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Identifying approaches to secondary school physics teaching

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ABSTRACT
The purpose of this study was to investigate the instructional approaches of physics teachers using a developed questionnaire and to assess the impact of demographic factors on these approaches. The study utilised a quantitative approach through a survey methodology. A total of 573 physics teachers from secondary schools in Iran were randomly selected to complete the researcher-made questionnaire. The data analysis revealed that physics teachers use three main approaches: one which focuses on learner-centred strategies (Approach A); one which focuses on teacher-centred strategies (Approach C); and one which shares characteristics of both (Approach B). The results showed that teachers tend to use a combination of these approaches in their teaching, with Approach B being the most commonly used. Furthermore, no significant relationship was found between teachers' teaching approaches and their gender or educational levels. However, the number of years of service did have an impact on teachers' teaching approaches.

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Introduction

The goal of science education has long been to educate future citizens and cultivate the next generation of scientists. In recent years, there has been a growing societal emphasis on science education that fosters scientific literacy (Muhfahroyin et al., 2024) and critical thinking skills among young learners (OECD, 2019).

Effective analysis and assessment of social issues based on science are made possible by scientific literacy, which fosters critical thinking and participation in thoughtful debates (Yacoubian, 2017). In order to adapt to this change, creative teaching strategies that prioritise scientific literacy and critical thinking are crucial. Critical thinking skills, problem-solving abilities, and information analysis are all highlighted in recent PISA findings as essential competencies for 21st-century learners (OECD, 2019).

In general, there are three important factors in the process of teaching and learning: curriculum, teaching approaches, and assessment. Teaching approaches are considered a set of tactics used in the implementation of a curriculum (Garrett et al., 1982), which are influenced by teachers' epistemological beliefs (Kang & Wallace, 2005). Tactics, characterised by techniques, determine strategies that reflect the general approach of the teacher (Qhobela & Kolitsoe , 2014).

Over the past five decades, teaching methods have evolved due to modern pedagogical theories, societal needs, and technological advancements (Jarvis, 2006; Wang, et al., 2024). Traditional methods, such as direct instruction and rote memorisation, have been replaced by dynamic, learner-centered methods such as constructivist and inquiry-based learning (Jarvis, 2006; Kasuga, et al., 2022). Technology integration has led to blended and online learning environments, enabling personalized experiences. Contemporary teaching practices now prioritise critical thinking, problem-solving skills, and a lifelong love of learning among students (Hunter, 2015; Fathonah, et al., 2022). Consequently, a comprehensive analysis of physics teachers' instructional approaches within educational systems is of paramount importance for enhancing both teacher effectiveness and student learning outcomes.

Traditional Teaching Approach Features

One of the defining features of traditional teaching is its teacher-centred nature, where the teacher serves as the primary source of knowledge and authority in the classroom. In this model, the educator is responsible for delivering content, guiding learning, and maintaining discipline, which fosters a structured learning environment. The teacher's dominant role often leads to a passive learning experience for students, who are expected to absorb information rather than engage in collaborative or interactive learning processes (Boumová, 2008). This approach aligns with conventional educational practices, where the teacher's authority is emphasized over student input.

A structured curriculum is another critical component of traditional teaching methods. Education follows a predefined syllabus designed by education authorities, detailing the content to be covered and the skills students are expected to acquire (Knight, 2015). This systematic framework allows for uniformity in educational delivery and is particularly effective in ensuring that essential knowledge and foundational skills are conveyed. However, the rigidity of such curricula may limit flexibility and adaptability to individual learning needs, which is a notable criticism of traditional educational frameworks.

Traditional teaching heavily depends on textbooks, which serve as the main resource for instruction. These books provide a wealth of information, exercises and assignments that shape the learning experience (Litz, 2005). Teachers typically base their lessons on textbook content, guiding students through the material and facilitating understanding (Knight, 2015; Emmer et al., 2023). While textbooks can offer a comprehensive overview of subjects, this reliance can restrict exposure to varied perspectives and learning modalities, as the curriculum often prioritises rote memorisation over critical thinking and problem-solving (Boumová, 2008).

The physical classroom environment is integral to traditional teaching methods. Learning occurs within the confines of a classroom, emphasising face-to-face interaction and a structured space for educational activities (Brukštutė, 2019; luo et al., 2024). This controlled environment supports a clear authority structure, where the teacher guides discussions and activities while learners engage with the content in a more passive manner (Eshel, 1991). However, the physical restrictions of a classroom may also inhibit creative teaching methods or alternative forms of assessment that could enhance learning outcomes.

Assessments in traditional teaching approaches typically take the form of tests and written assignments aimed at gauging student understanding and knowledge retention (Dikli, 2003). These methods are designed to measure performance across a consistent framework, facilitating comparisons between students’ achievements. Though standardised assessments provide a clear metric for evaluation, they often emphasise memorisation and regurgitation of facts rather than deeper comprehension of content or critical application of knowledge. This assessment style can inadvertently limit students' engagement and may not account for diverse learning styles or paces (Koretz, 2017).

Inquiry-Based Learning and Constructivist Teaching Features

Constructivist teaching approaches and inquiry-based learning have grown in popularity in modern education because they place a strong focus on critical thinking (Ezema et al., 2022), cooperative problem-solving, and active participation. The notion that knowledge is created via experiences rather than passively absorbed is fundamental to both strategies. The following is a review of key elements of learner -centered approaches.

For learning to be learner-centred, open curricula are essential. By enabling teachers to adapt instruction to unique needs, interests and experiences, they promote a more engaging and individualised learning process (Wiggins, 2005; Aina, 2017).

A fundamental component of inquiry-based learning is its focus on active learning and engagement. According to Lim and Chai (2008), learners are encouraged to ask questions, investigate problems, and draw conclusions based on their discoveries. This active participation significantly enhances students' critical thinking abilities, as they become active builders of their own understanding rather than mere recipients of information (Murni , et al., 2022) Research has consistently demonstrated that students exposed to inquiry-based environments develop superior problem-solving skills compared to those in traditional educational settings (Nesbit et al., 2023; Almulla, 2023). Also, constructivism supports this notion by asserting that learners must actively engage with the material to construct meaningful knowledge (Alfieri et al., 2011; Xu, et al., 2023). Activities that promote interaction, such as hands-on projects, discussions and group work, empower learners to connect new knowledge with their prior experiences.

Both constructivist and inquiry-based methods depend heavily on social interaction and teamwork (Mulyenı, et al., 2024) The social constructivist theory of Vygotsky contends that instructors and peers play a crucial role in the social interactions that shape knowledge (Atanasova et al., 2024; Akkus, et al., 2022). Collaborative learning settings promote discussion, the exchange of varied viewpoints, and the development of deeper comprehension through group projects (Tan & Nashon, 2015). Group activities improve the learning process by promoting students to express their ideas, question preconceived notions, and negotiate meanings, according to research (Ates, et al., 2018). When paired with learner-centred pedagogy, flexible learning environments are seen favourably by users for instruction, learning and student welfare (Kariippanon, et al., 2018).

Inquiry-based teaching methods often incorporate problem-based learning (PBL), where students confront real-world challenges that necessitate critical decision-making and research skills (Xu et al., 2023). This approach stimulates their curiosity and encourages them to explore and analyse the contexts surrounding the problems they encounter. Alfieri et al. (2011) argue that an optimal learning experience arises from a blend of structured guidance and open-ended inquiry, enabling learners to navigate complexities while receiving adequate support. The findings of Caleon et al. (2018) indicate that effective teaching strategies commonly derive from problem-based approaches, emphasising relevant challenges that promote collaboration and innovative thinking (Usman, et al., 2023).

Constructivist teaching methods advocate for assessment practices that align with the principles of reflection and ongoing improvement. Effective assessments within these frameworks are often formative (Ole, et al., 2023), integrating peer feedback, self-assessment, and authentic tasks reflective of real-world applications (Marquez et al., 2023). This emphasis on constructive feedback is crucial, as demonstrated by Gazmuri et al. (2015), who highlight the role of well-structured assessments in creating learning conditions that enhance academic success by providing targeted guidance for improvement.

