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SOURCES OF SELF-EFFICACY AND THEIR IMPLICATIONS ON SCIENCE TEACHER EDUCATION

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Abstract:
Bandura's reaction to the depictions of human agency that were propagated by the trait, behaviorist, and psychodynamic theories yielded the social cognitive theory. Through the social cognitive theory emerged the concept of self-efficacy. Self-efficacy is one's judgment of the capabilities to bring about desired outcomes. An understanding of the concept of self-efficacy and its sources has implications for the training of pre-service science teachers to effectively teach science. This article aims to use theoretical and empirical studies concerning Bandura's theoretical sources of self-efficacy - Enactive Mastery Experience, Vicarious Experiences, Verbal Persuasion, and Physiological and Psychological State – to guide science teacher educators in determining effective approaches to developing a sense of self-efficacy in their pre-service science teachers. The article summarizes each of the sources of self-efficacy. It simultaneously provides suggestions to science teacher educators for inculcating a high sense of self-efficacy in their pre-service science teachers.

Keywords: pre-service teachers, science education, teacher educators, self-efficacy, self-confidence

1. Introduction

The concept of self-efficacy, as it is known today, emerged in the late 1970s through Albert Bandura (Bandura, 1977) and was refined into a theory as part of Bandura's social cognitive theory published in 1986 (Bandura, 1986). According to Ulmer et al. (2013), the Social Cognitive Theory was developed as a result of Bandura's reaction to the depictions of human agency that were propagated by the trait, behaviorist, and psychodynamic theories. These theories proposed that the locus of agency in humans is either autonomous or mechanical (Ulmer et al., 2013). However, Albert Bandura found this proposition unacceptable. His alternative proposition was that the locus of agency of humans is an interactive relationship between determinants, action and environmental factors. To Bandura (1986), the relation between determinants, action and environmental

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factors was to a large extent reciprocal. Following this alternative proposition, he presented his conception of self-efficacy which was first published in 1977, as a theory.

Bandura (1977) defined self-efficacy as the self-belief an individual holds regarding his or her capabilities to plan and execute the course of action needed for the production of a given attainment. Self-efficacy is strongly associated with the individual's belief about his or her capacity and competency, and the outcome of the effort the individual exerts in activities. Tschannen-Moran and Woolfolk-Hoy (2001) defined self-efficacy as the judgment of an individual's capabilities to bring about desired outcomes.

According to Bandura (1986), self-efficacy belief is a powerful determinant of the choices individuals make, the effort they invest in activities, their persistence and perseverance in times of difficulty or challenging situations, and their calmness or display of serenity as they engage in different tasks. To Bandura (1977), self-efficacy is based on two factors; an individual's belief about his or her ability to cope with a task and belief in the outcome of an action. Self-efficacy is only a belief one has about his or her capabilities, hence, it may not match his or her actual capabilities. Self-efficacy may be an under or over-estimation of one's capability in a specific domain. However, it is a useful judgment of one's capabilities. Artino Jr. (2012) argued that self-efficacy is based on the idea that self-efficacy judgment is referenced to a goal and so it reflects the task-specific and situation-specific nature of self-efficacy. This makes self-efficacy contradict more general measures of expectancy like self-perceptions and self-concept of competence, which tend to be more global self-perceptions, though they may be domain specific.

Since the theory was developed, it has been the subject of research by education researchers. Researchers have found that self-efficacy is a predictor of students' academic achievements across academic disciplines as well as levels. Generally, research has shown that self-efficacy influences the motivation and behavior of students and teachers. Students have been the focus of most studies on self-efficacy in the academic setting. However, teachers' self-efficacy belief as a concept and the role teachers' self-efficacy belief plays in how teachers function in the classroom has been empirically documented. For example, Ghaffar, Hamid, and Thomas (2019), reported that science teachers' self-efficacy is the key factor that influences the use of active learning strategies, performance goals, and science learning value. Science teachers' self-efficacy in turn significantly influences students' motivation to learn science. Akhter, et al. (2022) found a positive association between teachers' self-efficacy and improvement in teacher effectiveness. According to Akhter, et al. (2022), Teachers' self-efficacy leads to teachers' welcoming and dealing with difficult tasks as things that must be mastered, fostering a deeper sense of commitment and interest to work, and recovering quickly from setbacks.

