2-The Impact of Engaging Technology and Ipsative Assessment in Mathematics on Grade 8 Students' Achievement and self-efficacy

أثر استخدام التكنولوجيا التفاعلية والتقييم التقارني الذاتي في الرياضيات على تحصيل طلاب الصف الثامن وكفاءتهم الذاتية.

Rana Halim Fleihan

PhD student in Education, Mathematics Coordinator and Teacher, specialized in training trainers on the STEAM curriculum.

بقلم الطالبة: رنا حليم فليحان

طالبة دكتوراه في التربية، منسقة ومعلمة رياضيات، متخصصة في تدريب المدربين على منهاج STEAM

rana.fleihan@gmail.com

تحت اشراف الأستاذ الدكتورة: سناء نعيم شهيب

أستاذ دكتور في الجامعة اللبنانية – كلية التربية

Sanaa Naim Shehayeb

Full professor at the Lebanese University Faculty of Education

https://orcid.org/0000-0003-3976-6380

Sshehayeb@ul.edu.lb

تاريخ الاستلام: 2026/2/17 تاريخ القبول: 2026/2/25 تاريخ النشر: 2026/3/25

Abstract

This study examines the impact of integrating technology-supported ipsative assessment into Grade 8 mathematics teaching in Lebanese public schools in Aley district. A mixed-methods design was used, combining a teacher questionnaire, repeated student assessments administered across two intervention phases, and focus groups with teachers and students. The intervention integrated e-learning, e-assessment, and e-feedback through online mathematics applications to support self-referenced progress monitoring. Quantitative findings indicate improved student performance across the intervention phases, while qualitative findings suggest increased confidence, engagement, and perceived usefulness of feedback. Teacher survey results did not show statistically significant associations between application use and the assessed feedback/assessment categories, suggesting that implementation quality and context may matter more than platform availability alone. The study used a quasi-experimental with one-group design without a control group and explored self-efficacy qualitatively rather than through a standardized scale.

A questionnaire was shared privately and filled out by 111 math coordinators and teachers out of 145. Four assessments were shared with students in two consecutive phases via online math apps that were integrated to provide students with e-assessment, e-learning, and e-feedback. 64 students participated in this study from 5 public schools. The analysis of the collected data was performed using independent sample t-tests with SPSS software. The mean score in the 1st phase increased from 2.98 to 3.94, which indicates a notable improvement in student performance. The boxplot analysis reveals a clear shift in the distribution of scores, with over 75% of students achieving higher scores (around 4 out of 5) after the intervention. The mean score in the 2nd phase increased from 3.11 to 3.92, indicating a positive shift. The distribution of scores shifted towards higher performance levels, with over 75% of students achieving scores of 4 or 5 out of 5.

Keywords: Ipsative e-assessment, educational technology, ipsative e-feedback, self-efficacy, Computer-based intervention

الملخص:

تسلّط هذه الدراسة الضوء على أثر تطبيق التقييم التقارني الذاتي (Ipsative) القائم على التكنولوجيا في تدريس الرياضيات لطلبة المرحلة المتوسطة، وتصف تطوّر أداء طلاب الصف الثامن في المدارس الرسمية اللبنانية في قضاء عاليه.

تم اعتماد منهجية بحثية تجمع بين الأسلوبين الكمي والنوعي، حيث وُزِّع استبيان بشكل خاص وتمت تعبئته من قبل 111 منسقًا ومعلمًا للرياضيات من أصل 145. كما تم تقديم أربعة اختبارات للطلاب على مرحلتين متتاليتين عبر تطبيقات رياضيات إلكترونية تم دمجها لتوفير التقييم الإلكتروني، والتعلم الإلكتروني، والتغذية الراجعة الإلكترونية. شارك في هذه الدراسة 64 طالبًا من خمس مدارس رسمية.