Both inquiry-based and constructivist approaches also endorse authentic learning experiences that connect classroom learning to students' lives. This alignment with real-world contexts motivates students and makes their learning relevant and engaging (Holmes et al., 2021, Uzel, et al., 2022). Research conducted by Yigit et al. (2017) indicates that when students can relate their educational experiences to authentic situations, including those relevant to their local environment and cultural context, their engagement and retention of knowledge significantly improve.

Review of Related Literature

Numerous studies (Agarkar, 2019; Antonio & Prudente, 2024; Hattie & Donoghue, 2016; Alanazı, 2020) emphasise the critical importance of adopting contemporary pedagogical methods that prioritise student engagement and promote active learning in science education.

Docktor et al.'s research (2015) on conceptual problem-solving in high school physics reinforces the significance of instructional methods that foster active engagement and critical thinking. Nevertheless, a study by Wallace and Kang (2004) highlights a troubling reality: secondary science teachers often harbuor conflicting beliefs regarding inquiry-based teaching methods, thereby underscoring the urgent need for professional development aimed at enhancing their instructional efficacy.

Yigit et al. (2017) conducted a study in Turkey that revealed interesting insights regarding the classroom environment. Their research demonstrated that students in smaller science classes, particularly in urban schools, reported more positive experiences within constructivist learning settings. Savasci and Berlin's (2012) study illustrated that various external factors, such as school culture and administrative support, significantly influence teachers' capacity to implement innovative teaching concepts successfully.

Tan and Nashon (2015) argue that collaborative efforts among teachers can lead to improved educational outcomes, increase teachers' confidence in employing modern teaching strategies, and enhance their overall comprehension of the curriculum. In addition, research conducted by Özdemir and Kaptan (2013) indicates that instructors' positive attitudes and proficiency in scientific process skills—key components of effective instruction—vary significantly.

Teaching methodologies are profoundly influenced by teachers' pedagogical beliefs, experiences, and the contextual factors surrounding their educational environments. According to Lim and Chai (2008), an educator's pedagogical beliefs play a significant role in determining how they plan and implement various teaching strategies, which, in turn, affects classroom dynamics. Teachers with progressive beliefs typically adopt creative and interactive teaching methods, while those with traditional beliefs tend to favour more conventional instructional techniques, as noted by Qhobela and Kolitsoe Moru (2014). A critical factor that influences the choice of teaching approach is the extent of teaching experience. Research by Caleon et al. (2018) has shown that teaching experience profoundly impacts the attitudes and behaviours of teachers, especially in challenging subjects such as physics.

As already noted, the context in which teachers operate significantly affects their teaching approaches. Institutional policies, curriculum mandates, and available support from school administrators can heavily influence teachers' decisions regarding instructional practices. Studies indicate that teachers working in supportive environments, characterised by mentoring and professional development opportunities, are more likely to explore innovative teaching methods (Allen, 2023; Davis & Chick, 2022). Conversely, those facing rigid curricular constraints may feel pressured to adhere to traditional methods, despite their progressive beliefs (Archer et al., 2020). Additionally, teachers' subject knowledge and pedagogical content knowledge (PCK)—a concept coined by Shulman (1986)—are vital factors that shape their classroom strategies. PCK refers to the interplay between content knowledge and pedagogical strategies, and teachers who have a deep understanding of their subject matter combined with effective pedagogical techniques are more likely to implement varied teaching methods that align with both their pedagogical beliefs and their students' learning needs.

Recent research has revealed significant trends in teacher attitudes and self-efficacy in science, particularly physics. These studies highlight current perspectives and areas needing further investigation (Vlachos et al., 2024; Stylos et al., 2023). Research on pre-service science teachers shows a generally positive outlook towards science education, along with high expectations for teaching effectiveness and personal confidence (Eric et al., 2018). Additional studies have examined teachers' abilities to manage constructivist learning environments, underscoring this pedagogical approach's importance (Can & Kaymakcı, 2015). An analysis of attitudes among physics, chemistry and biology teachers towards constructivist methods indicated a positive correlation with their demographic backgrounds, fostering innovative teaching strategies (Ã-nen et al., 2018). This suggests that teachers' backgrounds may shape their openness to innovative pedagogies. Lastly, a study in Zambia explored technology integration among 202 pre-service teachers, identifying key factors such as gender and year of study that influence this integration (Bwalya & Rutegwa, 2023). The findings revealed that male pre-service teachers and those in later years of training reported higher levels of technological self-efficacy, suggesting that both demographic and academic factors shape readiness for effective technology use in teaching.

In line with developments in many countries, the Iranian physics curriculum has been revised in recent years. The new curricula emphasise active approaches based on constructivism, such as inquiry and phenomenon-based learning using experiments. In Iran, the goal of science education is to educate responsible citizens towards themselves, society, and the environment. Considering the evolution of science education and its goals, choosing an appropriate approach to teaching science has always been one of the important challenges for educators (Shekarbaghani, 2016).

Despite extensive international research, empirical studies on in-service physics teachers in Iran remain scarce. Global findings cannot be directly generalised due to Iran's unique sociocultural and educational context. This study addresses this gap by examining Iranian physics teachers' instructional approaches and their relationship with key demographic factors. Conducting research on the teaching approaches employed by Iranian physics teachers is critically important, given the significant absence of scholarship in this domain. While global educational trends are increasingly embracing innovative pedagogical techniques—such as inquiry-based and constructivist teaching—there remains a conspicuous lack of rigorous examination and adaptation of these methods within the Iranian context (Golestaneh & Mousavi, 2024). This deficit not only inhibits the development of effective teaching strategies that could significantly enhance students' learning experiences but also restricts educators' opportunities to align their practices with the evolving international standards that prioritize active student engagement and critical thinking (Golestaneh & Mousavi, 2024). Moreover, understanding the intricate factors influencing teaching methodologies in Iran is essential for educational reform. Such insights will empower policymakers and educators to devise targeted interventions that address the unique challenges within the local educational environment (Zarean, et. al, 2024). By delving into these teaching methodologies, this research aspires to illuminate the educational landscape in Iran and contribute to the establishment of a comprehensive framework that promotes effective physics instruction, ultimately benefiting both teachers and students in their pursuit of knowledge and understanding.

Aims and Research Questions

The purpose of this study was to examine the instructional approaches of Iranian physics teachers and investigate these approaches in relation to their gender, age, and years of service.

Generally, understanding the differences between the methods teachers employ and those that are appropriate for teaching physics is the primary goal of our research on the teaching strategies of physics teachers. This study included the teachers of secondary schools in Iran and was conducted with the aim of addressing the following research questions:

Q1: What approaches are used by Iranian physics teachers in the classrooms?

Q2: What is the relationship, if any, between teachers' approaches and their gender, age, and the number of years in service?

Methods

This study employed a quantitative approach using a survey methodology. Surveys are a research design specifically intended to depict the present state of affairs (Fraenkel et al., 2023). The study was conducted in two phases: the first phase to develop and to validate a questionnaire, and the second phase to answer the research questions using the developed questionnaire. IBM SPSS Statistics 26 was used for the confirmatory and explanatory analyses. The EFA was used to determine the teaching approaches used by physics teachers, and the CFA was used to confirm the emerging teaching approaches.

Study Group

In the first phase, 573 secondary school physics teachers in Iran were invited to participate through professional teacher networks, and questionnaires were distributed to those who volunteered, using a convenience sampling approach.

It was given to 300 people for Explanatory Factor Analysis (EFA) and to 273 people for Confirmatory Factor Analysis (CFA). Finally, the developed and validated questionnaire, structured into three sections on teaching approaches, was distributed to 500 physics teachers across the country through a convenience sampling approach, ensuring no individual was selected more than once.

Data Collection Tools

To create the questionnaire, a pilot study was conducted to create a set of items (teaching activities) using the properties of teacher-centred and student-centred teaching and learning theories as a basis; six-point rating scale was chosen for each item, and the validity (face and content validity) and reliability of the questionnaire were assessed. Following the development of an item pool (the question pool consisted of 53 items), the questionnaire's content validity was evaluated using both quantitative and qualitative methods by a panel of six experts, three of whom were seasoned physics instructors with knowledge of various instructional techniques and the other three of whom were university personnel with extensive backgrounds in physics education.