Teachers' self-efficacy belief, which is synonymous with teaching self-efficacy belief is defined as teachers' belief in their capabilities in carrying out their professional tasks (Morris, Usher & Chen, 2017). Künsting, Neuber, and Lipowsky (2016), conceived teaching self-efficacy as "*a job-specific personal feature*" (p. 300) and defined it as teachers' characteristics that explain differences in students' learning and teachers' teaching practices. They conceptualized teaching self-efficacy as the extent to which teachers believe they will be able to cope with tasks, conditions, and situations in their

professional practices. For example, the degree to which a teacher believes he or she can promote learning among students, especially academically weak students, apply 'novel' active learning teaching methods, and resolve conflicts in the social setting can be termed teaching self-efficacy. Skaalvik and Skaalvik (2009), conceptualized teacher self-efficacy based on the social cognitive theory. To them a teacher's belief in his or her ability to plan, organize and perform activities needed for the achievement of educational goals constitutes self-efficacy.

It has been found empirically that, unlike teachers who doubt their capabilities, those who possess high teaching self-efficacy employ effective teaching strategies and they are less likely to experience teacher burnout and show more commitment to their profession. See Yuksel (2022), Kirkiç and Çetinkaya (2020) and Ojaghloo (2016). Also, teachers who possess high teaching efficacy tend to positively influence students' experiences which leads to better students' achievements (Kumar, Verma, & Kiran 2017; Shahzad, & Naureen, 2017). Teachers who have high teaching efficacy are able to promote meaningful learning in students even in the face of challenging conditions such as inadequate infrastructure and teaching resources. Such teachers are motivated to go all lengths to resourcefully use the scarce resources available for teaching and learning. How can science teacher educators build the self-efficacy of pre-service science teachers to enable them to become effective teachers? This paper discusses how science teacher educators can harness the sources of self-efficacy to prepare pre-service science teachers to develop high teacher self-efficacy before they become in-service teachers. Specifically, the paper discusses the four sources of self-efficacy and their implications on science teacher education.

2. Sources of Self-Efficacy

Self-efficacy comes from different sources of information and provides the bases for human foundation, well-being, and accomplishments. The quality and nature of the information received determine whether the information will weaken or enhance science teachers' self-efficacy. The information that enhances science teachers' self-efficacy causes them, according to Yılmaz and Çavaş (2008) to have the self-belief that their actions will produce the desired outcome. Bandura (1977) listed performance accomplishments, vicarious experiences, verbal experiences, and physiological and psychological states as the sources of self-efficacy. While the last three have been relatively stable concerning their original ideas, performance accomplishments have been expanded to include enactive mastery experiences, while keeping accomplishments as the central construct. In this section, the sources of self-efficacy are discussed in relation to science teachers' self-efficacy and their implications for science teacher education.

2.1 Enactive Mastery Experience

Science teachers' achievement of learning goals is the most reliable source of teaching self-efficacy (Kwarteng, & Sappor, 2021). The achievement of learning goals is strongly associated with increased technological, content, and pedagogical knowledge which are

very necessary for effective teaching. The accomplishment of teachers, for which they have tangible evidence of success plays an important role in teachers' self-efficacy. The achievements of teachers build their confidence to attempt and succeed in more difficult tasks. The reverse is true. If teachers fail in achieving learning goals consistently, their confidence is weakened and in effect their teaching self-efficacy becomes frail. Such teachers' determination to persist in the face of setbacks is greatly weakened. It is worth noting that it is not every accomplishment that boosts teaching self-efficacy. The two factors that make an achievement boost self-efficacy are; task-difficulty and the amount of effort required to accomplish the task. This explains why accomplishing easy tasks will not build confidence and improve self-efficacy.

How teachers choose to relive past experiences influences teachers' self-efficacy. The issue here is about whether the teacher sees an experience as a motivation to strive further or demotivation to fall back. If science teachers view classroom experiences as too challenging, non-rewarding, or a waste of effort, the likelihood that the teachers' self-efficacy would be low is high. By recounting only failed experiences, the teacher is remembering only negative experiences or failed experiences over positive or successful experiences. Teachers who recount negative or failed experiences very often face the danger of under-estimating their performance capabilities (Hendricks, 2016). There is an exception though. If a teacher recounts his/her negative or failed experiences, trying to understand what he could not do right, intending to improve his/her performance in the future, the reflective exercise becomes the springboard for future successes. Dwelling on positive or successful experiences improves self-efficacy and confidence, hence enhancing teachers' teaching self-efficacy. Science teacher educators should encourage pre-service science teachers to dwell on their positive and successful experiences and use the failed or negative experiences as learning situations.

