Varying Approaches to Dropout Control in Engineering Colleges: A Narrative Literature Review.

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DOI: https://doi.org/10.51583/IJLTEMAS.2026.150800007

Received: 03 June 2026; Accepted: 08 June 2026; Published: 01 September 2026

ABSTRACT

Dropping out of engineering colleges or programs increases sustainable skill gaps and future dependency rates among young people. Therefore, this study used systematic literature review to explore relevant theories, methods and practices related to dropout behavior prevention or control among engineering students in higher education institutions. Using PRISMA guidelines, the review identified 252 studies and reviewed 43 studies relevant to dropout prevention in engineering colleges. The findings revealed diverse approaches to student retention. It also found pedagogical variation as the frequent and effective intervention while andragogy/seminar, machine learning /data, mindset training and systemic/policy remains least effective measures. The study discusses the implications, recommendations, limitations and future research direction.

Keywords: School dropout; Intervention theories; Intervention methods; Systematic literature review; Engineering education.

Introduction to the study

School dropout is detrimental to student learning and therefore needs intervention (Rumberger, & Lim, 2008; Campbell, 2021). Intervention studies conducted have revealed that provision of mindset training and parental involvement are help-ful in retaining students in schools, including engineering colleges (Bajar & Bajar, 2019). Study outcomes further state that peer collaboration, institutional and environmental transformations, pedagogical variations, psychosocial support, and use of ICT in the delivery of courses contribute to student motivation and presence in school (Bergeson, 2005; Rapp & Corral-Granados, 2021; Trivedi, 2022).

Despite of increasing body of study in dropout prevention, there continues to be lack of clarity concerning which intervention is most impactful and under which conditions they triumph. Therefore, this systematic literature review answers this gap by synthesizing relevant existing studies on school dropout prevention strategies in engineering colleges, with specific attention to studies published from 2000 to 2026.

Recent study from 2022 to 2026 has increasingly concentrated on data driven methods including machine leaning and learning analytics for early identification of at -risk student (Li et al., Herbert, Yeom & Montgomery, 2022; Rubio-Tobar, 2025), and the use of AL-driven pedagogical instruments to influence engagement and self-regulations (Springer, 2026).

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

Objective(s)

The study intends to explore the various methods used in addressing the dropout behavior in engineering colleges. Specifically, it aims to (i) examine different theories relevant to student retention in engineering colleges published from 2000 to 2026 (ii) explore dropout interventions studies in engineering colleges (iii) compare the effectiveness of specific retention intervention (iv) identify conditions under which interventions succeed.

LITERATURE REVIEWED

Theoretical Review

The school dropout prevention study is ground in multiple perspectives that explains motivation, management and persistence in engineering educational environments. Key theoretical frames include Task–Centre Practice, psychological development theory, social learning theory, cognitive behavioral theory, and system theory (Writer, 2020).

Task-Centre Practice was proposed by Reid and Epstein and focuses on the organization of student learning around a constraint with a specific timeline to solve it (Schachter, 1974; Essa, 2018). This method increases the attention and motivation of the student on the task as well as works against the timeline (Getting, 1989; Essa, 2018). This emphasis the importance of practical's experiences or hand—on in keeping students activated. However, the theory is criticized for denying student autonomy and freedom to choose leaning path and limiting leaning activity within a specific time limit (Schachter, 1974). Thus, a need for more psychosocial support during pressure (Munley, 1975). This is likely to affect student performance as emphasis is is laid on only the psychomotor alone intead of the combination of the three learning domains namely engineering cognitive, psychomotor and affective domains.

The psychosocial developmental support of the learner is key to dropout reduction among students. Freud and Erik Erikson (1963, 1968) describe human psychosocial development period as a moment of crisis in which people struggle to pick up identity at various unavoidable stages of life. In other words, it comprises several critical points individual passes through the various developmental stages and must navigate through to become successful in life (Munley, 1975; Writer, 2020). Therefore, aiding learners overcome difficult tasks as they move along the various task levels in different stages is key to restoring student confidence in themselves and the learning process (Essa, 2018). This may include teachers' occasional interventions during learning to make clarifications and encourage students to strengthen their efforts (Meichenbaum, 1977). Despite the roles psycho social development plays in student motivation and confidence, findings suggest that it lacks strong connection between the psychosocial stages and its failure to show the impact of culture on the various stages (Essa, 2018). Thus, a strong connection between the stages will offer smooth learning.

