



In-Service Teachers' Performance Using Guided Inquiry Computer Simulations to Learn Cellular Respiration

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ABSTRAK

Respirasi adalah salah satu topik biologi yang sulit, dan guru memiliki tantangan untuk mengajarkannya secara efektif untuk meminimalkan kesalahpahaman. Tujuan dari penelitian ini adalah untuk menganalisis pengaruh simulasi komputer inkuiri terbimbing terhadap kinerja guru prajabatan. Sebuah desain kuasi-eksperimental digunakan dengan 65 guru in-service: 33 kelompok eksperimen diajarkan menggunakan simulasi komputer inkuiri terbimbing, dan 32 kelompok kontrol menerima instruksi menggunakan kapur-dan-bicara tradisional. Data dikumpulkan menggunakan Tes Kinerja Akademik dan dianalisis menggunakan T-test untuk mengetahui perbedaan antar kelompok. Analisis kovarians digunakan untuk mengetahui pengaruh intervensi. Kedua kelompok diuji sebelumnya untuk mengukur pengetahuan mereka sebelumnya dan setelah diuji untuk menetapkan perubahan setelah pengajaran. Hasil penelitian menunjukkan kelompok eksperimen mengungguli kelompok kontrol. Juga, kinerja laki-laki dan perempuan dalam kelompok eksperimen serupa, menunjukkan bahwa simulasi komputer inkuiri terbimbing disukai kedua jenis kelamin. Ini menyiratkan bahwa simulasi komputer inkuiri terbimbing adalah alat yang efektif untuk meminimalkan kesalahpahaman mengenai respirasi seluler. Dengan demikian, para peneliti merekomendasikan menggunakan simulasi komputer inkuiri terbimbing dalam pendekatan kualitatif dan kuantitatif dengan sampel besar guru dalam jabatan dari wilayah geografis yang berbeda.

ABSTRACT

Respiration is one of the difficult biology topics, and teachers have challenges effectively teaching it to minimise misconceptions. The aims of this study was to analyse the effect of guided inquiry computer simulations on pre-service teachers' performance. A quasi-experimental design was used with 65 in-service teachers: 33 experimental groups taught using guided inquiry computer simulations, and 32 control groups received instructions using traditional chalk-and-talk. Data were collected using the Academic Performance Test and analysed using a T-test to determine the differences between the groups. Analysis of Covariance was used to find out the effect of the intervention. Both groups were pre-tested to gauge their previous knowledge and post-tested to establish changes after the teaching. The results show experimental group surpassed the control group. Also, males and females performance in the experimental group was similar, suggesting that guided inquiry computer simulations favoured both genders. It implies that guided inquiry computer simulations are effective tools to minimise misconceptions regarding cellular respiration. Thus, the researchers recommend using guided inquiry computer simulations in qualitative and quantitative approaches with a large sample of in-service teachers from different geographic regions.

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1. INTRODUCTION

Learners need teachers' guidance using different strategies. Guided Inquiry Computer Simulations (GICS) are one strategy for improving performance. Computer Simulations in education help view abstract concepts in a real-life situation (Ade-Ojo et al., 2022; Kärner, 2017). The guided inquiry has four levels: open, guided, structured, and confirmation. This study focuses on GICS, which differs from the Traditional Chalk and Talk (TCAT) strategy. GICS assist in learning science concepts regarding cellular respiration. TCAT strategy focuses on the mastery of content with less emphasis on developing skills and inquiry attitudes. It is concerned with learners qualifying for the next level. According to previous research TCAT limits learning through inquiry (Dudu & Vhurumuku, 2012). Teachers use inquiry to confirm concepts, limiting the development of higher thinking skills that lead to meaningful learning (Manfra, 2019; Yuliana et al., 2022). GICS is a social learning environment that inculcates competence and engagement and improves academic performance (Cohen et al., 2020; Suebsing & Nuangchalerm, 2021). Teachers should have the highest level of conceptual understanding to aid them in teaching effectively. The GICS strategy was against what in-service teachers were accustomed to TCAT, where they laboured to transfer information to the learners. The strategy

allowed in-service teachers to undergo a paradigm shift where they inquired about concepts using computer simulations under the guidance of their lecturer. Changing teacher practice to GICS practice was a challenge. Professional development programmes can assist in-service teachers in changing and reconstructing their role as science facilitators (Al Mamun et al., 2022; Bell, 2010). The professional development programme in any school setup is a step in the right direction (Aslam et al., 2018; Hwang et al., 2022).