Both practical experiences and mastery of science concepts are needed to build a strong self-efficacy through enactive mastery experiences. In other words, both subject matter content knowledge and pedagogical content knowledge are required to build enactive mastery experiences. Studies have shown that a good conception of science increases teachers' self-efficacy (Rohaan, Taconis, & Jochems, 2012; Velthuis, Fisser, & Pieters, 2014). Velthuis, Fisser, and Pieters (2014), for example, reported a large difference in science teaching efficacy for teachers with self-rated insufficient knowledge and teachers with self-rated sufficient knowledge. The difference favored those with self-rated sufficient knowledge. Good subject matter content knowledge is valuable, since science teachers with a self-belief of having good subject matter content knowledge confidently explain science concepts, using different analogies and examples. Good pedagogical content knowledge informs the selection of appropriate teaching strategies. When science teachers can use suitable teaching strategies to teach learners, it increases their confidence in managing classrooms and applying varied instructional strategies in a lesson. Generally, this is what the possession of good pedagogical content knowledge does to teachers' self-efficacy.

To build pre-service science teachers' enactive mastery experiences, science teacher educators can provide pre-service science teachers extra opportunities for

practice. Science teacher educators may give pre-service science teachers the opportunity to master novel and or challenging teaching strategies and content before the pre-service science teachers implement them in their classrooms. Pre-service science teachers can be directed to practice teaching skills, focusing on how they can use the practice to generate learning and skills application. They should be challenged to practice difficult skills and tasks. By practicing difficult skills and tasks, they are likely to develop strong self-efficacy (Bray-Clark & Bates, 2003). Another way science teacher educators can enhance pre-service science teachers' self-efficacy is to provide pre-service science teachers with opportunities to exercise autonomy and control over their learning (Velthuis, Fisser, & Pieters, 2014). The opportunities may include self-expression and self-selection of teaching strategies to promote a sense of accomplishment. This may lead to more practice efficiency and cognitive engagement, and prepare pre-service science teachers to work and solve problems independently. As observed by Bandura (1986), pre-service teachers who develop a strong self-efficacy through enactive mastery experiences are equipped to educate themselves in situations when they have to depend on their initiatives.

2.2 Vicarious Experiences

Observing the more knowledgeable others perform tasks is one way to build the confidence of pre-service science teachers to perform the same or similar tasks. Vicarious experiences are all about the experiences gained through observation. Loo and Choy (2013), defined vicarious experiences as "*the observation of actions of someone's attainment related to a task*" (p. 87). When pre-service science teachers observe other colleagues and science teacher educators performing a task successfully, it provides them with a sense of confidence in their capacity to perform the same or similar tasks. Irrespective of differences such as age and experience, the pre-service science teachers observing develop the convictions that a task is doable if the individual being observed executes the task efficiently. However, if the pre-service science teachers see the observed as having similar characteristics as he or she possesses, the pre-service science teacher will have a greater sense of confidence in his/her abilities to teach a concept.

A pre-service science teacher will have a greater boost in science teaching self-efficacy when he/she observes a colleague teach a concept. Observation only provides a sense of science teaching self-efficacy which may fade when the pre-service science teacher begins to teach similar or the same concept. It is only when pre-service science teachers begin to teach the lesson, they have observed that they will get to know how easy or difficult it is to teach that lesson they observed. This notwithstanding, observing a colleague perform an experiment or teach a lesson builds the confidence of the observing pre-service science teacher, that he/she can also perform the same experiment or teach the same lesson. when the pre-service science teacher fails in his/her attempt to perform the same experiment or teach the same lesson, he/she will have an example to reflect on in order to perform the same activity.

As observed by Bandura (1977) and Hampel, et al. (2023), the influence of vicarious experiences is not as strong as enactive mastery experiences. However, this is not true for all cases. In some instances, the observation of the model can override the influence of

the enactive mastery experience. One such case was reported by Brown and Inouye (1978). Brown and Inouye (1978) found that participants' exposure to a confidence-building model caused the participants to develop a strong attitude of persistence, despite repeated failure. Science teacher educators should not underestimate the role of demonstration and mentorship in training pre-service science teachers. In countries like Ghana, where most basic schools do not have science laboratories, and so science concepts are treated theoretically (Oladejo, et al., 2023; Yeboah, Abonyi, & Luguterah, 2019), it is good to demonstrate science experiments, show videos of other performing such experiments or use virtual laboratories. Demonstrating, say, the laboratory preparation of gases, gives the pre-service science teachers a sense of how gases are prepared in the laboratory. This will build the confidence of pre-service science teachers in conducting such experiments when they become in-service teachers and are lucky to be in well-resourced schools.