According to Bandura's social learning theory, learning intervention can be done through observation of the social environment, such as lecturers, colleagues, and significant others (Bandura, 1969). However, such learned behaviors can also be unlearned through modifications, comparison, and sanctions (Cherry, 2022). Despite such valuable roles, social leaning theory is delimited for the fact that it can lead to the adoption of wrong learning behaviors form the social environment (Bandura, 1969). Notwithstanding, another study indicated that organizing learning around peer tutoring, teachers' guidance, experts' knowledge sharing, internship and placements, seminars, workshops, and field trips to relevant institutions can enhance student engagement and motivation, which can lead to school retention (Bergeson, 2005).

The cognitive behavioral Theory of Ellis and Beck considers restructuring of student mind set as key to student retention during engineering lessons (Ellis, 1962; Beck, 1976; Meichenbaum, 1977; Bergeson, 2005; Campbell, 2021; Stewart, & Lah, 2023). It is argued that students lacking cognitive restructuring potentials or opportunities

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often cannot overcome their learning challenges and ultimately leading to their potential school exit (Campbell, 2021). Therefore, providing positive mindset training to student will help raise their confidence as indicated by (Meichenbaum, 1977; Bergeson, 2005; Campbell, 2021), which will ultimately minimize their school dropout behavior in engineering colleges. This theory is important for the study because it helps teachers understand how learner become optimistic about learning using mindset trainings and scenarios settings during teaching and learning session. However, it was criticized for not exhaustively addressing children with leprosy and other social problems associated with the mind, as well as not including external conditions (Stewart & Lah, 2023).

The system theory of Niclas Luhmann also offers a solution to learners' challenges by describing that a person is affected by the system in which he/she belongs and within which he/she must confront challenges and overcome them, such as overcoming difficult learning stages with resilience and rigor (Luhmann, 1995; Campbell, 2021; Rapp & Corral-Granados, 2021). Although this theory is seen as enabling people to navigate the various system affecting them in life yet it is not perfect since alterations at one point affect the rest of the system (Rapp & Corral-Granados, 2021; Campbell, 2021).

The theory of needs, which was propounded by Abraham Maslow in 1943, is one of the motivation theories emphasizing the continuous state of human motivation as they try to achieve the five basic needs of life (Maslow, 1943, 1954; Medvedeva, 2023).These needs are physiological needs such as food, water, clothes, sex. When these needs are achieved, man thinks of the next level needs called safety and security needs, such as money, employment, law); then followed by love and belonging needs such as love and being loved to self-esteem needs such as having respect, confidence, mastery, competency and finally self-actualization needs such as achieving all that one needs (Medvedeva., 2023). The author argues that man must achieve all five levels of needs to be considered successful in life. However, this claim is arguable because people have different actualization levels, and those initially considered “actualized groups” were only 18 mostly Caucasian, highly-educated men from western backgrounds, instead of the general population, and only women from the” high class”.

Self-Determination Theory proposed by Deci and Ryan also posits that well supportive environment provides learners psychological needs such as autonomy, competence and relatedness (Deci & Ryan, 1985; Peters & Calvo, 2023; Alberts et al., 2024). In tech-rich settings, SDT-based technology-enhanced designs leverage adaptive feedback, valid rationales, and options to persistency promote durable and quality motivation (Peters & Calvo, 2023; Alberts et al., 2024). In SDT models recently integrated to theory of technology acceptance in higher education settings, the readiness of students to embrace digital technologies is explained by their use in a way that supports their feel of competence and autonomy (Rosli & Saleh, 2023; Katona, & Gyonyoru, 2026).

