphasis on honing professional capabilities and craftsmanship, and emphasizes skilled operations while fostering a strong appreciation for corporate values and learning aptitude. Company culture, operational guidelines, and safety principles are integrated throughout the training process to execute the standardized optical fiber fusion splicing practical training initiative.

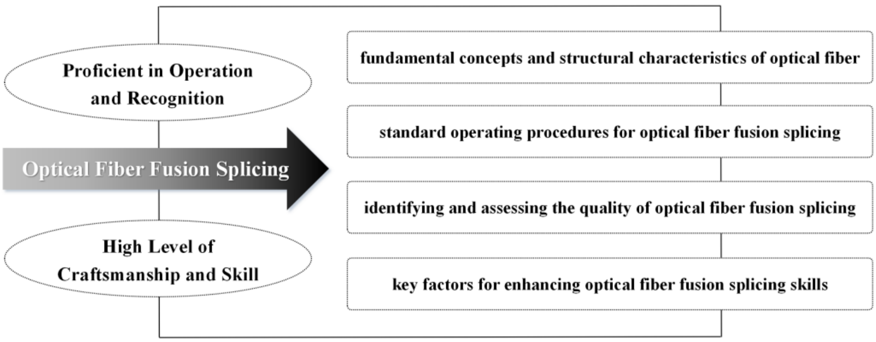

Fig. 4. Teaching content of optical fiber fusion splicing.

The optical fiber fusion splicing practical training encompasses four main components: fundamental concepts and structural characteristics of optical fiber, standard operating procedures for optical fiber fusion splicing, identifying and assessing the quality of optical fiber fusion splicing, and key factors for enhancing optical fiber fusion splicing skills (see Fig. 4.).

Considering the paramount importance of proficient operation of optical fiber fusion splicing machines and equipment, as well as precise assessment of its quality, the basic process is identified as key curriculum focus necessitating operational competence and discernment skills. Given the explicit numerical criteria for assessing the quality of optical fiber fusion splicing, achieving proficiency in related techniques poses a considerable challenge to learners.

3.4 Teaching Process

Pre-class Feedback. Pre-class feedback involves comprehensive evaluation of learners' knowledge and learning requirements prior to course commencement. This assists in precisely determining teaching priorities, formulating instructional content and activities beneficially, thereby improving teaching and learning efficacy. Utilizing State Grid E-Learning platform, pertinent materials regarding optical cables are furnished to learners prior to class, inclusive of theoretical knowledge, practical cases, operation videos, etc., intended to aid learners in establishing foundational comprehension of optical cable technology. Pre-class research tasks are allotted to stimulate learners to freely voice their opinions and inquiries in the discussion area and engage in exchanges with peers. Examining the word cloud of discussion area messages provides insight into salient topics and prevalent issues of scholarly interest to learners. This feedback is vital for refining instructional content and methodologies, constructing a communication conduit between educators and learners, aligning instruction with learners' needs, and elevating learning efficiency and precision.

Scenario Introduction. Scenario introduction is crucial in creating an effective environment, captivating learners, fostering their curiosity, and aiding their swift engagement in the learning process. By highlighting the case of a damaged optical cable results in multi-million losses, with the message "cyber security, no national security", learners' comprehension of network security can be deepened. This case bears substantial real-world implications and aligns closely to learners' professional landscape. By dissecting the case, learners encounter the severe repercussions of optical cable damage, including communication disruptions, financial losses, societal impacts, etc., fully acknowledging the significance and urgency of maintaining and repairing optical cables. This contextual introduction effectively stirs learners' emotions, instilling a robust sense of duty and mission, laying a robust psychological foundation for subsequent learning. Concurrently, a pivotal question is posed - how to reconnect severed optical fiber? This question directly targets the core technology of optical cable maintenance, a fundamental competency that every optical cable worker must possess.