Science teacher educators should also demonstrate effective teaching skills in their classrooms. It is known that teachers learn how to teach while they are receiving pre-tertiary education, through observation of their teachers' teaching. By carefully choosing and demonstrating the use of varied teaching approaches in their teaching, science teacher educators will be providing valuable examples for their pre-service science teachers to follow. Another way of demonstrating teaching to pre-service science teachers is by letting students watch pre-recorded lessons of experience teachers or even lessons of colleagues. After watching the lesson, the pre-service science teachers can be asked to critique the lessons and reflect on lessons they have already taught to identify inefficiencies and suggest ways to correct them. By demonstrating good examples of teaching skills for pre-service science teachers, science teacher educators are becoming good mentors.

Pre-service science teachers should be mentored to be optimistic rather than pessimistic. Song (2022) made a list of attributes that contribute to the attainment of teacher well-being. The distinctive factor that shows the degree to which science teachers possess positive anticipation is optimism. Carver, Scheier, and Segerstrom (2010) defined 'optimism as the generalized constructive anticipation that good occurrence will take place in place of bad [*occurrence*]' (n.p.). This constructive optimism enables pre-service science teachers to deal with difficult situations with self-confidence. Optimism leads to bravery in the face of challenging situations. An optimistic science teacher educator will go all out to teach students to understand whatever is being taught. He/she will not give up on his or her learners. Science teacher educators can build optimism in their pre-service science teachers by not giving up on weak pre-service science teachers, but finding all possible means to assist such teachers. Science teacher educators must demonstrate a strong positive mental attitude while training pre-service science teachers.

2.3 Verbal Persuasion

Words have the power to influence teaching efficacy. As noted by Bandura (1977), the use of words to compel or motivate individuals to alter their behavior is common. Individuals can be led into believing that they can accomplish challenging tasks, a mere

suggestion. Individuals can even be persuaded, through suggestion or encouragement to believe that they can accomplish a task they have attempted and failed in the past. However, efficacy built through persuasion is not robust. They are weaker than efficacy attained through enactive accomplishments or vicarious experience. Persuasions do not provide the individual with an authentic experiential base as compared to enactive mastery and vicarious experiences. In view of this, when the individual accepts the suggestion to be true and faces distressing moments soon after attempting the task, the distressing moment will extinguish the persuasion created by the suggestion. This notwithstanding, verbal persuasion is effective in getting teachers to attempt tasks they will ordinarily not attempt.

It is worth noting that persuasions are limited in their ability to create huge increases in self-efficacy (Usher & Pajares, 2008). However, it is rather easy to jeopardize teachers' self-efficacy using persuasion than enhancing it. Especially for teachers who are developing skills and hence attend to the feedback they receive from science teacher educators. The quality of verbal feedback pre-service science teachers receive from science teacher educators influences their self-efficacy. Agricola, Prins, & Sluijsmans (2020) studied the impact of verbal feedback on students and found that students perceived verbal feedback to be better than written feedback. Verbal feedback was perceived to be superior in terms of usefulness, quality, and timing as compared to written feedback. Students will consider verbal feedback useful when it judges their work and also fosters dialogue with their educators (Beaumont, O'Doherty, & Shannon, 2011). When science teacher educators communicate their feedback verbally, it creates an opportunity for the pre-service science teachers to ask for clarification to enable them better understand and interpret the feedback. This results in pre-service science teachers' appreciation of the feedback provided.

When pre-service science teachers consider verbal feedback useful, it makes them persistent and improves their performance. This is because the students are motivated to act when they face difficulties or challenging situations (Pajares, 2012). As reported by Pajares (2012), students who perceive feedback to be positive usually have high self-efficacy and as a result have the confidence to complete similar tasks, after their efforts at completing a task have been successful. It is worth mentioning that, inappropriate, excessive, or superficial feedback is either ineffective or detrimental to building pre-service science teachers' self-efficacy. Science teacher educators should therefore provide verbal feedback cautiously.