The expert panel was responsible to assess the structure, rating scale, and wording of the items of the questionnaire. In the first step, the expert panel reviewed the items of the questionnaire and reached consensus on wording, sequencing, and removing the items. Overall, 46 items were selected.

In the next step, the expert panel surveyed the structure of the questionnaire using pre-defined three criteria, i.e. not at all representative, somewhat representative, or clearly representative. Subsequently, a three-point rating scale ranging from 0 to 2 and also CVR (Waltz & Bausell, 1981) were calculated for each item. CVR was determined based on the formula as follows:

$$CVR = \frac{n_e - N/2}{N/2}$$

Where n_e is the number of experts who considered the item as 'clearly representative', and N is the total number of experts. The results of the evaluated CVR for each item are reported in Table 1. In the second step, none of the items were omitted. Finally, with the help of the expert panel, an even (six-point) Likert-type, including strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree, was selected for all the items.

Table 1

CVR coefficients for questionnaire items

Item number	CVR	Item number	CVR	Item number	CVR	Item number	CVR
1	1	13	0.88	25	1	37	1
2	0.88	14	0.88	26	1	38	1
3	1	15	1	27	1	39	1
4	0.88	16	1	28	1	40	1
5	0.88	17	1	29	0.88	41	1
6	1	18	1	30	1	42	1
7	1	19	1	31	1	43	1
8	1	20	0.88	32	1	44	1
9	1	21	1	33	0.88	45	1
10	0.75	22	1	34	1	46	1
11	1	23	0.88	35	1		
12	1	24	1	36	1		

*Note.*The numerical value of CVR was determined from Lawshe's table for determining the minimum value.

To measure the face validity of the questionnaire, we conducted a pre-test to assess the clarity and readability of the developed 46-item questionnaire among 15 teachers, representing both genders, from novices to experienced, and different education levels from Bachelor's to Doctoral. During pre-testing, some participants gave suggestions to change question items to spoken patterns instead of sentence patterns and also modify some words of question items for further clarifying and understanding. To assure face validity, we changed the wording of the items based on pre-testing results and suggestions from the participants. These alterations were not influenced the original items' intrinsic meaning but improved the questionnaire's clarity and accuracy in data collection.

Data Analysis

The explanatory (EFA) and confirmation (CFA) factor analyses were performed using IBM SPSS Statistics 26. The EFA was used to determine the teaching approaches used by physics teachers, and the CFA was used to confirm the emerging teaching approaches. Before performing EFA, the sampling adequacy and sphericity assumptions were assessed. The Kaiser–Meyer–Olkin (KMO) measure indicated that a sample of 273 responders was adequate (KMO=0.914) to conduct EFA, and Bartlett's sphericity test rejected the null hypothesis that the correlation matrix was identical ($p<0.001$). The collected data were analysed using IBM SPSS Statistics 26 to answer the research questions. To carry out factor analysis, we needed to extract the number of factors. To this end, we used the scree plot. EFA was run using the maximum likelihood factor extraction method with the Varimax rotation and Kaiser normalization based on the polychoric correlation matrix. Only items with factor loading greater than 0.4 were considered in EFA. To check the validity of the construct, we ran CFA using IBM SPSS Amos 26. The discriminant validity was also checked by evaluating the factor correlation matrix of the final exploratory factor analysis. Also, the average variance extracted (AVE) values of all factors were calculated. In the second phase of the study, to compare the dominant teaching approach between female and male teachers, we used the Mann-Whitney U test. Also, in order to compare the dominant teaching approach between teachers with different work experiences, we employed the Kruskal-Wallis H test.

Findings

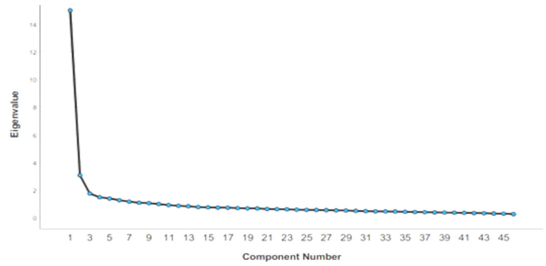
Data Extracted to Answer the First Research Question

First-Order EFA

The created questionnaire was given to 273 physics teachers to investigate the teaching methods they employed in their classrooms. We performed a univariate item analysis on the data collected. The data were converted to numeral scores, ranging from 1 to 6, for items based on participants' responses as mentioned previously. Blank responses were omitted case-wise from the analysis. The data were analyzed using the SPSS software package (version 26) and Microsoft Excel Spreadsheet Software (version 2016). The mean scores of the items in the questionnaire were 4.22 (as minimum score) and 5.49 (as maximum score), and standard deviations were from 0.769 to 1.339. The results of the scree plot and the total variance explained in the output showed that six factors could explain 57% cumulative rotation sums of squared loadings (Fig. 1).

Figure 1

Scree plot



The first EFA output revealed that among 46 items, 10, 6, 5, 6, 5, 3, 4, 3, and 2 items were loaded in factors 1, 2, 3, 4, 5, 6, 7, 8, and 9, respectively. In this step, the factor loading of items 2 and 40 was lower than 0.4 (Table 2). The discriminant validity showed no correlation coefficients were greater than 0.7; hence, the factors derived from EFA revealed adequate discriminant validity among the factors. The factors and related items are shown in the Table 2.

Table 2

Factors and related items

Factor	Number of items	Items
Interactive class (IAC)	10	Q44, Q37, Q39, Q30, Q41, Q27, Q13, Q14, Q34, Q46
Interesting class (IC)	6	Q4, Q7, Q9, Q10, Q11, Q24
Textbook-based class (TBC)	6	Q1, Q12, Q22, Q26, Q29, Q31
Technology-based class (TC)	3	Q15, Q23, Q28
Criterion-based class (CBC)	3	Q33, Q35, Q43
Process-based class (PBC)	5	Q18, Q36, Q16, Q20, Q21
Rule-based class (RBC)	5	Q3, Q5, Q6, Q8, Q19
Problem-based class (PC)	4	Q17, Q25, Q32, Q45
Discipline-based class (DBC)	2	Q38, Q42

Factors Extracted From First-Order EFA

The Interactive Class (IAC) factor reflects an approach in which the teacher designs classroom activities based on interaction and tries to promote students' learning through interaction with themselves (e.g. Q39, Q14, Q37, Q27), peers (e.g. Q44, Q13, Q41) and the teacher (e. g. Q34, Q39, Q41). In this factor, teachers aim to create an environment where students can apply scientific process skills; they also ask students to explain their perceptions of each activity, draw conclusions, and generalise those conclusions to new situations. This type of instructor creates an environment in the classroom where students feel comfortable sharing their ideas and makes use of various (optimal) setups to keep an easy eye on their actions. All learners are assessed based on their own abilities, and the teacher attempts to assist students in solving problems on their own. Such a teacher undoubtedly understands contemporary approaches to education.

The Technology-Based Class (TC) factor reflects an approach in which the teacher uses slides and clips to teach a topic and usually prepares a related clip or experiment for each training session. The teacher evaluates the students' activities by filling in checklists.

In the Discipline-Based Class (DBC) factor, when a teacher does not have sufficient time to complete a concept, instruction is continued in the following session, and questions unrelated to the current topic are deferred until after class.

In the Intersting Class (IC) factor, the instructor uses activities that draw the attention of students and hold their interest at the start of the class, such as experiments or activities based on prior knowledge; attempts to guide them based on their preconceptions about the subject and helps them to complete the activity steps independently; asks them to reflect on and discuss how they can apply what they have learned to their daily lives and tries to relate what is taught to daily life; concludes each book chapter with a test. This instructor values deep understanding and feels that positive interactions with pupils are essential for this.

In the Rule Based Class (RBC) factor, the teacher usually expresses the students' educational expectations and goals at the beginning of the class; asks her/his students to express in their own words what they have learned; designs educational activities based on the results of the diagnostic assessment. This teacher uses a variety of diagnostic assessments.

In the Textbook-Based Class (TBC) factor, the teacher usually divides the book chapters into small parts; covering the textbook content is important, and they have a structured programme for it throughout the academic year. Monitoring is essential, so the classroom is arranged to allow the teacher access to all parts of the class. When necessary, teachers also address students' faulty pre conceptions.

