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Implementing Interactive Lectures in Large Physics Classes: An Action Plan for a Bangladeshi College Context

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ABSTRACT

Student enrolment at the tertiary level in Bangladesh is increasing to support the rapidly emerging economy. Due to limited budget allocation, insufficient infrastructure support, and a high teacher-student ratio, class sizes have expanded significantly, raising a serious pedagogical issue: conventional lecture-based approaches, commonly used in Bangladeshi contexts, are failing to meet students' demands for conceptually rich, complex subjects like Physics, leading to rote learning, limited conceptual understanding, and a decline in student interest. Considering the limitations of the Bangladeshi tertiary-level college system, this study explores the prospect of Interactive Lectures (IL) as a paradigm-shifting approach for large Physics classes. This study highlights a significant gap in pedagogical practice in Bangladesh by critically reviewing the existing international literature on IL methods, including technology-enhanced Audience Response Systems (ARS), interactive lecture demonstrations, and peer instruction. Through a critical examination of current teaching practices and contextual challenges, including examination-driven curricula, inadequate infrastructure, and excessive faculty workload, the author proposes an integrated action plan that includes pre-class, in-class, and post-class activities using available technologies. The study concludes that, despite systematic challenges, implementing IL can create a more active, student-centered learning environment, potentially reversing the trend of disengagement in science education and better aligning with the objectives of Bangladesh's National Education Policy (2010).

Keywords: Interactive Lecture, Physics Education, Large Classes, Action Plan, Peer Instruction, Kahoot!, Audience Response Systems, Tertiary Education.

INTRODUCTION

Tertiary education in Bangladesh faces a paradoxical situation. While student enrollment is increasing rapidly to support the emerging economy, budget allocations, infrastructure support, and teacher recruitment remain insufficient (Wolfman, 2002; Rahman et al., 2019; Elhabashy, 2019; The World Bank, n.d.). However, academicians have treated large classes as an instructional and administrative problem because of the lower student learning outcomes resulting from restricted learning activities, limited interaction between teachers and students, and weaker student engagement (Gibbs, 1992; Lynch & Pappas, 2017; Mulryan-Kyne, 2010). However, as with other subjects in the natural sciences, learning Physics involves gathering and applying information in different situations (Šlekienė & Ragulienė, 2010). Numerous studies have found that Physics concepts can be taught through guided activities to reduce confusion and foster active engagement rather than through traditional lectures (Meltzer & Manivannan, 2002). On the other hand, most Physics teachers, like other science teachers at the postsecondary level, feel comfortable with lecture-based instruction in large classes (Deslauriers et al., 2011). Therefore, educators worldwide are trying to convert lecture-based classes into an interactive student-centered learning environment where students are motivated to learn and have the freedom to explore, discover, and inquire by incorporating different active learning strategies into a traditional lecture method, called an interactive lecture (Crouch et al., 2007; Šlekienė & Ragulienė, 2010; Deslauriers et al., 2011; "Interactive Lecture," n.d.).

In this context, the traditional lecture-based approach is the default mode of instruction in the country. Despite its efficiency in content coverage, TL is commonly criticized for promoting passive learning, rote learning for examinations, and its inability to address misconceptions (Armstrong, 2011; Banu, 2011). Therefore, this study aimed to investigate the viability of Interactive Lectures (IL) as a realistic solution. It aims to answer a critical question: How can IL strategies be effectively implemented to transform large, traditional Physics classes in a Bangladeshi college, given the significant contextual constraints?

This study presents a comprehensive action plan to address this issue. It begins by outlining the current practices and challenges in Bangladesh, provides a literature review on effective IL models, offers a critical reflection on the author's teaching practice, and finally proposes a concrete three-stage framework for implementing IL using accessible technology.