To improve pre-service science teachers' self-efficacy, science teacher educators can provide frequent, focused, and task-specific verbal feedback. As noted by Margolis and McCabe (2006), when science teacher educators provide task-focused feedback on what pre-service science teachers did correctly and on the steps that are needed for improvement, they give pre-service science teachers a map for success. This leads to strengthening the pre-service science teachers' self-efficacy. Providing immediate, task-specific feedback is essential when pre-service science teachers are given challenging tasks to perform. Mistakes are common among pre-service science teachers. That is expected because they are novices who are at the skill acquisition stage. Science teacher

educators should therefore endeavor to provide immediate feedback to correct undesirable skills and mistakes so that they do not become deep-seated and cause the pre-service science teachers' self-efficacy to diminish.

The five forms of teacher-directed feedback suggested by Cowan (2015) help enhance pre-service science teachers' self-efficacy through verbal persuasions. Corrective feedback should be used to correct pre-service teachers' mistakes using corrective strategies like reteaching prerequisite skills and changing or rephrasing questions; Pre-service science teachers should be prompted in time when they need the information to enable them to correct their mistakes; When pre-service science teachers are unsure whether or not they have executed a task correctly though they have executed a task correctly, process feedback should be used to indicate to them why they are right; When science teacher educators notice that pre-service science teachers require additional information to be able to undertake an activity, instructive feedback will be useful to the pre-service science teachers; lastly, when pre-service science teachers deserve to be praised, they should be praised accordingly.

2.4 Physiological and Psychological State

Bandura (1977) posited that the perception of an individual's abilities is influenced by the individual's awareness of the body's emotional and physical reaction to situations. Hendricks (2016) argued that experiences of strain versus strength, stress versus relaxation, and fatigue versus energy can leave students with a low or high perception of the ability to persist in a task. Depending on the situation, emotional arousal may provide information concerning the individual's capabilities. Due to this information value, emotional arousal is considered a source of information that affects the self-efficacy of pre-service science teachers. As suggested by Bandura (1977), pre-service science teachers rely on their physiological and psychological state to judge their anxiety and vulnerability to stress. How emotional arousal has been found to debilitate performance (Mensah, 2023), hence pre-service science teachers are likely to expect success when their emotional arousal is not aversive. In a viscerally agitated state, expectations to succeed may be low (Artino, 2012). It has been empirically established that self-efficacy can be enhanced through stress situation reduction, development of physical strength, and development of positive thought patterns especially in tasks that require strength and stamina.

Performance anxiety is common among pre-service science teachers. Especially, when lessons of pre-service science teachers are being observed by mentors and science teacher educators (Kamonjo, & Nyambura, 2023). When pre-service science teachers become aware that they are being observed, a combination of adjudicator evaluation and social comparison pressures increases anxiety. Performance anxiety and fear lower self-efficacy. However, if self-efficacy is developed, it reduces performance and fear. Science teacher educators can help students overcome their fear and performance anxiety by helping them to monitor and challenge any inaccurate self-belief or self-perception. Self-belief or self-perception is a good predictor of pre-service science teachers' achievement (Kebebe, 2020). Science teacher educators can consciously implement self-efficacy

improvement strategies such as verbally encouraging pre-service science teachers to set personal goals and self-monitor their progress. This intervention can lead to improved motivation and performance and in effect improve self-efficacy. By paying attention to pre-service science teachers' perceptions and self-belief, science teacher educators can help their students confront their fears and limitations through 'self-regulation, self-evaluation [and] time management (Hendricks, 2016; p.4).

3. Conclusion

self-efficacy is the belief individuals hold regarding their capabilities to successfully plan and execute tasks. Self-efficacy is associated with belief about one's capacity and competency, and the outcome of the effort one exerts in activities. It has been empirically established that teachers who possess high teaching self-efficacy employ effective teaching strategies and are more committed to the teaching profession. To build the self-efficacy of pre-service science teachers, they may be offered extra opportunities for practice. Science teacher educators may allow pre-service science teachers to master novel and or challenging teaching strategies and content before the pre-service science teachers implement them in their classrooms. They may also be directed to practice teaching skills with the aim of building their capabilities to learn and apply the practiced skills when they become in-service teachers. The role of demonstration and mentorship should not be underestimated in the training of pre-service science teachers. Science teacher educators should endeavor to demonstrate effective teaching skills in their classrooms. As science teacher educators carefully choose and demonstrate the use of varied teaching approaches in their teaching, they provide valuable examples for pre-service teachers. It is important for pre-service teachers to be provided prompt and task-specific feedback when they perform a task, in order to guide them to form habits that enhance self-efficacy. Lastly, science teacher educators may consciously implement self-efficacy improvement strategies with the aim of improving motivation and performance and consequently improving their self-efficacy.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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