In the Problem Based Class (PC) factor, the instructor assigns a variety of tasks for students to practise in different topics and provides relevant books and resources. This teacher prioritises the learning process over the end result.

In contrast, the teacher in a Criterion Based Classroom (CBC) usually pays more attention to the pupils who receive the highest marks. The teacher goes on to the following subject after the majority have achieved good marks. The teacher expects students to remain quiet and compliant during teaching.

First and Second-order CFA

To determine whether EFA proposed a nine-factor model with the 46-item questionnaire can assess the teaching approach of physics teachers, we ran CFA using a different sample of 300 participants two times: the first time for first-order CFA and the second time for second-order CFA (Table 3, 4).

Table 3

Factor loading results of the final EFA model

Item	Factor									Communalities
	IAC	IC	PBC	TBC	RBC	TC	PC	CBC	DBC	
q44	.724	.094	.081	.123	.093	.200	.043	.036	.092	0.615
q37	.717	.330	.056	-.041	.066	.094	.136	.036	.011	0.661
q39	.667	.215	.032	-.100	.051	.186	.074	-.055	.220	0.596
q30	.633	.038	.127	.018	.242	.214	.032	.209	-.081	0.574
q41	.611	.161	.314	.195	.125	.029	.082	-.041	.080	0.567
q27	.602	.187	.214	.304	.222	.002	-.022	.164	.036	0.613
q14	.529	.228	.271	.075	.315	.230	.078	-.122	-.008	0.584
q13	.493	.330	.149	.173	.068	-.013	.153	-.181	.081	0.471
q34	.439	.058	.418	.027	.336	.229	-.146	.174	-.026	0.589
q46	.420	.027	-.177	.365	.233	.317	.049	.069	.001	0.504
q4	.055	.732	.048	.037	.175	-.003	.057	.074	-.094	0.590
q11	.374	.649	.072	-.027	.239	.162	.049	-.138	.080	0.678
q9	.266	.629	.013	-.070	-.002	.380	-.079	.197	.023	0.661
q7	.358	.588	.104	.220	.041	-.014	-.014	-.209	.075	0.585
q10	.259	.521	.198	.001	.354	.234	.014	.124	.199	0.612
q24	.180	.476	.473	.288	.060	.022	.110	-.092	-.066	0.596
q2	.291	.339	.117	.257	.318	.187	.037	-.046	-.008	0.419
q18	.216	.140	.666	.171	.144	-.007	.050	.063	.157	0.591
q36	.427	.015	.559	.148	.203	.016	.092	.000	.091	0.575
q20	.188	.234	.514	.406	.166	.073	.011	.022	-.069	0.558
q16	-.195	.022	.472	.235	-.013	.355	.135	.199	.227	0.552
q21	.396	.174	.459	.031	.196	.264	.137	.118	.000	0.540
q22	.113	.029	.227	.672	-.010	.127	.063	.224	-.016	0.588
q12	-.045	.065	.047	.558	.217	.138	.203	-.122	.272	0.516
q26	.467	.065	.091	.494	.138	.045	.012	.190	-.012	0.532
q29	.049	.046	.400	.458	.023	.241	.160	.135	.236	0.533
q1	.160	-.021	.197	.431	.304	.334	.195	-.181	-.009	0.526
q31	.353	.181	.192	.420	.101	-.053	.098	-.108	.268	0.476
q5	.118	.232	.043	.141	.755	-.035	.118	.050	.127	0.693
q6	.211	.344	.230	.034	.587	-.002	-.112	.075	.024	0.580
q19	.304	-.019	.374	.041	.481	.365	-.011	.135	.070	0.623
q3	.338	.102	.167	.268	.466	.144	.096	.043	.024	0.474
q8	.315	.330	.246	.138	.415	.381	.061	-.185	.007	0.643
q28	.299	.167	-.018	.199	-.015	.690	.091	.052	.004	0.645
q15	.107	.222	.145	.204	.005	.682	.031	-.094	.137	0.617
q23	.276	-.056	.125	-.029	.333	.571	.136	.190	-.020	0.588
q25	.031	.030	.028	.146	.043	-.020	.766	.137	-.060	0.636
q32	.079	-.068	.122	.298	-.090	.110	.664	.315	.057	0.678
q45	.413	.176	.017	.014	.087	.171	.541	.025	.092	0.540
q17	.161	.005	.312	-.091	.198	.207	.431	-.267	.131	0.488
q43	.086	.011	.004	-.035	.117	.063	.154	.713	.070	0.564
q35	-.017	-.215	.197	.295	.150	-.107	.112	.487	.243	0.515
q33	.420	.253	.128	.278	-.168	.055	.102	.422	.054	0.556
q40	-.036	.052	.227	.333	-.081	.179	.109	.386	.383	0.513
q38	.143	-.040	-.080	.122	.038	.085	-.139	.108	.757	0.656
q42	.098	.052	.294	.017	.111	-.011	.178	.067	.616	0.527
Variance (%)	12.699	7.343	6.859	6.497	6.121	5.912	4.266	4.140	3.642	
Cumulative (%)	12.699	20.042	26.901	33.398	39.519	45.430	49.696	53.836	57.478	

Note. IAC: Interactive class, IC: Interesting class, TBC: Textbook-based class, TC: Technology-based class, CBC: Criterion-based class,PBC: Process-based class,RBC: Rule-based class,PC: Problem-based class,DBC: Discipline-based class

Table 4

Factor correlation matrix of the final EFA model

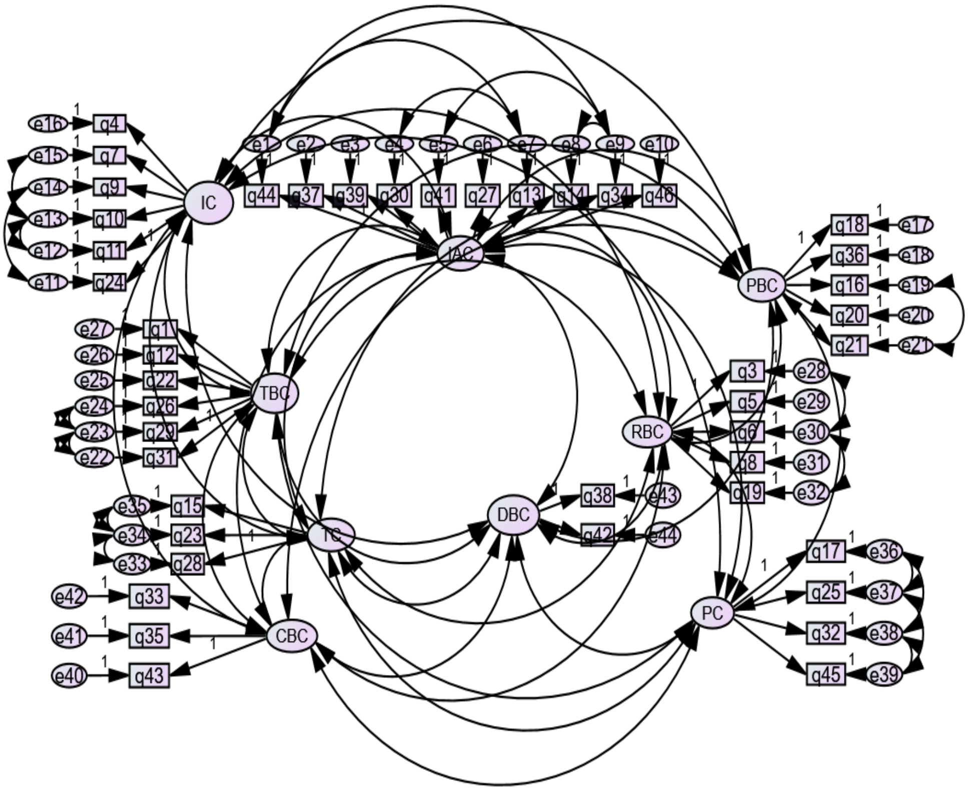
Factor	IAC	IC	TBC	TC	CBC	PBC	RBC	PC	DBC
IAC	1.000								
IC	0.647	1.000							
TBC	0.610	0.491	1.000						
TC	0.540	0.415	0.632	1.000					
CBC	0.689	0.623	0.621	0.545	1.000				
PBC	0.545	0.451	0.454	0.467	0.510	1.000			
RBC	0.397	0.269	0.423	0.441	0.334	0.373	1.000		
PC	0.316	0.156	0.394	0.370	0.244	0.226	0.327	1.000	
DBC	0.250	0.168	0.295	0.323	0.249	0.182	0.180	0.290	1.000

Note. IAC: Interactive class, IC: Interesting class, TBC: Textbook-based class, TC: Technology-based class, CBC: Criterion-based class,PBC: Process-based class,RBC: Rule-based class,PC: Problem-based class,DBC: Discipline-based class

We described the first-order CFA nine-factor model with the SEM diagram (Fig. 2).