Integration of Theories

These theories combinedly show the interventions reviewed in this study as indicated in Table 1. **Table 1** demonstrates how each theory links to specific dropout prevention techniques.

Theory	Key Proponent	Core Principle	Related Intervention
Task-Centred Practice	Reid & Epstein (1972)	Structured problem-solving	Project-based learning, time-bound tasks
Psychosocial Development	Erikson (1963, 1968)	Identity formation through stages	Emotional support, guidance through transitions

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Social Learning Theory	Bandura (1969)	Learning through observation	Peer mentoring, internships, expert lectures
Cognitive Behavioral Theory	Beck, Ellis (1962, 1976)	Mindset reconstruction	Mindset training, cognitive restructuring
Systems Theory	Luhmann (1995)	System-level interactions	Institutional support, pol
Hierarchy of Needs	Maslow (1943, 1954)	Motivation through needs fulfilment	Counseling, financial aid, psychosocial support
Self-Determination Theory	Deci & Ryan (1985)	Autonomy, competence, relatedness	Adaptive feedback, personalized learning, choice opportunities

Dropout Intervention Studies.

Several dropout intervention studies have been conducted, as explained below. To determine the influence of mindset training on retention of engineering students.Campbell (2021) did a systematic analysis of 15 studies, with specific attention to different mindset interventions, their effectiveness, and the beneficiaries (Campbell, 2021). The review drew studies from quantitative, qualitative and mixed methods designs sources using measuring scales ranging from 3 to 9 items and 5- 6 Likert scale points. The review also considers the method of trainings used in each study includes reading scenarios, watching videos, and online materials as well as discussions and readings. The review also observed the assessment techniques employed in these studies and found that a positive correlation between mindset training and students' motivation for engineering education. It was further found that training anchored on online tutorials and lecture; discussion, and mindset training for learning, as well as valuing students' feedback better enhanced students' mindset than mere reading (Campbell, 2021).

These findings are useful for educators who want to retain their student through mindset training yet the study was criticized for being focused on western experiences most, since more than eighty-seven percent of the journals reviewed came from the United States and 13.3% from the United Kingdom (Campbell, 2021). This implied the contextual factors were not taken into consideration.

Another study was conducted by Babapour Vajari to determine the role of learning experiences in choosing agricultural engineering majors as a career (Babapour Vajari, 2023) .Specifically, the study focused on the reasons for low retention at Faculty of Agricultural engineering at the University of Zanjan, Zanjan, Iran,(Babapour Vajari, 2023). The study used qualitative methods in which 12 undergraduate students were asked open-ended unstructured interview questionnaires and th and that e data was analyzed through content analysis, and findings revealed that associative and instrumental learning are helpful in the situation. This implied that improper teaching and learning strategies might be responsible for low retention rate. And the associative learning can be used to address it.

This systematic literature review was conducted by Palomino & Ortega on school dropout intervention and found that suitable internal measures, good education policies, and a strong information management system help monitor and control student dropout behavior in higher education engineering institutions. However, study was criticized for being limited to only 2018-2022 thereby narrowing the information scope on the subject matter (Palomino & Ortega, 2023).

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A pilot study was also conducted on the impact of "student community" on twelve adult engineering undergraduate students' retention. The study consisted of twelve (12) adult undergraduate students from engineering and engineering technology programs who received instructions through seminars. Prior to delivery they were first asked to choose the subject they feel more secured and motivated to do which are engineering and engineering technology. The delivery instruction format was seminar during which participants had racially diverse sessions. The perception of the participants was taken pre seminar and post seminar on the level of confidence and motivation towards their chosen program. The findings indicated that the students demonstrated high confidence and motivation level towards their chosen programs (Bullington, 2021). This suggests that engineering students feel more secure and integrated in engineering programs they prefer more.

Another study was conducted on ways to improve student motivation during Engineering graphics challenges (Budinoff, 2020) and it was found that students' 3D modelling efficacies; their CAD work abilities during lab time, and their average visualization skills enable them overcome graphic challenges. This implied that educators most focus on nurturing on those individual talents rather than using "one side fits it all". However, the impact of sketching on course materials has mixed outcomes.