Context: The Challenge of Large Classes in Bangladesh

In Bangladesh, there are two forms of parallel higher education institutions: highly competitive public and private universities and a large number of Tertiary Colleges (government and non-government) affiliated with the National University of Bangladesh (NUB) (Nagashima et al., 2014). Although around two-thirds of the total students are enrolled in NUB-affiliated colleges, these colleges lag behind universities in terms of academic and financial decision-making freedom, teacher qualifications, infrastructure, and funding (Nagashima et al., 2014; Rahman et al., 2019). Moreover, most NUB college students could not attend an adequate number of classes because of the compact central examination schedule of the NUB authority, teachers' ignorance due to interest in private tuition, insufficient classrooms, and shortage of faculty members (Nagashima et al., 2014; Ahmed, 2019; Al Faruki et al., 2019). Students in science disciplines suffer from inadequate laboratory and research facilities (Ahmed, 2019). The situation in government colleges is worse because of a high teacher-student ratio of 1:100 at the undergraduate level, which is the leading cause of large class sizes (Nagashima et al., 2014). The author's own government college exemplifies these issues: over 10,000 students are taught by only 82 faculty members, with chronic classroom shortages and seating so crowded that physical interaction is inhibited.

Bangladesh practices results-based education that emphasizes memorization of content rather than understanding the material to do well in examinations (Holbrook 2005; Prodhan 2016). Teachers' duty is to prepare their learners for examinations by conveying the necessary information from textbooks (Tapan, 2010; Prodhan, 2016). Teachers, therefore, feel reluctant to engage their students in classes and are strict in their traditional, lecture-based instructional methods (Sarkar & Corrigan, 2014). The author's college experience aligns with this scenario. Although the scenario is changing at the secondary and pre-secondary levels because of the introduction of student-centered learning and assessment systems in accordance with Bloom's taxonomy, there are no dedicated Higher Education policies, and teaching in higher educational institutions is still based on rote learning, similar to the colonial period (Chowdhury & Muhammad, 2010; Hossain & Khan, 2014; Monem & Sarkar, 2018). However, the "National Education Policy-2010" specifies "the creation and sustainable continuity of new knowledge" as an aim of higher education in Bangladesh, which could be achieved through students' hands-on activities, life experiences, and understanding (MoE, 2010; Chowdhury & Sarkar, 2018). To this end, the learning environment in tertiary education should be transformed from boring, ineffective, one-way traditional methods to engaging, dynamic, and compelling interactive methods to enhance students' engagement and learning outcomes.

LITERATURE REVIEW: MODELS FOR INTERACTIVE LECTURING

Numerous studies in physics education research have demonstrated the limitations of traditional lectures (TL) and the efficacy of active learning strategies (Hake, 1998; Deslauriers et al., 2011). Interactive Lecture (IL) is a very effective way of teaching in a large class that involves active, structured engagement and participation by learners, where the role of the teacher shifts from instructor to facilitator (Yvonne & Snell, 1999; Eison, 2010). Students should have at least one opportunity for direct and active interaction with the learning material associated with specific learning tasks (Leshner & Obando, 2017). During IL, instructors begin with engagement triggers to attract and maintain students' attention, break their lectures into small segments, and incorporate activities that allow students to apply their learning or provide background on upcoming lecture material (Macdonald et al., n.d.; Bunce et al., 2010). This approach is particularly effective for classroom activities. IL often incorporates active learning strategies such as Think-pair-share, Demonstration, Peer Instruction, and the Flipped Classroom (Crouch et al., 2007; "Interactive Lecture," n.d.). Conversely, TL in large classes frequently fails to engage students, foster critical thinking, and impart behavioral skills (Bligh 2000; Bligh & Cameron