Figure 2

SEM diagram of the first-order CFA nine-factor model



All loadings ranged from 0.466 (q38) to 0.863 (q32), and the average of each factor was greater than 0.690. Standardized factor loadings of nine factors are presented in Table 5.

Table 5

Standardized factor loadings of different factors

	Factor								
Item	IAC	IC	PBC	TBC	RBC	TC	PC	CBC	DBC
q44	0.775								
q37	0.733								
q39	0.721								
q30	0.671								
q41	0.766								
q27	0.733								
q14	0.764								
q13	0.704								
q34	0.673								
q46	0.540								
q4		0.685							
q11		0.762							
q9		0.706							
q7		0.623							
q10		0.815							
q24		0.71							
q2									
q18			0.667						
q36			0.689						

q20			0.732						
q16			0.748						
q21			0.739						
q22				0.572					
q12				0.595					
q26				0.538					
q29				0.705					
q1				0.636					
q31				0.673					
q5					0.557				
q6					0.739				
q19					0.780				
q3					0.727				
q8					0.790				
q28						0.744			
q15						0.774			
q23						0.740			
q25							0.592		
q32							0.863		
q45							0.683		
q17							0.697		
q43								0.509	
q35								0.586	
q33								0.660	
q38									0.466
q42									0.811

Note. IAC: Interactive class, IC: Interesting class, TBC: Textbook-based class, TC: Technology-based class, CBC: Criterion-based class,PBC: Process-based class,RBC: Rule-based class,PC: Problem-based class,DBC: Discipline-based class

Each item exhibited a statistically significant loading on its respective latent factor. Using these factor loadings, the average variance extracted (AVE) values of all (1-9) factors were calculated. The values of all factors, except for factor 4, were above 0.5. The value of AVE of the same factor was below 0.5, meaning that factor 4 has insufficient convergent validity. However, factors specific item loadings were acceptable for convergent validity, and there were no items with loading below 0.5. As these items were significant during CFA and measured the teaching approach of physics teachers, we preserved this factor in the model. Model fit indicating the first-order CFA nine-factor is shown in Table 6.

Table 6

Model fit indices of the first-order CFA

Factor	Value	Factor	Value
CMIN	1831.171	Df	847
Chi-square/df	2.162	GFI	0.874
NFI	0.853	CFI	0.848
RMR	0.077	RMSEA	0.062

The ratio of the chi-square to the degree of freedom ( ) was used to determine the overall model fitness. As recommended by Schreiber et al. (2006), the ratio should not exceed 3. In the current study, the observed value was 2.162, suggesting that the model is fit for purpose. Other measures of fitness have been observed, as well. Bagozzi and Yi have reported that the acceptable range for RMR is less than 0.08 and for GFI, NFI, and CFI is greater than 0.9 (Bagozzi & Yi, 1988). These results show that all the values are either in the acceptable range or closer to the acceptable range; therefore, the model fitness is appropriate.

After performing the first-order CFA nine-factor, we run a second-order CFA based on the teaching approach. This second-order model was provided in accordance with the approaches proposed by Trigwell and Prosser (1996). Thus, considering emerging factors in EFA, the following three approaches were suggested: student-focused strategy aimed at them developing their own conception (approach A), teacher/student interaction with the intention that they acquire deep concepts of the discipline by themselves (approach B), and teacher-focused strategy with the intention of learners acquiring the concepts of the discipline (approach C) (Table 7).

Table 7

Emerging approaches based on CFA

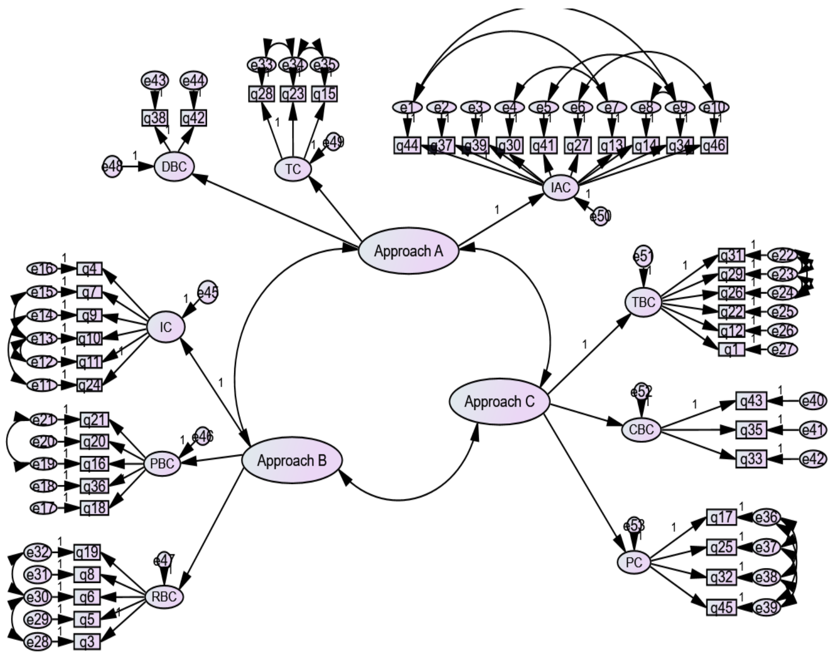
Factor	IAC	IC	TBC	TC	CBC	PBC	RBC	PC	DBC
Approach A: student-focused aimed at students developing their conception	✓			✓					✓
Approach B: teacher/student interaction with the intention that students acquire deep concepts of the discipline by themselves		✓				✓	✓		
Approach c: teacher-focused with the intention of students acquiring the concepts of the discipline			✓		✓			✓	

Note. IAC: Interactive class, IC: Interesting class, TBC: Textbook-based class, TC: Technology-based class, CBC: Criterion-based class,PBC: Process-based class,RBC: Rule-based class,PC: Problem-based class,DBC: Discipline-based class

The SEM diagram is shown in Figure 3.

Figure 3

SEM diagram of the second-order CFA



Model fit indices showed all the values are either in the acceptable range or are closer to the acceptable range; therefore, model fitness is appropriate (Table 8).

Table 8

Model fit indices of second-order CFA

Factors	Values	Factors	Values
CMIN	1909.260	Df	868
Chi-square/df	2.20	GFI	0.862
NFI	0.843	CFI	0.839
RMR	0.063	RMSEA	0.063

After evaluating the validity of the questionnaire, its reliability was assessed. The result is depicted in the Table 9.

Table 9

Cronbach's alpha reliability coefficient of the questionnaire

Approach	Cronbach's alpha	number of items
A	0.897	15
B	0.923	16
C	0.811	13
overall	0.954	44

Data Extracted to Answer the Second Research Question

The electronic version of the questionnaire was distributed between participants in the second phase of this study. The distribution of teachers according to gender, age, and the number of years in service is summarized in the Tables 10 , 11.

Table 10

Distribution of physics teachers according to gender

Participants	Number	Female	Male
Number of teachers	500	273	227
Percentage	100	54.6	45.4

Table 11

Descriptive statistics of physics teachers according to age and the number of years in Service

Factor	Minimum (%)	Maximum (%)	Mean	SD
Age	20	70	40.24	8.78
Number of years in service	1	52	17.69	9.48

The mean and standard deviations of physics teachers' approaches are depicted in Table 12.