أُجري تحليل البيانات المجمّعة باستخدام اختبار (t) للعينات المستقلة من خلال برنامج SPSS. وقد ارتفع المتوسط الحسابي في المرحلة الأولى من 2.98 إلى 3.94، مما يشير إلى تحسن ملحوظ في أداء الطلاب. كما أظهر تحليل مخطط الصندوق (Boxplot) تحولًا واضحًا في توزيع الدرجات، حيث حقق أكثر من 75٪ من الطلاب درجات أعلى (حوالي 4 من 5) بعد التدخل. وفي المرحلة الثانية، ارتفع المتوسط الحسابي من 3.11 إلى 3.92، مما يدل على تحسن إيجابي. كما تحوّل توزيع الدرجات نحو مستويات أداء أعلى، حيث حقق أكثر من 75٪ من الطلاب درجات 4 أو 5 من 5.

الكلمات المفتاحية: التقييم الإلكتروني التقارني الذاتي، التكنولوجيا التعليمية، التغذية الراجعة الإلكترونية التقارنية الذاتية، الكفاءة الذاتية، التدخل القائم على الحاسوب.

Introduction

Despite the longstanding existence of ipsative assessment, formal systems implementing it remain limited. Hughes admits that a large number of teachers are probably using this type of assessment without being aware of or familiar with the word ipsative. Considerable research has been done about assessment and technology, previous studies implemented formative ipsative assessment as part of inquiry learning in high school (Nishizuka, 2022) or as effective ipsative feedback in languages (Martínez-Arboleda, 2021).

Choosing grade 8 students was due to the importance of this grade level in learning the mathematical basic skills that are considered the core of middle school curriculum. Learners at this age usually engage in activities that show their strengths and not their weaknesses. This study focuses on implementing online computer-marked assessments integrated with ipsative assessment, a less popular kind of assessments, to keep pace with today's educational progress and examine the efficacy of ipsative e-assessment and e-feedback regarding intra- and inter-individual differences. While choosing public schools was one of the main goals of this study since the national books and the learning strategies needs improvement, where implementing new assessment strategies may reveal faster progress in students' achievements in mathematics.

Providing students, the confidence they need to complete self-referenced math assessments is the main objective where grades will reflect their progress. This will limit the high-achievers' showing off and give space for other students to show their abilities through scoring depending on their progress. Moreover, this study will provide invaluable insights for educational trainers, school supervisors, teachers, and, most importantly, curriculum designers. The study findings will facilitate the development of innovative materials and online applications that support effective e-assessment and e-feedback practices.

However, the findings of this study will be limited to math subject and cannot be generalized to other subjects. The study has been conducted through the last school semester of the academic year (2023-2024) and the location of schools has been in the same district. The used accounts from the IXL site were free for one month. So, creating accounts for students via IXL app, sharing the passwords with students and using them in a period of one month limited the interference time of feedback between the assessments. The last technical limitation was the availability of network for some students that obliged the researcher to give more time for some stages to be fully completed. Few school principals were not cooperative and kept postponing the visit to their schools to avoid the participation of their students in the study. While in other schools only some students didn’t participate for personal reasons, though teachers and students were always reminded that the results are confidential and won’t affect school results.

The primary objectives of this study are to examine the integration of technology into mathematics education through the use of e-assessments, e-feedback, and ipsative evaluation methods. It investigates changes in students’ performance following the implementation of multiple digital assessments and individualized feedback, with the aim of enhancing teaching and learning practices. Mathematics applications are employed to encourage students to practice regularly, monitor their progress, and receive tailored feedback aligned with their individual responses. Mobile applications provide continuous e-feedback, enabling systematic reflection on learning outcomes. Central to the study is the application of ipsative assessment, which evaluates each student’s progress against their own prior results rather than in comparison with peers. This approach fosters a personalized learning environment that promotes self-improvement while reducing competitive pressures in mathematics education.

Materials and Methods

Research design and plan

This study adopted a mixed-methods design combining quantitative and qualitative components. Quantitative approach, as explained by Edmonds and Kennedy (2017) is framed by the belief of one truth requires to be discovered and is known as realism. Typically, this approach is favored to study the outcomes effected by integrating technology into assessment. To validate the findings, qualitative research method was also used in tandem. Qualitative research method is considered a must to rely on others experiences and their different perspectives towards using math apps, e-assessments, e-feedbacks and particularly using them ipsatively. Edmonds and Kennedy (2017) inferred in their book that thoughts, feelings and experiences are unobservable and it doesn’t suggest one reality. It is based on true understanding of actions.