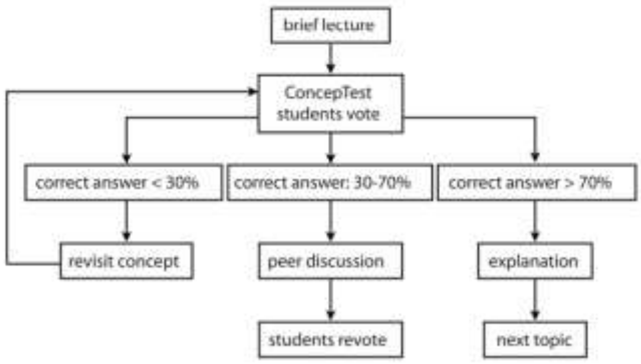
2000; Kopf et al. 2005; Deslauriers et al. 2011). It also leads to a lack of student engagement, learning opportunities, and interaction, resulting in high absenteeism and a lack of understanding of fundamental physics concepts (Eison 2010; Sharma et al. 2010; Schmidt et al. 2015). Instead of delivering lectures, IL strategically integrates teaching and learning activities to break up content and engage students cognitively. These limitations highlight the need for alternative pedagogical approaches, such as IL, which offer promising strategies to address them. Drawing on the reviewed models for interactive lecturing, the following key IL strategies are identified as particularly relevant to the Bangladeshi context.

Key IL Strategies:

Peer Instruction (PI)

Eric Mazur's 'Peer Instruction (PI)' simplifies teaching physics in large classes by encouraging student interaction (Mazur, 1997). Mazur (1997) used a mix of short lectures and conceptual questions while emphasizing student interaction and peer learning. Class time is divided into mini-lectures and concept tests, with class progression determined by students' immediate feedback on ConcepTests (multiple-choice conceptual questions) (Lasry et

Figure 1: The implementation sequence of PI (Lasry et al., 2008)



al., 2008). Mazur (1997) introduced the central idea of the content with a short lecture or presentation before engaging students in PI activities. In PI, students first respond to the question individually, then again after discussing with their peers, and the cycle is completed with an instructor explanation to clarify any incorrect responses (Schell, 2013). The implementation sequence of the PI is shown in Figure 1.

Question-Driven Instruction (QDI):

The QDI is a developed version of PI. Beatty, Leonard, Gerace, and Dufresne developed a technique called “Question Driven Instruction (QDI)” where they introduce posing, answering and discussion of the conceptual question in the classroom using an "Audience Response System" (ARS) (Beatty et al., 2006). Here, ARS plays a central role, acting as an engagement and learning trigger to support students' "Active Learning." In contrast, the teacher's responses and feedback on students' answers and the teacher's monitoring of their progress are

Figure 2: An illustration of QDI (Beatty et al., 2006)

referred to as “Agile teaching” (Figure 2).

Interactive Lecture Demonstrations (ILDs)

Sokoloff and Thornton (1997) introduced the "Interactive Lecture Demonstration (ILD)" in a large Physics class, in which the instructor described the demonstration and asked students to record their individual predictions.

They then engaged in group discussions and recorded their final predictions. The instructor then conducted a demonstration using a multimedia tool, after which a few students discussed the demonstration results, and the instructor wrapped up with a discussion of an analogous situation. ILDs combine interactive demonstrations with traditional physics lectures (Šlekienė & Ragulienė, 2010). In contrast, Deslauriers et al. (2011) adopted the "Deliberate Practice" (Ericsson et al., 1993) concept in the form of a series of thought-provoking questions and tasks that require students to exercise high-order reasoning and problem-solving skills, as a physicist would, with regular feedback provided.

Audience Response System (ARS)

ARS is essential for enhancing student engagement and participation in class activities and recording their feedback for formative assessments (Bruff 2009; Kay et al. 2010). There are different types of ARS, including manual and commercial electronic products (Meltzer & Manivannan, 2002). Among them, "Clicker" is the most popular ARS for large physics classes (Bruff, 2009; Schell et al., 2013). Mazur (1997), Beatty et al. (2006), and many other Physics educationists choose "Clicker" as ARS in their classes (Bruff, 2009). Simultaneously, Meltzer and Manivannan (2002) used "Flashcard," a very popular manual ARS. Despite their lower cost, capturing exact feedback remains challenging. Comparatively newer ARSs, such as "iClicker" and "Plicker," offer greater opportunities to go beyond Multiple-choice Questions (Schell et al., 2013). "Kahoot!", a game-based student response system, could also be a good ARS for formative assessment and creating a competitive environment in the classroom (Wang & Tahir, 2020).