Table 12

Mean and standard deviations of physics teachers' approaches

Approach	Numbers of items	Maximum attainable scores (%)	Maximum attainable scores (%)	Mean	SD
A	15	90	78.8	70.92	9.98
B	16	96	84.12	80.76	10.11
C	13	78	81.87	63.86	7.26

Overall	44	264	81.64	215.54	24.92

Also, we studied the effect of gender, education, and the number of years of service on the physics teaching approach. The scores of responders showed that each teacher uses a combination of approaches that we found in the previous phase. Thus, based on the order of the teaching approach used by teachers, we divided each approach into three levels: first, second, and third. These levels determined the teaching approach's order based on the teacher's scores in each approach. As shown in Table 13, the results showed that the dominant teaching approach among teachers was Approach B, followed by Approach C and Approach A; the dominant teaching approach did not depend on the gender of the teachers.

Table 13

Distribution of order of teaching approach based on gender

Approach	Order	Number of females	Number of males	total
A	First	24	24	48
	Second	91	68	159
	Third	158	135	293
B	First	163	123	286
	Second	89	78	167
	Third	21	26	47
C	First	97	86	183
	Second	82	75	157
	Third	94	66	160

The results of Mann-Whitney U test are presented in Table 14.

Table 14

Analysis of the order of teaching approach based on gender

Approach	Gender	N	M	SD	Z	P
A	Female	273	2.49	0.65	-0.15	0.87
	Male	227	2.48	0.68		
B	Female	273	1.47	0.63	-1.44	0.14
	Male	227	1.57	0.68		
C	Female	273	1.98	0.83	-1.02	0.30
	Male	227	1.91	0.81		

Note. Mann-Whitney U test was used in above table.

The results also showed that approach B is the dominant teaching approach for all teachers of both genders. The distribution of the dominant teaching approach based on the teacher's education level is shown in Table 15, which indicates that the dominant teaching approach does not depend on the teacher's education level.

Table 15

Distribution of order of teaching approach based on teacher's education level

Approach	Order	Number of BSc	Number of MSc	**total**
A	First	24	24	48
	Second	78	81	159
	Third	156	242	293
B	First	144	142	286
	Second	89	78	167
	Third	25	22	47
C	First	97	86	183
	Second	84	73	157
	Third	77	83	160

In order to compare the dominant teaching approach between teachers with BSc and MSc degrees, the Mann-Whitney U test was used. The results of this test are shown in Table 16.

Table 16

Analysis of the order of teaching approach based on the teacher's education level

Approach	Education level	N	M	SD	Z	P
A	BSc	258	2.51	0.66	-0.82	0.40
	MSc	242	2.46	0.67		
B	BSc	258	1.53	0.66	-0.626	0.53
	MSc	242	1.50	0.65		
C	BSc	258	1.92	0.81	-0.867	0.38
	MSc	242	1.98	0.83		

Note. Mann-Whitney U test was used in above table.

The results showed that approach B is the dominant teaching approach for all teachers with every level of education. The distribution of the dominant teaching approach based on the teacher's number of years in service is shown in Table 17. The number of years in service was categorised based on five-year intervals, and all the teachers with more than 30 years of experience were placed in one category (category 7).

Table 17

Distribution of order of teaching approach based on teacher's number of years in service

Approach	Order	> 5	5-10	10-15	15-20	20-25	25-30	<30	total
A	First	25	11	6	5	1	0	0	48
	Second	15	17	23	44	34	26	0	159
	Third	60	15	22	47	71	62	16	293
B	First	48	23	31	59	64	53	8	286
	Second	44	12	10	29	33	31	8	167
	Third	8	8	10	8	9	4	0	47
C	First	36	14	16	34	40	35	8	183
	Second	32	9	16	21	40	31	8	157
	Third	32	20	19	41	26	22	0	160

The results of the Kruskal-Wallis H test showed that the significance level of approach A was 0.0001, which was less than 0.05, and in approaches B and C, these levels were 0.52 and 0.06, respectively, which were greater than 0.05 (Table 18). The results also demonstrated a significant difference in approach A based on the teacher's work experience. To determine the difference between categories, we used the Bonferroni correction test.

Table 18

Analysis of the order of teaching approach based on the teacher's number of years in service

Approach	Number of years in service	N	M	SD	χ^2	P
	Below 5	100	2.35	0.85		
	5-10	43	2.09	0.78		
	10-15	51	2.31	0.67		
A	15-20	96	2.43	0.59	43.76	0.0001
	20-25	106	2.66	0.49		
	25-30	88	2.70	0.45		
	More than 30	16	3.00	0.000		
	Below 5	100	1.60	0.63		
	5-10	43	1.65	0.78		
	10-15	51	1.58	0.80		
B	15-20	96	1.46	0.64	5.18	0.52
	20-25	106	1.48	0.65		
	25-30	88	1.44	0.58		
	More than 30	16	1.50	0.51		
	Below 5	100	1.96	0.82		
	5-10	43	2.13	0.88		
	10-15	51	2.05	0.83		
C	15-20	96	2.07	0.88	11.80	0.06
	20-25	106	1.86	0.78		
	25-30	88	1.85	0.79		
	More than 30	16	1.50	0.51		

Note. Bonferroni correction test was used for approach A and < 5 vs. > 30, SN, p<0.0001; 5-10 vs. 20-25, SN, p<0.0001; 5-10 vs. 25-30, SN, p<0.0001; 5-10 vs. More than 30, SN, p<0.0001; 10-15 vs. 20-25, SN, p<0.0001; 10-15 vs. 25-30, SN, p<0.0001; 10-15 vs. More than 30, SN, p<0.0001; 15-20 vs. More than 30, SN, p<0.001.

Discussion and Conclusion

1. Answer to the First Research Question: What Approaches Are Used By Iranian physics Teachers in the Classrooms?

Based on modern theories of science education, physics educators need to introduce the physics "way of knowing". To achieve this goal, teaching methods should go beyond the traditional methods based on lectures and knowledge transfer (DeBoer, 2019). Sometimes, although they are aware of the high goals of education, teachers and education officials insist on using traditional methods for various reasons, such as covering the headlines of textbooks, responding to parents and officials, high-stakes testing, and saving time and money (Darling-Hammond, 2015). As Gormally (2009) argues, inquiry-based approaches are crucial for developing leaners' scientific literacy and understanding of the "physics way of knowing". Moreover, the results of some studies, such as the study by Antonio and Prudente (2024), encourage science teachers to adapt these approaches to improve their teaching practices and support students in strengthening their higher-order thinking skills.

In approach A, teachers are knowledgeable about various learning theories and believe in the essential role of students in the learning process that is consistent with findings of Hattie and Donoghue (2016). They use students' perceptions and help them construct scientific knowledge through group discussions, reasoning, and reflection. This is consistent with the findings of Aina (2017), who emphasised the importance of physics teachers considering students' prior knowledge, facilitating student interactions, and respecting their ideas for effective learning. Teachers monitor student activities to provide guidance and feedback, rearrange the classroom to facilitate observation, and use multimedia to engage them. This is consistent with the findings of YiGit et al., (2017), who suggested that teachers should focus on encouraging collaboration and designing classrooms for better learning experiences. They use checklists to track student performance and assess each students based on their abilities. This approach fosters deep understanding and critical thinking skills by emphasising interactive lesson plans and peer interaction (Agarkar, 2019). In addition, it incorporates technology and maintains an awareness of time and knowledge limits, which is consistent with constructivist principles. Teachers adopt a targeted approach to teaching with the goal of assisting them in developing their concepts. This approach appears to be consistent with inquiry-based constructivist approaches, and as Gormally (2009) argues, inquiry-based learning consistent with this approach has been shown to be effective in promoting student engagement, scientific literacy, and critical thinking skills. Furthermore, Simeon, et al., (2020) show that the design thinking approach, which is consistent with these principles, positively impacts student achievement in physics, reinforcing the importance of engaging teaching strategies in STEM education.