Also, a systematic literature review consisting 28 journal papers was carried out on University Industry partnership in Engineering Education and the result suggested) that students were more motivated towards learning skills from industrial experts, workshops, practicing staff, and industrial internships, as it enhances their technical competencies, confidence, and engagement (; Murray et al., 2020; Shah & Gillen, 2023). Thus, becoming a good dropout intervention measure. The finding also indicated that industrial placements strongly increase engineering students' concentration (Tennant et al., 2018; Haag et al., 2006). However, the study recommended the initiation of cross university partnership, industry sponsor and senior design projects, the creation of industry advisory boards, and more students' participation in partnership trainings (Shah & Gillen, 2023).

Similarly, another systematic review was conducted on the effects of intervention on learning burnout, in which the author used evaluation techniques to categorize interventions and their results (Tang et al, 2021). The study divided interventions into individual, organizational, matching, and learning engagements. And tt was uncovered that individual, group, and organizational interventions were the most effective. Group counseling in specific improved student's self- efficacy and in selecting positive coping methods; facilitates: environmental interactions, respect, and understanding among students. Finally, exercise intervention was the most effective and 8 weeks or more was the recommended time for the exercise (Guo, 2016; Tang et al, 2021).

This study also was conducted on how to improve student's retention using Machine Learning. The author used decision trees, support vector Machine (SVM) and Neural Networks (NN) to predict students' retention by analyzing dropout, attrition, and completion risks using available school data (Trivedi, 2022). And it was found that machine learning helps maintain students in school through risk identification and information sharing with stakeholders.

This review was carried out on learning models for higher education institutions in the implementation of Engineering education. The results revealed that online self and peer assessment, student-feedbacking, self-efficacy, digital literacy, and used of blended learning were very effective retention tools. It was also uncovered that performance expectancy, intrinsic motivation, and satisfaction influence novice students' intention to continue. Also, academic self -efficacy influenced intrinsic motivation, which also influenced retention rather than the opposite (Bustamante-Mora et al, 2023).

These study findings reveal a pool of dropout prevention intervention strategies that can be employed to better engineering education for emerging students globally. However, the review was focus on global context instead

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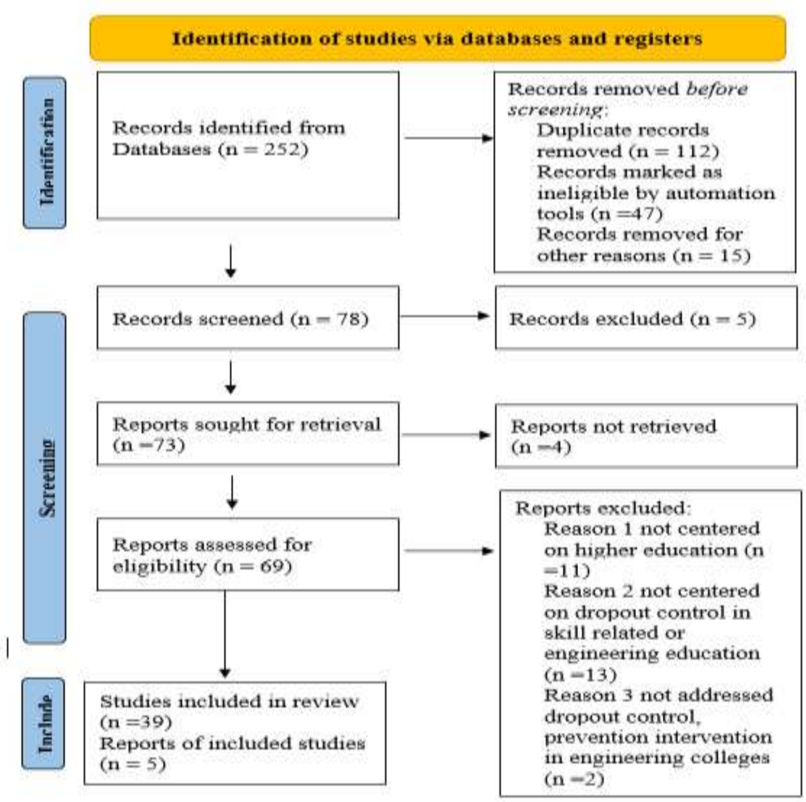
of localizing the review to be able to identify a context specific dropout prevention intervention need which is a gap. Not with standing, the findings are both valuable and applicable to engineering settings.