TCAT used by teachers does not encourage dialogues like those used by scientists to build arguments (Akkus et al., 2007; Weiss et al., 2022). TCAT only responds to a cookbook type by following five steps of the scientific method: purpose, methods; observation; results and conclusion. Thus, language is important and used to recognise scientific issues. Thus, GICS allows exploring, questioning, acknowledging claiming, forming prompts and suggesting evidence, describing data, and reflecting on the thinking process. Recent studies show that questioning is important in teaching (Bhurekeni, 2020; Holland & Ulrich, 2016). How the GICS and TCAT affect in-service performance using cellular respiration is not well studied. Therefore, this empirical study sought to add to the literature regarding the effects of GICS on in-service performance in cellular respiration. Contends that inquiry teaching develops scientific skills. In-service teachers' inquiry concerns diagnosing problems, critiquing experiments, and distinguishing alternatives (Piotrowska et al., 2022; Ugwu, 2019). It is about finding solutions through investigations. In guided inquiry, the teacher presents the activity and learner support materials to enhance learning. The materials could be a chart, a flow diagram, a story or computer simulations that relate to everyday life, which render credence to their conceptual understanding (Jacques et al., 2020; Schlegel et al., 2021). Teachers have beliefs and feelings about their teaching strategy, and they have the potential to use inquiry (Garba et al., 2015; Yu et al., 2022). However, in-service teachers worry about inquiry implementation. Inquiry learning is not for only high-performers but all categories of learners. Inquiry learning demand critical reasoning and concrete thinking. Therefore, in-service teachers need orientation in inquiry using computer simulations and how to ensure success in their respective classes after the development programmes. After all, inquiry provides opportunities for locating, evaluating, and using various tools, such as computer simulations. It encourages meaningful curriculum connections for deep learning for all school-age groups (Hsiao et al., 2022; Taufan, 2022).

The goals of the GICS are based on scaffolding learning and encouraging individual investigations. Thus, the need for Self-Directed Learning (SDL) and effective teaching skills (Al Mamun et al., 2022; Tytler & Prain, 2022). Guided Inquiry explores, invents, and applies the concept to everyday life, and it encourages learners to build on earlier knowledge to learn sequentially and hierarchically (Rands et al., 2021; Taufan, 2022). Hence, it was suggests that in-service teacher professional development programs positively affect learner performance in high schools. GICS can enhance learning efficiency and improve higher-order thinking skills (Payu et al., 2022; Yu et al., 2022). There are two options for enhancing GICS: providing guidance on what to learn and letting in-service teachers explore content using computer simulations. GICS learning emphasises active participation and discovering new knowledge (De Jong & Van Joolingen, 1998; Williams, U. J., & Dries, 2022). Learners in SDL use an inductive-deductive approach. They investigate the relationships between dependent and independent variables. Learners learn best by interacting with and learning from each other (Tytler & Prain, 2022; von Kotzebue, 2022). In this strategy, learners are provoked to innovative actions. They perform experiments, collect data, and provide evidence to support their findings (Goeltz & Cuevas, 2021; Solikah & Novita, 2022). Studies show that students and in-service teachers have learning difficulties and misconceptions about various topics in biology (Jimerson et al., 1997; Uhl et al., 2021). Respiration is among the difficult topics for high school learners to master possibly, the in-service teachers have similar misconceptions as their learners (Byukusenge et al., 2022; Yuliana et al., 2022). Therefore, this study sought to use GICS to minimise those difficulties among in-service teachers. This study contributes to the literature to reduce learning difficulties and misconceptions in high school and enhance learner performance through an in-service professional development programme. The aim was to analyse the GICS effect on in-service teachers and the effect of GICS on males and females using the cellular respiration topic. The researcher try to effect of GICS on in-service teachers' performance when taught using cellular respiration through the professional development programme. Beside of that found the differences between males' and females' performances in the experimental group taught using GICS.

2. METHOD

A quasi-Experimental Design (QED) using none-equivalent CG was used. QED was chosen because it produces evidence faster with less cost and resources than true experimental designs and is used to infer the causal treatment effects. QED Also, QED is useful during this period when there is an increased need for innovation and original research that minimises replication in educational studies (Gopalan et al., 2020; Madadzadeh, 2022). The population comprised in-service high schools in one province of the country. These in-

service teachers attended professional workshops to improve their science teaching skills from 2016 to 2017. The study sample comprised 65 in-service high school teachers where 33 (16 males: 17 females) were assigned Experimental Group (EG) and 32 (16 males: 16 females) Control Group (CG): 18 males and 18 females) per group. All in-service teachers volunteered to participate and attended the professional development programme under the authors' Quality Teaching and Learning (QTL) research chair grant number R792 from 2012 to 2017.