Teachers in Approach B establishe a methodical process during the class, accompanied by particular guidelines and the approach's key component. Also, instructors place a strong emphasis on the value of student participation in the learning process, because they think that learning occurs most effectively when students' attention is directed toward pertinent topics. They strive for a profound comprehension of subjects by relating classroom material to real-world occurrences and students' existing knowledge. Teachers encourage pupils to express what they have learned in their own terms while guiding them according to their preconceptions. To track progress, they establish clear goals, communicate expectations, and administer tests frequently based on the material in textbooks Recent research indicates that adolescents' participation opportunities significantly enhance student well-being and can lead to increased independence and self-efficacy, which are crucial for effective learning environment (ott, et al., 2023). Additionally, studies show that class participation and feedback are essential for improving academic performance, as active engagement in class activities correlates positively with better learning outcomes (Márquez, et al., 2023). All things considered, this method encourages participation, connects learning activities to students' experiences, and supports in-depth comprehension through regular interaction and evaluation. The size of the school can also influence student participation, with smaller schools often fostering a stronger sense of community and engagement compared to larger institutions (Lotulung, 2023). Furthermore, engaging high school students in active learning classrooms has been shown to enhance their overall educational experience (Davis & Balfanz, 2022; Torsdottir, 2024). In summary, the integration of clear goals, regular assessments, and a focus on real-world connections not only promotes deeper understanding but also aligns with contemporary findings on the importance of student engagement in educational success.

In Approach C, the instructional focus is on delivering information from the textbook according to a predetermined program, prioritising the learning process over the learning outcome. The teacher selects specific sources and sets criteria to guide students in acquiring subject-matter concepts. This approach views teaching as the transmission of knowledge to students. They control the classroom atmosphere by rearranging the classroom, assigning and solving problems related to the subject, and setting expectations for student behaviour and academic progress, as highlighted by Emmer et al., (2021), who discuss how contextualized teaching and learning strategies can improve student engagement and learning outcomes. Their research details the various roles teachers play in managing classroom dynamics and facilitating effective learning processes. Teachers play an essential role in the teaching-learning process and believe that a positive classroom atmosphere and external conditions lead to better learning outcomes. This finding is consistent with the findings of Luo et al., (2024), who believe that the quality of teaching is influenced by teachers' skills in communication and evaluation, and is further shaped by the pedagogical ideas and management techniques employed in the classroom.

As for the primary roles, teachers in Approaches A and B agree that students play a crucial part in the education process. They use various approaches to include them in the learning process, but they hold differing opinions about the nature of their activities and the role of learners. The instructor emphasizes interpersonal and collaborative skills in Approach A. With approach B, on the other hand, the instructor places more of an emphasis on helping each learner grow personally and engage in learning activities (internal conditions), which provides the students the framework for learning. Teachers play a number of roles that are essential to students' learner-centered learning, according to Badjadi's (2020) research. These roles include those of controllers, assessors, managers, resources, tutors, participants, investigators, role models, prompters, editors, instructors, activators, supporters, and facilitators. Teachers are facilitators in Approach A and supporters in Approach B, according to this research's findings. Our results regarding the role of students in Approaches A and B are in line with those of Bhuttah et al., (2024), who emphasized the benefits of creative pedagogical approaches on learning outcomes and student engagement as well as the significance of teacher leadership in establishing nurturing learning environments that support students' interpersonal and personal growth. In contrast to the first two methods, approach C holds that learning can only occur when external factors are under control. Teachers are an integral part of the teaching-learning process and monitor it. In this approach, the teacher has the role of a controller and this role naturally influences classroom practices (Özdemir & Kaptan, 2013).

In terms of the activities designed by the teacher, Approach A encourages students to apply and develop their scientific process abilities through tasks such as generalizing and drawing conclusions, presenting and elaborating on concepts, and reflecting. In contrast, Approach B places greater emphasis on direct instructor assistance for skill development and performance of activities, as highlighted by Gizaw and Sota (2023), who discuss how different teaching strategies can effectively enhance learners' engagement and learning outcomes in science education. Teachers play a more important and systematic role in the teaching-learning process in this approach compared to approach A, as noted by Caleon, et al., (2018), who noted that teaching experiences influence teachers' beliefs and practices, which ultimately affect their effectiveness in managing classroom dynamics and facilitating learning. They emphasised that classroom practices were more aligned with teachers' beliefs about learning physics, rather than teaching physics. Approach C involves a teacher who views problem solving as a means of teaching. The instructor designs activities that require students to solve a large number of problems, believing that this approach helps students develop their skills and learning. From the perspective of evaluation, pupils are assessed according to their abilities in Approach A and according to textbook chapters in Approach B. With strategy C, the instructor often presents the students with the highest scores after evaluating them based on the subject matter of each course. Research indicates that problem-solving methods significantly enhance student engagement and learning outcomes (Ezeddine, 2023; Emmer et al., 2021), while also promoting higher-order thinking skills (Tambunan, 2019). This integration provides a well-rounded reference base for your discussion on Approach C.

It can be claimed that Technique A is congruent with constructivism because, in general, the instructor aims for students to develop critical thinking abilities, collaboration, and a comprehensive grasp of subjects. According to research, constructivist classrooms encourage learners to engage in self-reflection and self-questioning, which enhances their ability to evaluate information critically and build knowledge independently (Xu, et al., 2023). Studies indicate that constructivist environments promote deeper knowledge acquisition through interactive learning experiences, allowing learners to relate new information to their existing knowledge bases (Le & Nguyen, 2024). Strategy C, aligns with findings that emphasise a more traditional style of teaching, where the teacher exerts significant control over classroom dynamics, often at the expense of student engagement and autonomy.

According to a study by Gazmuri et al., (2023), effective classroom management is crucial for maintaining order and achieving educational goals, but an overly controlling environment can hinder pupil participation and critical thinking. The research indicates that while some level of control is necessary for classroom management, excessive focus on content delivery can detract from fostering a collaborative learning atmosphere that encourages student input and reflection. In other words, if we consider the three approaches as a spectrum, Approach B falls in the middle of the spectrum between Approach A and Approach C, which represent two extremes. As we move closer to Approach C, the role of the teacher becomes increasingly important, and the focus shifts from conceptual understanding to the transfer of predetermined knowledge. This observation aligns with previous studies that highlight the need for a balance between teacher-led instruction and student-centred learning to foster critical thinking skills effectively.

This research showed that teachers use a combination of three approaches in their teaching. The dominant approach among physics teachers was approach B, as was also highlighted by Caleon et al., (2018); and in second place is approach C, and the use of approach A is the least popular among teachers in teaching physics.

According to the results, it can be said that the teaching approach used by teachers does not meet the objectives of Iranian physics textbooks, and this result can be seen in international tests such as TIMSS. The distribution of approaches shows that most physics teachers tend to cover all the contents of the textbook (as also noted by Wallace and Kang (2004)), and students learn the contents presented in the textbooks in depth and do not try to develop their concepts. In order to achieve this goal, they often seek direct guidance from the students or teach with their own focus and convey the concepts of physics to the students. As further noted by Qhobela and Kolitsoe-Moru (2014); Tan and Nashon (2015); Savasci and Berlin (2012), one of the causes of this behaviour is probably a nationwide university entrance exam that is administered at the conclusion of secondary school.

Parents and educational officials expect teachers to prepare students well for this examination. Another reason could be the personal and economic cost that teachers have to pay for the implementation of approaches based on conceptual development. To implement these approaches, a teacher should spend time (Docktor, et al., 2015) and money for participating in and studying the related courses. Alfieri, et al., (2011) and Nesbit et al., (2023) have highlighted that few educators in the education community tend to use pure discovery learning, because this educational approach mostly focuses on the process of science instead of the content. Likewise, construction of correct scientific ideas in pupils, even in proper environments, is time-consuming. McDermott and her collaborators (1999) have proposed discovery learning approaches, which is a combination of scientific constructivism with strong guidance to cover the content of the discipline. In scientific constructivism, a suitable environment to attain the largest fraction of profited students in the teaching and learning process is important. This approach outperforms more than pure discovery and also traditional lecture-based instruction and demonstrates a low reasonably good understanding of science to reach students to large efficiency of understanding. In this regard, Thornton and Sokoloff (1998) have used the McDermott model and revealed that using guided discovery methods during education can be beneficial for a large fraction of students having a robust and functional understanding of many complex topics. Nelsen (2014) and Ates et al., (2018) have also believed that teachers expand their teaching habits based on being educated in, being in, and working in situations made by previous teachers and their discipline's traditions. Overall, habits, capacities of individuals for responses to situations and problems arising from a specific sociocultural context, are acquisitive.