METHODOLOGY

This study adopted a systematic literature approach to identify relevant studies on dropout prevention strategies in engineering colleges and used narrative techniques to synthesis the findings. The review used PRISMA guidelines to ensured comprehensiveness and transparency of the of the study inclusion and exclusion process (Moher et al., 2009). Thus a detail searched was conducted on four databases namely: Web of Science, Scopus, ERIC and IEEE Xplore (Li et al., 2022, Rubio-Tobar, 2025).The keywords and Boolean Operators used for the search were :("student retention" OR "student persistence" OR "dropout prevention" OR "attrition") AND ("engineering education" OR "engineering colleges" OR "STEM education") AND ("intervention" OR "support program" OR "counseling" OR "mentoring" OR "industry partnership" OR "mindset training" OR "learning analytics" OR "machine learning").In the selection criteria, studies were included in the synthesis if they were: peer reviewed journal articles, conference proceedings or empirical reports and published between 2000 and 2026 and in the English language as well as address dropout prevention, control or retention interventions in engineering higher education institutions.-Besides studies were included-if they contain- empirical evidences from quantitative, qualitative or mixed-methods studies.

On the contrary, studies were excluded from the synthesis if they: address dropout prevention or retention in K-12 or other discipline e(s); did not address specific engineering intervention. A total of 252 articles was returned from the initial database search. After removal of all duplicates, 78 articles were selected based on titles and abstracts for full text review, leading to the inclusion of 44 articles in this review for data synthesis. The PRISMA chart in **Fig.2** contains the study identification process from the databases.

Figure 1: Research Methodology / Prisma Chart



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The quality of the included studies was checked against relevant checklists (e.g. CASP for qualitative study and MMAT for mixed methods study). All included studies were assessed in terms of the clarity of research objectives, the suitability of study design and methodology, and the way data was collected, and validity of results.

The data were extracted using a literature matric table that contains the followings: author(s), year, and country; type and context of the study and the sample; intervention characteristics and delivery; main conclusions and outcomes. The findings were synthesized using a thematic analysis approach, in which interventions were clustered by type and the relative effectiveness of each cluster was considered. We specifically highlighted newly developed or highly innovative interventions such as those incorporating learning analytics or AI or those integrating various components.

RESULTS

The review shows that dropout intervention is key to maintaining students at risk of dropping out from engineering colleges or programs. This is true since engineering programs are hands-on and can thus become challenging, which ultimately leads some to withdraw without the necessary support. Studies have shown that student retention in engineering programs or schools can be maintained through several interventions (Campbell, 2021).

Theoretical findings indicate that student motivation for learning increases with provision of problem solving tasks, giving examples, taking them through mindset shifting and training, use of varied teaching methods and observation of colleagues; experts; seminars and workshops; and making field visits to specialize industries as well as receiving collaboration and support from parents, teachers, schools, and colleagues in the form of moral, psychological, financial, materials, pedagogies and tolerance among peers (Meichenbaum., 1977;Writer, 2020; Rapp, & Corral-Granados, 2021; Campbell, 2021; Cherry, 2022; Medvedeva, 2023).

Intervention study results demonstrate that helping students develop a positive mindset in dealing with learning challenges improves their motivation. Therefore, instructors should use motivating videos, photos, audios, scenarios, and examples to restore learners' confidence and motivation to stay in school (Campbell, 2021). Provision of suitable internal measures, good education policies with strong information management and risk prevention were reported relevant to students' retention (Palomino & Ortega, .2023).