The researchers designed a pre-test of 12 questions as the Academic Performance Test (APT) using various literature on two-tier multiple choice questions and three-tier questions (Kumandaş et al., 2018; Prodjosantoso & Hertina, 2019; Saat et al., 2016). APT had two sections: Section A was a two-tier multiple-choice questions, and Section B was a three-tier explanation questions (Appendix 1). Three experts, two physical science teachers, and one lecturer checked the APT for the instrument's face and content validity. Reliability was established using a pilot study with 10 in-service teachers who did not participate in the study, and a Cronbach Alpha of .82 was obtained, suggesting that the instrument was suitable for the study. The APT as a Pre-test comprised 12 questions given to EG and CG to ascertain conceptual understanding regarding cellular respiration before the beginning of the study. The second author taught Experimental Group (EG) and Control Group (CG) to avoid personality differences. EG was taught using GI, while CG was taught using TCAT. The same pre-test was used as a post-test, but the numbers of the questions were re-arranged to reduce the recognition effect (Kibirige & Teffo, 2014; Saat et al., 2016). Pre-and post-tests data were analysed descriptively: means, standard deviations (SD), and inferential: t-test to establish the differences between the two groups. As well as a Mann Whitney U-test to ascertain differences in performance among male and female in-service teachers, and an Analysis of Covariance (ANCOVA) was to determine any differences in performance after the intervention. The research analysed data using Statistical Package for Social Science version 22.

3. RESULT AND DISCUSSION

Result

This study aimed to analyse the GICS effect on in-service teachers and the effect of GICS on males and females using cellular respiration. The major findings were that the EG performed better than the CG and (ANCOVA, $p < .05$). The APT results of EG using ANCOVA revealed differences in favour of EG learners. EG demonstrated a clear understanding of how cellular respiration takes place. For example, in the formation of Adenosine Triphosphate (ATP), EG shows the three steps: step one is glycolysis, and the product is Glucose \rightarrow 2 pyruvate; step two is Pyruvate \rightarrow acetyl-CoA, and tricarboxylic acid (TCA) cycle where the end product is Pyruvate \rightarrow 6CO₂ and step three is the Electron transfer chain (oxidative phosphorylation where the end products $12\text{H}_2 + 6\text{O}_2 \rightarrow 6\text{H}_2\text{O}$). For the CG, it was not all that simple to explain the process of ATP formation and electron transfer processes because they can see in the simulation how electrons move during the process, and this part of respiration has been a challenge in cellular respiration studies (Lenz et al., 2022; Reidelbach et al., 2021). A few in-service teachers stated it is the same as the gaseous exchange in the lungs. Thus, some teachers had misconceptions, which concurs with those who found misconceptions regarding the breathing concept (Maeng & Gonczi, 2019; Nunaki et al., 2019).

Discussion

It was suggested that the change was because of the GICS, the intervention. This finding agrees with previous research that state teaching strategies like guided inquiry positively impact learner performance (Zimmerman, 2020). Also, in-service teachers using GICS were more active and motivated than their counterparts taught using TCAT. During the pre-test, in-service teachers did not know many concepts, which is similar to the findings from previous research, there were no differences in performance between the two groups regarding cellular respiration (t-test, $p > .05$) (Marshall et al., 2017; Schippers et al., 2021). It implies that the two groups had a similar conceptual understanding. These results agree with previous research that learners improve performance when actively engaging in hands-on activities (Dam et al., 2019; Nardo et al., 2022). The tasks to EG learners were like a game, and they enjoyed learning. It is not surprising because learning through games has been reported to improve motivation. Also, their explanations were clearer than those from CG because they used computers, which agrees with (Strømme & Mork, 2021). The study had two limitations: in-service teachers from one geographical area and the use of a quantitative approach which might have missed out on social and aesthetic issues. Therefore, the researcher recommends further study using qualitative and quantitative approaches to a large sample from different geographic regions.

4. CONCLUSION

Because EG performed better than CG, the GICS intervention was highly effective. Based on the findings, there was no difference in performance between the two groups regarding cellular respiration. This

implies that both groups have the same conceptual understanding. Assignments for EG learners are like games, and they enjoy learning. This is because learning through games has been reported to increase motivation.

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