2. Answer to the Second Research Question: What is the Difference, If Any, in Teachers' Approaches Based on Their Gender, Age, and Years of Service?

We examined the correlations between some variables, including gender, educational level, and years of service, and teachers' physics teaching approaches after collecting data on these approaches. Although years of service has an impact on physics teachers' teaching style, the results showed that there was no significant correlation between teachers' gender and educational attainment and their physics teaching approach, which is consistent with the findings of Atanasova et al., (2024), Tan and Cho (2018). It appears that the likelihood of a teacher using only student-centred techniques decreases with experience, which is contrary to the conclusions of study by Lim and Chai (2008). This finding appears to be related to contextual factors such as institutional policies, curriculum mandates, available support from school administrators, and teacher self-efficacy, as suggested by Allen, 2023, Davis and Chick, 2022, and Rashidi et al., (2014) in their study.

Despite the stated limitation, the current study provides insight into the domain-specific beliefs and practices of Iranian physics teachers and underscores the important role that beliefs play in shaping practices situated within authentic classroom settings. Specifically, the findings suggest that more experienced teachers may be less inclined to implement purely student-centred approaches due to various external pressures and expectations. Overall, these findings underscore the need for ongoing professional development that encourages physics educators to adopt inclusive and interactive teaching strategies that balance content delivery with active studnt participation to meet contemporary educational goals.

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Appendix A

Teaching Approach Survey

The questions in this survey will ask you about the teaching activities often used in their classrooms. Please answer the questions patiently, and truthfully. Your answers are very important because we need to understand your teaching approach. Please do your best to answer each question and if you have no idea, skip the question and move on.

You may choose whether or not you want to fill out this survey. By filling out the survey, you agree to be part of this research. Your participation is greatly appreciated!

Gender: Woman ☐ Man ☐

Age: 20-25 years old ☐ 26-30 years old ☐ 31-35 years old ☐ more than 35years old ☐

Level of Education: Below bachelor ☐ Bachelor ☐ More than bachelor ☐ PHD ☐

Years in service: 5 years and below ☐ 6-15 years ☐ 16-25 years ☐ More than 25 years ☐

	Items	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly disagree
Q6	I ask my students to express in own their words what learned.						
Q2	Before starting the teaching, I ask about the student's prior knowledge.						
Q8	I use a variety of diagnostic evaluations						
Q9	At the beginning of the teaching, to start a discussion between students, I propose an activity or an experiment related to the topic.						
Q11	I ask the students to discuss and think about the application of what learned in their daily life.						
Q14	I try to provide conditions for students to use the skills of the scientific process, such as classification, prediction, etc.						
Q18	I use simple activities and examples to attract students' attention.						
Q5	Usually, at the beginning of the class, I express my expectations from the students.						

Q19	I design educational activities based on the results of the diagnosis assessment.						
Q21	I guide the students in activities in such a way they carry out the activity steps themselves.						
Q23	To assess the students' activities, I prepare a checklist and fill it out.						
Q26	The arrangement of my classrooms is in such a way that I have access to all parts of the class.						
Q46	I am familiar with various learning theories.						
Q15	I usually prepare a clip or experiment for each training session.						
Q3	I carefully determine the objectives related to content, before teaching it.						
Q12	Covering the topics of the textbook is important during the design of educational activities.						
Q29	I usually divide book chapters into small parts.						
Q1	I have a program for covering the topics of textbooks during the academic year.						
Q16	At the end of each book chapter, I take a test.						
Q22	I try to cover what is intended to teach.						
Q32	I assign and solve many problems for different topics.						
Q25	I assign a large number of problems to students as exercises.						
Q33	After making sure that the students are proficient in solving the problems, I start teaching the next topic.						
Q28	I use slides and clips for teaching a topic.						
Q35	During teaching, my students should be calm and quiet.						
Q38	If my students ask a non-related question during teaching, I will postpone the answer until after the class.						
Q40	The final score of the students is determined based on the total score of class tests, class activities, and a final exam.						

Q43	Usually, the students who gain the highest grades are introduced.						
Q4	I use the activities which engage students at the beginning of teaching.						
Q31	Sometimes I find it necessary to correct the students' preconceptions.						
Q7	Students preconceptions about the content taught are important to me and I try to guide them based on their preconceptions about that topic.						
Q10	I try to design activities based on student's prior knowledge.						
Q41	The atmosphere of my class allows the students to present their ideas.						
Q13	I design the problems and activities that make students think.						
Q17	In my opinion, the learning process is more important than the learning result.						
Q44	I design activities that make students interact with each other in their groups.						
Q39	I ask my students to explain their perceptions about the content which was taught.						
Q30	I use different(best) arrangements in my classroom to easily monitor the activities of my students.						
Q42	If I don't have time to complete teaching a concept, I continue teaching it in the next session.						
Q36	In my classroom, a deep understanding of conceptions by students is more important than anything.						
Q20	I have well interaction with students during teaching.						
Q27	My feedback to the students makes them find the answer to questions themselves.						
Q24	I try to relate what is taught to daily life.						
Q37	After each activity, I ask students to draw conclusions about it and generalize it to new situations.						
Q45	I try to provide some books and resources related to the topic that is taught to help students.						
Q34	I assess each student according to her/his ability.						

Appendix B

Questionnaire based on approaches

		Items	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly disagree
Approach A	Q44	I design activities that make students interact with each other in their groups.						
	Q37	After each activity, I ask students to draw conclusions about it and generalize it to new situations.						
	Q39	I ask my students to explain their perceptions about the content which was taught.						
	Q41	The atmosphere of my class allows the students to present their ideas.						
	Q14	I try to provide conditions for students to use the skills of the scientific process, such as classification, prediction, etc.						
	Q13	I design the problems and activities that make students think.						
	Q30	I use different(best) arrangements in my classroom to easily monitor the activities of my students.						
	Q15	I usually prepare a clip or experiment for each training session.						
	Q34	I assess each student according to her/his ability.						
	Q27	My feedback to the students makes them find the answer to questions themselves.						
	Q23	To assess the students' activities, I prepare a checklist and fill it out.						
	Q46	I am familiar with various learning theories.						

	Q38	If my students ask a non-related question during teaching, I will postpone the answer until after the class.						
Approach B	Q4	I use the activities which engage students at the beginning of teaching.						
	Q18	I use simple activities and examples to attract students' attention.						
	Q10	I try to design activities based on student's prior knowledge.						
	Q20	I have well interaction with students during teaching.						
	Q24	I try to relate what is taught to daily life.						
	Q11	I ask the students to discuss and think about the application of what learned in their daily life.						
	Q9	At the beginning of the teaching, to start a discussion between students, I propose an activity or an experiment related to the topic.						
	Q7	Students preconceptions about the content taught are important to me and I try to guide them based on their preconceptions about that topic.						
	Q21	I guide the students in activities in such a way they carry out the activity steps themselves.						
	Q36	In my classroom, a deep understanding of conceptions by students is more important than anything.						
	Q6	I ask my students to express in own their words what learned.						
	Q16	At the end of each book chapter, I take a test.						
	Q5	Usually, at the beginning of the class, I express my expectations from the students.						
	Q19	I design educational activities based on the results of the diagnosis assessment.						

	Q3	I carefully determine the objectives related to content, before teaching it.						
	Q8	I use a variety of diagnostic evaluations						
Approach C	Q29	I usually divide book chapters into small parts.						
	Q1	I have a program for covering the topics of textbooks during the academic year.						
	Q22	I try to cover what is intended to teach.						
	Q12	Covering the topics of the textbook is important during the design of educational activities.						
	Q31	Sometimes I find it necessary to correct the students' preconceptions.						
	Q26	The arrangement of my classrooms is in such a way that I have access to all parts of the class.						
	Q35	During teaching, my students should be calm and quiet.						
	Q43	Usually, the students who gain the highest grades are introduced.						
	Q33	After making sure that the students are proficient in solving the problems, I start teaching the next topic.						
	Q25	I assign a large number of problems to students as exercises.						
	Q32	I assign and solve many problems for different topics.						
	Q45	I try to provide some books and resources related to the topic that is taught to help students.						
	Q17	In my opinion, the learning process is more important than the learning result.						