An Integrated Model:

Instead of following a single IL approach, adopting the "Integrated Approach to Managing Active Learning Process" proposed by Drinkwater et al. (2014) and Elhabashy (2019) is more practical for large classes. This approach is more like the 'Flipped Classroom' model (Brame, 2013). It has the opportunity to customize different IL strategies, such as Peer Instruction (PI)" (Mazur, 1997), "Question-Driven Instruction (QDI)" (Beatty et al., 2006), "Interactive Lecture Demonstration (ILD)" (Sokoloff & Thornton, 1997), and "Deliberate Practice (DP)" (Deslauriers et al., 2011), according to the different learning outcomes of the content of physics. Following Elhabashy's (2019) guidelines, it is convenient to group activities into three categories: pre-class preparation, in-class active learning, and post-class feedback.

Generally, pre-class preparation includes reading assignments from the textbook or other sources specified by the instructor, as well as assessing the student's work and incorporating the teacher's feedback (Drinkwater et al., 2014). It can help students get a clear idea of the content, develop a habit of reading before class, and ensure the coverage of an extensive syllabus in a short period. The instructor also gets the opportunity to prepare their lesson plans and select appropriate strategies.

In-class active learning starts with a follow-up discussion based on students' feedback from pre-class activities (Drinkwater et al., 2014). Different strategies are implemented for the core learning sequence based on the topic's demands (Elhabashy, 2019). For conceptual development, PI (Mazur, 1997) and QDI (Beatty et al., 2006) sequences are more appropriate than others. However, to boost critical thinking and problem-solving skills, ILD (Sokoloff & Thornton, 1997) and DP (Deslauriers et al., 2011) methods are suitable. All the aforementioned strategies are similar and can be implemented in traditional classroom settings. Post-class activities reinforce learning and provide personalized support (Elhabashy, 2019). This structure not only ensures content coverage but also promotes student engagement in the learning process.

Literature Gap:

Learning is an interpretive process in which people construct knowledge by linking and relating it to their prior learning and experiences (deWinstanley & Bjork, 2002; Schmidt et al., 2015). Therefore, educators emphasize interactive pedagogy, in which students enjoy autonomy and actively participate in the learning process (Riley & Myers, 2014). Despite various interactive lecturing strategies being experimented with and implemented in teaching Physics in large classes worldwide, TL is the only method of instruction at the tertiary level in Bangladesh. No research has been conducted on the introduction of IL at the undergraduate level for teaching physics so far.

Physics educators use a single strategy to implement IL in large Physics classes. Some studies have attempted an integrated approach. Owing to convenience and infrastructure constraints, this study adopted an integrated approach. For ARS, most researchers use "clickers." Nevertheless, it requires some technical and infrastructural development to use "clicker" in my classroom, which is not possible right now. While 'Clicker' is the most common ARS, some studies redefine "Kahoot!" as an engagement trigger at the secondary school level (Wang & Tahir, 2020). It could also serve as a low-cost alternative to the ARS at the tertiary level. Therefore, this study focuses on introducing a combination of suitable IL strategies, using "Kahoot!" as an ARS, in a large Physics class at a tertiary-level college in Bangladesh.