It is also reported that students' involvement in topic identification, design, and use of seminars in delivering complex subjects in complex disciplines such as engineering, maintains students' presence in school as well as in class, due to motivation from content ownership (Bullington, 2021). The study also recommends for the assessment of course intervention, the collection of more data be conducted to conduct exploratory factor analysis and face validity for the discovery of new themes in the discipline. Also, it is revealed that active lab time engagement with the teacher increases their visualization and sketching skills; however, it is argued that sketching may not have a great influence on course materials, as reported by some students. Notwithstanding, students engaged in 3D preparations applaud the effectiveness of these techniques in motivating them (Budinoff, 2020).

Also, it emerges that learners' motivation is greatly influenced by expert lectures, workshops, and industrial experiences such as internships and placement programs in engineering colleges. However, it is also suggested that there is need for the establishment of the cross-university partnership, introduction of industry sponsor senior design projects, creation of industry advisory board and students' participation in decision making (Haag et al.; 2006; Tennant et al, 2018; Shah., & Gillen., 2023). Thus, it is pivotal in student retention.

The result further indicates that support vector machine, Neural networks and decision tree help reduce students' attrition and dropout behavior through students' data monitoring and analysis (Trivedi, 2022).

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Findings also indicate that academic and career counseling programs are very effective in students' retention plans; the results further reveal academic and career counseling programs best works via individual, group, or organizational format; it also shows that group counseling improves students' self -efficacy, coping mechanisms, and facilitates intergroup interaction, promote respect for others, and build understanding among students (Guo, 2016).

The result also finds that practical lessons are very effective in building students' motivation during lessons, especially within 8 weeks duration (Tang et al, 2021). Results further demonstrate that students' self-online learning -and peer assessment promote feedback sharing, blended learning, intrinsic motivation, high satisfaction, increases' motivation and intention to complete program of study (Bustamante-Mora et al, 2023).

Inconclusion, pedagogical variations is found to be the most effective dropout intervention measures in engineering school based on the frequency of the intervention while andragogy/seminar, machine learning /data, mindset training and systemic/policy remains least effective measures.

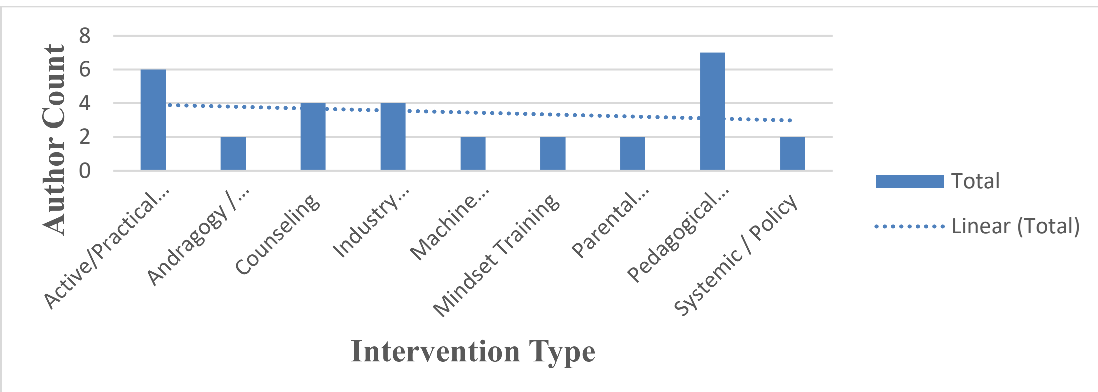

Figure 2: Intervention effectiveness Table

The above (Fig.2) contains the authors count and intervention type. The bar chart indicates that the higher the bar, the most relevance and effective is the intervention toward dropout control or prevention among engineering students in engineering colleges. This conclusion is based on the frequency of the study. This is reflected by the height of the bar. Based on this criteria, pedagogical variations found to be the most effective dropout prevention measures in engineering colleges while systemic /policy, parental training, mindset training, machine learning /data and andragogy /seminar are the least effective measures. This information can be used for identifying relevant and most effective dropout intervention measures to choose in dealing with similar situation.