In-class Implementation. In the classroom instruction, participants are organized into six groups, concentrating on the optical fiber fusion splicing task. Five games are constructed, including Lucky Wheel, Fun Puzzle, Showing One's Skill, Vying for the Top, Who Takes the Prize. Detailed information is displayed in Table 1.

Table 1. Design of gamified teaching activities.

Gamified Activities	Teaching Points	Duration	Gamified Elements
Lucky Wheel	Miller Clamp Optical Fiber Cutter Optical Fiber Fusion Splicer	3min	Wheel Points
Fun Puzzle	Structure of Optical Cables Optical Fiber Transmission Principles Construction of Optical Cable	5min	Pizzle Competition Cooperation Points
Showing One's Skill	Five Steps of Optical Fiber Fusion Splicing	10min	Challenge Points

Vying for the Top	Optical Fiber Fusion Splicing Process Optical Fiber Fusion Splicing Quality	10min	Competition Cooperation Points
Who Takes the Prize	Tips and Techniques of Optical Fiber Fusion Splicing	2min	Points Ranking Badges Rewards

Lucky Wheel. The device randomly selects one of the six learning groups. The teacher spins it, and the group indicated by the pointer must designate a representative to identify three optical fiber fusion splicing tools: Miller pliers, fiber optic cutting knife, and optical fiber fusion splicing splicer. If all responses are accurate, the group receives 2 points; 2 accurate responses yield 1 point; 1 accurate response earns 0.5 points; no accurate responses result in zero points. This activity aids students in understanding fiber optic tools more deeply.

Fun Puzzle. Each group receives a random assortment of puzzle kits pertaining to power optical cables. Upon instruction, all six groups commence assembling the puzzle within a 5-minute timeframe. This exercise evaluates students' manual dexterity, spatial reasoning, and team collaboration. The first group to complete the puzzle receives 2 points. In case no group finishes within the designated time, no score is awarded. This activity facilitates visual comprehension of optical cable inner/outer structure, fiber optic transmission principles, and construction sites.

Trial by Fire. The instructor explains and executes the specific operational steps of optical fiber fusion splicing, encompassing threading, stripping, cutting, fusing, and heating. Subsequently, a challenge is issued to the six groups, with the first group to accept sending a delegate to the stage to execute the specified steps as directed. If the students successfully complete the task on the initial attempt, the group earns 3 points; if errors occur but rectified under the teacher's supervision, they receive 2 points. This activity assesses students' practical application of theoretical knowledge, as well as the precision and standardization of hands-on operations.

Competing for Excellence. Six groups simultaneously conduct intra-group fiber fusion tasks, aiming for fusion loss under 0.05dB. Members collaborate with distinct roles - preparing fibers, operating equipment, testing loss, all in a time-sensitive manner. Post-exercise, the teacher awards the top three groups with 3 points, 2 points, and 1 point, respectively. This engages both intra-group collaboration and inter-group competition, enhancing students' fusion speed and quality, fostering teamwork and competitiveness.

Whose Turn to Shine. A large screen displays real-time scores of six groups per class, aggregating and ranking performance per segment. Each member of the highest-scoring group receives a red flower, scoring an extra 1 point in subsequent assessments. Through timely visual feedback and rewards, this segment encourages student involvement, fosters competition, and incentivizes future evaluations.

Through designing pertinent teaching activities such as lucky spins, puzzle games, quizzes, competitions, etc., students acquire comprehensive understanding of fiber optic communication knowledge, improving their learning engagement and fostering their all-round excellence and innovation capabilities. This efficacious teaching method not only heightens teaching efficiency but also promotes interaction and communication between educators and learners, cultivating a positive learning environment and laying a robust foundation for students' comprehensive growth.