Critical Reflection and Need for Change

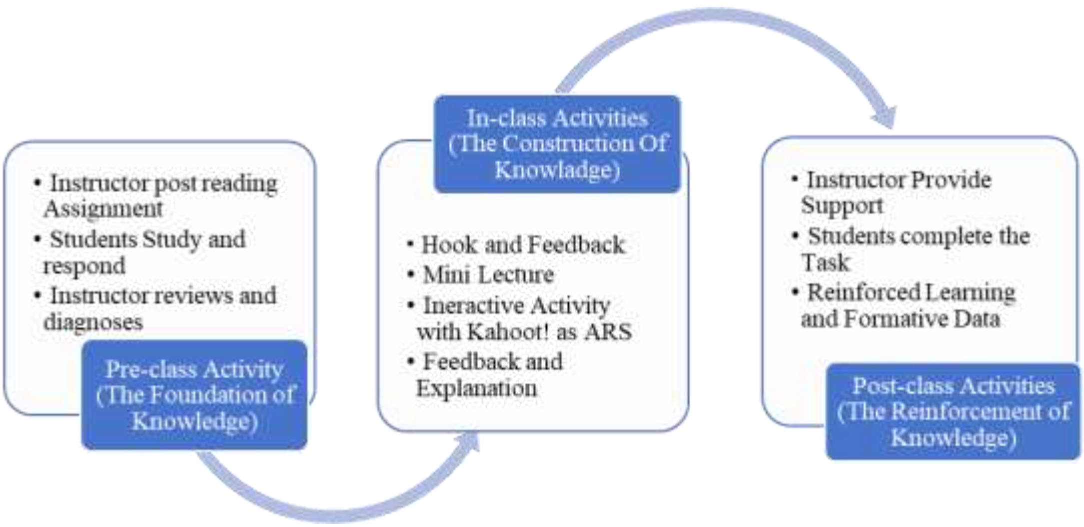
In Bangladesh, a teacher's depth of knowledge, loud and commanding voice, ability to maintain discipline in the classroom, and autocratic personality are considered the qualifications of a good teacher (Al Faruki et al., 2015). The author also adopts this traditional thought and prepares himself in a typical manner for his classes. The author's current practice is a typical TL: starting with a recap of the previous class to bridge prior learning with the new material, followed by content delivery via whiteboard and PowerPoint, minimal student interaction, and a focus on exam preparation. While this method is logistically manageable, it has some critical flaws, such as student attention waning after 15-20 minutes, fundamental misconceptions remaining unaddressed, and a higher absenteeism rate. The author realized that his typical teaching method was effective only in large classes with limited resources, a disciplined environment, and inadequate technological support (Al Faruki et al., 2015). Despite a tendency to connect students' prior knowledge to current learning, use real-life examples to construct new knowledge, and employ multimedia to attract students' attention, this practice fails to promote students' critical thinking and creativity because it lacks active student engagement.

Educationists from all over the world are now focusing on technology-embedded, constructivist pedagogy to enhance teacher-student interaction and student engagement, in line with the challenges of the 21st century (Lubienski, 2000; Kuh et al., 2011; Drinkwater et al., 2014; Milner-Bolotin et al., 2019). The interactive lecture is one of the learning techniques that could transform a large, theoretically and mathematically condensed Physics class into a less daunting one by breaking the lecture into small segments and incorporating technology-enhanced active learning activities (Middendorf & Kalish, 1996; Bunce et al., 2010). Learning Physics involves developing fundamental concepts, reasoning, critical thinking, and problem-solving skills. IL offers a path to create a "small class feel" in a large room (Lynch & Pappas, 2017), boosting attendance, enhancing conceptual understanding, and making learning more sustainable by moving beyond rote memorization. The challenge is to adapt these global best practices to resource-constrained settings.

Proposed Action Plan

This plan adopts the integrated model of Drinkwater et al. (2014) and Elhabashy (2019) customized for local constraints. The activity sequences of the proposed action plan are illustrated in Figure 3.

Figure 3: Brief Summary of the action Plan



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Pre-Class Activity:

Objective: To enhance students' fundamental understanding.

Action: Following Drinkwater et al. (2014), the pre-class activity included reading assignments from the textbook or other sources specified by the instructor, and assessing the students' work and the teacher's feedback. For this activity, a Facebook Messenger group was used to interact with the students, as it is the most popular platform in Bangladesh. This activity helps students get a clear idea of the content, develop a habit of reading before class, and ensure coverage of an extensive syllabus in a short period.

Outcome: Students arrive prepared, freeing up class time for higher-order activities. The instructor reviewed the students' responses to identify common difficulties.

In-Class Activity:

Objective: To actively engage students in knowledge construction.

Action: The 45-minute lecture was structured into segments.