DISCUSSIONS

Interventions are the primary instrument for keeping students at risk of dropping out in school especially engineering institutions. Because engineering programs are hands- on, they can become pressing for some students, which may influence their intention to drop out without enough help. However, studies conducted on this matter identify how students can be maintained in engineering schools or programs up to graduation using different intervention mechanisms.

Theoretical models such as Maslow's hierarchy of needs emphasis the relevant of proving the basic psychological needs of students at risk of dropping out of school (Medvedeva,2023). These include safety, self- esteem, belonging, and self-actualization. Provision of these needs do not only motivate but also increase student resilience in the program. This finding agrees with the assertion of both Maslow and Medvedeva who emphasize the important of achieving basic need during learning (Maslow, 1942, 1954; Medvedeva, 2022).

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Additional theories also emphasis the important of conducting practical's (task centered practice), providing guidance and counseling (psychosocial development), indicating procedures (system theory) and given freedom and power to learners (self-determination theory) in preventing school dropout behavior. This concords with the theoretical assumptions of Ellis, Erikson, Bandura, Schachter, Munley, Beck, Deci and Ryan, Getting, Luhmann and Essa) (Ellis, 1962 Erikson, 1963, 1968, Bandura, 1969; Schachter, 1974; Munley, 1975; Beck, 1976; Deci & Ryan, 1985; Getting, 1989; Luhmann, 1995; Essa, 2018,) This synthesis also aligns with the empirical results of the review.

Empirically, the study find that motivation plays a key role in maintaining students' attention in school. This finding agrees with the work of Campbell et al. (2021) who found a positive relationship between mindset training and students 'motivation for engineering education. They indicate that training based on online tutorials, discussions, and growth mindset activities promotes students' mindset more strongly than reading alone. Also, Tang et al. (2021) uncovers that group counseling enhances students' self-efficacy and positive coping strategies, which supports the argument that motivational strategies are crucial to retention.

Again, it is revealed that pedagogical differences, observational learning, peer and group sharing, and expert support reinforce student retention. This result corroborates with the study of Babapour et al. (2023) who found that associative and instrumental leaning experiences greatly influence engineering majors' commitments. Also, Bandura 's social learning theory confirms that learning happens through observation either from colleagues, teachers, experts or through field experiences (Bandura, 1969). This finding aligns with the practical interventions mentioned by Bergeson and Heuschel who stressed seminars, workshops, and field trips as motivational tools. (Bergeson and Heuschel, 2005)

The results further emphasize the value of expert lectures, workshops, and industrial experiences like internships and placement programs in student motivation. This finding is directly supported by Sha and Gillen who confirmed that students feel motivated by learning from industrial experts, workshops, and internships (Sha & Gillen, 2023). The findings further indicate that such experiences enhance technical capabilities, self- efficacy, and engagement. This outcome is supported by Tennant et al. who uncovered that industrial placement firmly increases engineering students' concentration and commitment (Tennant et al. (2018), Similarly, Haag et al, found that student industry performance grows through internship and efficacy (Haag et al, 2006)

Additionally, findings indicate that active lab time and practical exercises accelerate students' motivation which is in agreement with Bundinoff who narrated that active lab time and engagement improve students' 3D modelling efficacy, CAD work ability, and visualization skills (Bundinoff (2020). Moreover, Tang et al. confirmed that training interventions that last upto eight weeks or more have a greater effect on reducing learning burnout and improving student motivation (Tang et al. (2021); this validates the present review's findings about value of practical engagement during engineering lessons.

Furthermore, the findings that associate academic and career growth to student retention corroborate with Guo's findings that individual, group, and organization intervention programs increase student self-efficacy, coping strategies, and intergroup respect (Guo, 2016). Also, the findings that link machine learning tools such as vector machines, neural networks, and decision trees to reduce dropout risk directly corroborate with Trivedi findings which emphasis that school data analysis can help detect retention strategies, attrition trend, and completion risks among students (Trivedi,2022). Moreover, Bustamante- Mora et al, (2023) uncovered that online self- and peer assessment, blended learning, and student feedback increase student motivation and retention in school and this finding corelates with technological intervention strategies discussed by Trivedi (2022).