Summary and Assessment. End-of-lesson summaries can be created using mind maps, promoting efficient student knowledge organization, consolidation, and enhancing critical thinking skills. An inter-group exchange of mind maps for evaluation enhances group interaction, stimulating problem examination and viewpoint diversification. Enhancing fiber fusion expertise, students engage in post-class tasks researching the specific requirements of the global skills competition's fiber fusion module, understanding advanced international standards, and implementing these through collaborative learning and practical exercises. Furthermore, exploring fiber rings/gyroscopes' application in the Shenzhou-15 spacecraft broadens their knowledge base, facilitates understanding of fiber optic technology's latest space application, and inspires patriotism and national pride. This exploratory learning approach allows for effective integration of theoretical knowledge and practical skills, enhancing hands-on operation and problem-solving abilities, and highlighting the significance of fiber optic technology to national scientific and technological advancement and defense. Moreover, the examination assessment analysis system [18] with question-label classification model (Q-L Model) based on long short-term memory (LSTM) [19] can be used here to conduct multi-dimensional analysis on learners' test results and give training suggestions. As shown in Table 2, the records of learners are used to save trainee records. The evaluation results the Q-L Model on the test data are shown in Table 3 with the accuracy of 98.35%.

Table 2. Learner table of the question-label classification model.

Description	Field Name	Type	Key	Nullable
Student ID	student_id	int	Primary	No
Student Name	student_name	varchar(255)	None	No
Student Number	student_number	varchar(255)	None	No
Student Gender	student_gender	tinyint	None	Yes
ID Number	id_number	varchar(255)	None	Yes
Student Unit	student_unit	varchar(255)	None	Yes
Education	education	tinyint	None	No
Position	position	varchar(255)	None	Yes
Major	major	varchar(255)	None	Yes
Position Major	position_major	varchar(255)	None	Yes
Batch ID (Deprecated)	batch_id	int	Foreign	No
Certificate Obtained	zhengshu	varchar(255)	None	Yes
Status	student_state	tinyint	None	No
Create Time	create_time	datetime	None	No
Update Time	update_time	datetime	None	No

Table 3. Evaluation results of the question-label classification model.

Training Set Loss	Training Set Accuracy	Test Set Accuracy
0.0114	0.9966	0.9835

4 Conclusion

In summary, this work, rooted in learner-focused gamified thinking, offers an innovative methodology for designing fiber fusion training for State Grid recruits. This approach underscores learners' requirements and experiences, invigorates learning drive, accelerates knowledge and skill attainment via the incorporation of gaming elements and mechanisms, and fosters a pleasurable learning environment. Through situation-based learning tasks, escalating level design, prompt feedback and incentives, and other gamification strategies, learners can sustain high concentration and engagement, mastering fiber fusion theory and practice in a relaxed and enjoyable manner. In the gamified learning process, positive communication and collaboration through group tasks, team competitions, and other formats not only encourage knowledge and experience exchange but also deepen the comprehension and mastery of fiber fusion technology, augment interaction and trust among new hires, and enhance team unity and collaboration efficacy. The principles and strategies inherent in gamified thinking, such as learner-orientation, interactive experience, immediate feedback, and incentive mechanisms, hold universal significance for stimulating learning drive, promoting knowledge and skill acquisition, and crafting a positive learning experience. Learner-focused gamified thinking infuses new concepts and vitality into the design of fiber fusion training for State Grid recruits. Nevertheless, the advancement of gamified teaching still confronts numerous challenges, including optimizing and integrating teaching resources, augmenting teaching team capabilities, and enhancing organizational support and institutional guarantees, necessitating collaborative efforts from organizations, teaching teams, learners, etc., to continually refine the design principles, implementation paths, and evaluation optimization mechanisms of gamified teaching through practical exploration, fostering its innovative evolution in talent cultivation within enterprises. Future research is warranted to further validate the effectiveness and applicability of gamified teaching, optimize the design models and application frameworks of gamified teaching, explore gamified teaching application modes and promotion strategies in diverse scenarios and fields, and provide more theoretical guidance and practical experience for advancing the transformation and innovation of gamified teaching in the education and training sector.

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