- **Hook (5 minutes):** Discussion on the issue or feedback from students during the pre-class activity.
- **Core Concept 1 (10 minutes):** Mini lecture on a key idea.
- **The interactive activity (10 minutes):** Followed an instruction-response-discussion sequence. Moll and Milner-Bolotin (2009), Weimer (2011), and Deslauriers et al. (2011) reported that incorporating various interactive teaching strategies during lectures can foster attitudes and expand students' engagement, learning, and academic achievement in large-enrollment Physics classes. According to Drinkwater et al. (2014), selecting a suitable strategy is crucial in this regard. For conceptual development, 'Peer Instruction' (PI) and 'Question Driven Instruction' (QDI) are more suitable, while for boosting critical thinking and problem-solving skills, 'Interactive Learning Demonstration' (ILD) and 'Deliberate Practice' (DP) could be appropriate (Crouch & Mazur, 2001; Knight & Wood, 2005; Lasry et al., 2008; Schmidt et al., 2015). All of the mentioned instruction-response-discussion sequences depend on the Audience Response System (ARS). Here, the "Kahoot!" poll was proposed as an ARS because of its accessibility from any device and low installation cost.
- **Feedback and explanation (5 minutes):** Address misconceptions revealed by the activity.
- Repeat for Core Concept 2.

Tool: "Kahoot!" was chosen as the ARS because of its game-like interface, accessibility on any mobile device and low cost.

Post-Class Activities

Objective: To reinforce learning and provide personalized support.

Action: Be available in the Messenger group to address students' queries and provide necessary feedback. Assign short reflective paragraphs or group problem-solving tasks related to the class content.

Outcome: Learning beyond the classroom is extended and formative assessment data are provided.

Advantages, Challenges, and Mitigation

Advantages

Researchers have admitted the effectiveness of Interactive Lecture (IL) as a form of active learning approach in large-enrollment undergraduate physics classes over the Traditional Lecture (TL) method (Meltzer & Manivannan, 2002; Deslauriers et al., 2011; Meltzer & Thornton, 2012; Drinkwater et al., 2014; Riley & Myers, 2014; Lynch & Pappas, 2017). Crouch & Mazur (2001) reported that the Peer Instruction (PI) method led to a significant increase in students' conceptual understanding compared to the TL at Harvard University. Mazur and his colleagues found more than a doubling in improvement in the pretest-posttest setting for the concept of Force in an introductory Physics class after introducing PI as an instructional method (Schmidt et al., 2015). PI also benefited both higher- and lower-background students and reduced the dropout rate (Lasry et al., 2008).

Deslauriers et al. (2011) used a series of "clicker"- based challenging questions instead of a lecture to teach "Electromagnetic wave" and observed more than twice the learning among students. Moreover, Knight and Wood (2005) observed that students who engage in active learning strategies such as IL achieve significantly higher learning gains and conceptual understanding. Tanahoung et al. (2009) and Sharma et al. (2010) also reported the development of Physics concepts and increasing efficacy of learning and teaching using ILD. Furthermore, Moll and Milner-Bolotin (2009), Weimer (2011), and Deslauriers et al. (2011) revealed that incorporating various interactive teaching strategies during lectures can foster attitudes and expand students' engagement, learning, and academic achievement in large-enrolment Physics classes.

Compared to regular classrooms that allow students to share their diverse perspectives and experiences, large classroom settings exhibit greater diversity in terms of gender, quality, and class (Jawitz, 2013). The diverse student population may not be motivated or have their needs satisfied by a tedious TL approach. Conversely, this presents a fantastic opportunity for IL, as the diversity of learners fosters more collaborative and cooperative learning (Jawitz, 2013). Additionally, IL can transform a large classroom into a typical small-group discussion, provide teachers and students with a wide range of learning opportunities, and increase tertiary-level student attendance (Meltzer & Manivannan, 2002; Riley & Myers, 2014; Lynch & Pappas, 2017). It also improves students' capacity for higher-order cognitive processes and critical reasoning (Michael, 2006).

The proposed plan promises increased engagement, improved conceptual understanding, the development of peer-learning skills, and sustainable learning habits. It also provides instructors with valuable real-time feedback on student learning.