Again, finding associate psychological, moral, material, and financial support from parents, teachers, schools, and peers to student retention in engineering college. This assertion is consistent with the system's theory approach mentioned by Campbell et al and Rapp and Corral -Granados (Campbell, 2021; Rapp & Corral -Granados, 2021).

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Additionally, Rumberger and Lim narrated that student engagement and parental involvement reduces student dropout risk (Rumberger & Lim (2008). This emphasis the crucial role of student engagement and parent participation in their children education. Bajar and Bajar (2019) mentioned that text messaging interventions with parents regarding their children learning greatly reduced dropout risk behavior implying cost-effectiveness program (Bajar and Bajar, 2019).

Studies also indicate that expert lectures and seminar workshops minimize student dropout behavior. This narration agrees with the views of Bullington et al, (2021), whose pilot study found that seminar -based teaching improves adult learners' efficacy in engineering studies.

Inconclusion, pedagogical variations is found to be the most effective dropout intervention measures in engineering institutions based on the frequency of the intervention while andragogy/seminar, machine learning /data, mindset training and systemic/policy remain least effective measures. See Fig.2.

Implications of the study

This study contains valuable implications for multiple stakeholders participating in engineering education. These comprise policy, institutional practice, pedagogy, and future research.

At the policy level, regional, national and institutional administrator should treat student dropout as a combination of systemic gaps in support structures rather than as individual student failure. At engineering colleges and universities, institutional cultural shift is paramount. They should promote a ground mindset culture where difficult tasks are developed as learning opportunities rather than terms of an indicator of incompetence (Campbell, 2021). Also, the presence of student support services such as regular academic and career counselling, peer mentoring programs, and psychological support should be institutionalized rather than sporadically. Establishing a formal partnership with industry in terms of internships, guest lecturers, and sponsored projects will significantly enhance students' motivation and retention (Sha & Gillen, 2023). Additionally, institutions should establish a parents and community engagement program to build a supportive ecosystem around engineering students.

Moreover, teachers and faculties should employ pedagogical diversity such as task—centred practice, observational learning, collaborative projects and field visits, as reliance on lecture alone may disengage at risk of dropping out t. Another important variable is the integration of mindset training, such as embedding growth mindset messaging into daily lessons, assessments, and feedback. Furthermore, creating regular feedback loops is key to students' retention. Initiation of formal assessment, self- assessment, and peer assessments enables students to know their strengths and weaknesses (Bustamante-Mora, Diéguez-Rebolledo, & Hormazábal, 2023). Teachers can further strengthen student confidence by acting as counsellors and helping to raise their hopes through reframing pessimistic self-talk to overcome their academic challenges (Meichenbaum, 1977).

Students and families are also key to students' retention. Engineering students should be motivated to own their learning though self- topic identification, project-based work, and peer collaboration, as it increases motivation (Bullington, 2021). Education and training of parents and guardians about the challenges of engineering education and the psychological support they should demonstrate without pressure must be promoted. Peer networking, such as the establishment of study groups, engineering clubs, and peer mentoring programs, should encourage to boost peer's self-efficacy (Bandura, 1969).

CONCLUSIONS

This study has investigated the retention strategies for engineering students in colleges. The findings uncovered several dropout intervention measures in engineering college.

The theoretical review helps to established relationship between the theoretical assumption and student dropout behavior reduction. The empirical findings have also uncovered the various dropout intervention techniques common in engineering educational setting. However, the most important dropout behavior reduction intervention in engineering college is pedagogical variations while andragogy/seminar, machine learning /data, mindset training and systemic/policy remains least effectives as shown in Fig. 2. This emphasis the need for stakeholders' consideration of multiple teaching approaches in engineering colleges.

Limitation and Future Research

The study did not show the condition under which each intervention is effective. Future research should identify the conditions under which each intervention is successful. It should also consider conducting a survey to compare the effectiveness of specific retention interventions, such as mentoring programs, academic support services, financial aid initiatives, and student engagement activities.

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