Challenges and Solutions

Student Reluctance: Students may be reluctant to adopt new teaching strategies as they are used to traditional methods. Briefing strategies and advantages of IL at the beginning could overcome this problem. Some students may be unwilling to participate in class activities. By motivating with the gamified 'Kahoot!' platform and introducing an ARS-based attendance system, they will be encouraged to participate in the activity.

Time Constraints: A typical IL sequence is very time-consuming and lacks in-depth coverage of the syllabus (Eison, 2010; Meltzer & Manivannan, 2002). This issue can be solved by introducing pre-class learning (Crouch & Mazur, 2001). Combining two consecutive class time management issues could be resolved. For this, necessary corrections should be made in the class routine by consulting other colleagues and the concerned authority.

Classroom Noise: Generally, an IL-based class is noisy. The institution's authority may not like it, as it violates the discipline. Therefore, before planning to introduce IL, teachers should brief the authority on the pedagogical value of active learning noise.

Technology Failure: The IL sequence is highly dependent on technology-related factors. The multimedia projector and internet connection should be checked before the class to avoid any disturbance. Uninterrupted electricity and broadband Internet access should be ensured. In the case of any technological failure, there should be non-tech backup plans, such as flashcards and ConceptTest.

Workload Increase: IL requires extensive preparation by teachers to design and develop study materials and select proper strategies, which may increase teachers' workload (Eison, 2010). A gradual, small-scale implementation of IL in one or two classes per week could help resolve this issue.

CONCLUSION AND RECOMMENDATIONS

To advance globally in the field of science and technology, Bangladesh's economy is shifting from a traditional agriculture-based economy to an industry- and service-based economy, creating opportunities for a highly skilled youth workforce with a science and technology background (Choudhury, 2009; Rahman et al., 2019). However, the youth of Bangladesh are losing their interest in science because of insufficient infrastructure, large class size, unsatisfactory assessment system, lack of the teacher's pedagogical knowledge and training regarding the content matter, and limited scope to participate in "hands-on" activities related to the content knowledge, which leads to a steady decline in science enrolment in higher education (Choudhury, 2009; Hossain, 2017; Iraj, 2017). To improve the quality of physics teaching in Bangladesh's congested colleges, passive lecture halls must be transformed into active learning spaces. This action plan offers a practical, situation-specific structure for implementing Interactive Lectures. However, systemic support is essential for their success.

RECOMMENDATIONS

Policy Reform: Bangladesh practices an examination-driven education system where students are evaluated by a written examination (only summative assessment) at the end of the semester or year (Holbrook, 2005; Prodhan, 2016). There is no provision to include formative assessment during class in the final grade, which may discourage students from engaging in the class activities. Thus, NUB should revise its assessment policies to include formative assessment marks in the final grades, incentivizing participation.

Faculty Support: Teacher training in active learning techniques should be provided, and administrative responsibilities should be reduced to alleviate the lack of confidence and capacity to design appropriate interactive sequences, thereby freeing up time for pedagogical innovation.

Infrastructural Investment: Our classrooms are neither structurally nor technologically sound for IL (Rahman et al., 2019). Policymakers and administrators should take the necessary steps to promote infrastructure development. Moreover, the educational budget is insufficient for these developments (Nagashima et al., 2014; Rahman et al., 2019). The government of Bangladesh should consider this for the sake of quality education.

Use of Teaching Assistants: Many researchers, including Mazur (1997), Deslauriers et al. (2011), Drinkwater et al. (2014), and Elhabashy (2019), recommend using Teaching Assistants (TAs) in the IL environment to help the teacher meet students' demands and provide feedback. However, unfortunately, there is no opportunity to employ TA in Bangladeshi tertiary colleges. This study strongly recommends creating opportunities for TAs to work in large classes.

By adopting this plan, educators can take a crucial step towards creating a dynamic and effective learning environment that aligns with the 21st-century goals of the Bangladeshi education system, ultimately inspiring a new generation of scientists and critical thinkers.

Future research recommendation

To make sure the suggested action plan is effective, a pilot study or a full-scale action study is advised, and the results should be adjusted accordingly.

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