The quantitative component included: a questionnaire administered to mathematics coordinators and teachers, and repeated student assessments implemented in two consecutive phases through online mathematics applications. A survey was shared privately with math coordinators and teachers all over Lebanon. 111 math coordinators and teachers filled the questionnaire out of 145. The questionnaire was composed of 4 main parts: the demographic part about the coordinators and teachers, questions specifying the school main features where they are employed, 2 Likert Scale parts the first to identify the overall feedback applications and the second to identify assessment applications of teachers and the overall implementation levels of technology in their classrooms.

Students completed four online assessments over time, which were designed and piloted, Score changes were examined across phases. Because no control group was included, the design supports interpretation of improvement patterns within the participating group but does not by itself establish causal effects.

Thus, the student intervention component followed a quasi-experimental one-group repeated-assessment design.

The qualitative focus groups were used to interpret and contextualize the quantitative findings (including students' perceptions of feedback, confidence, and engagement) and to identify implementation constraints in real school settings. This approach included a focus group of 10 teachers, who were interviewed in an online meeting via Microsoft Teams' application. Another 2 focus groups were included, of 11 students each to explore experiences with e-learning, e-assessment, and e-feedback.

Population and sampling method

The links for the google form of the questionnaire were sent as private messages via WhatsApp, Facebook messenger or e-mail. Data was collected from Math coordinators and teachers teaching K−12 from private and public schools all over Lebanon. 111 teachers participated in the survey out of 145 that could have been reached due to the crisis of Israeli attacks.

Students that enrolled in the study were of Aley district, from 5 different public schools. The number of schools is considered representative due to the fact that only 9 schools were opening their doors and teaching their students by the time this study was implemented. Thus allowing 64 students of the 8^{th} grade to participate in this study out of 103 students. The same student group participated across the intervention sequence, although some missing responses occurred across assessments.

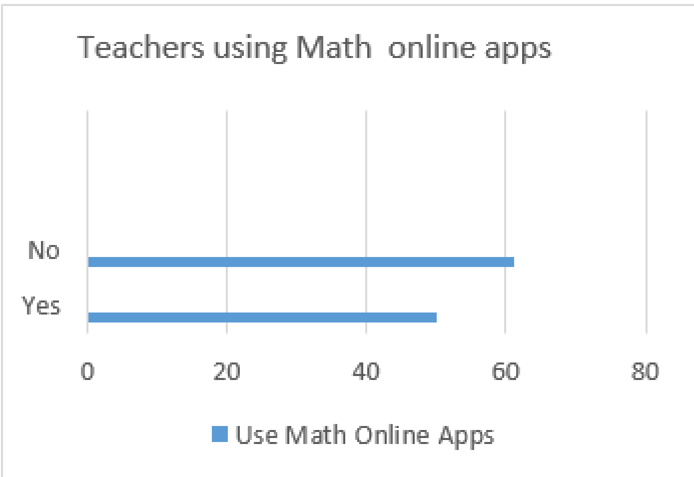

Figure 1.1 Teachers using Math online apps

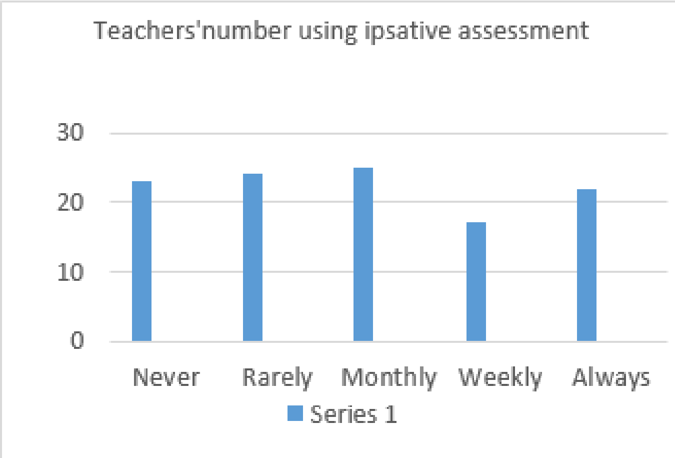

Figure 1.2 Number of teachers using ipsative assessment

Sampling the focus group was based on the results of the questionnaire. 50 teachers used online math apps with their students (fig 1.1) and 17 teachers use ipsative assessments weekly and 22 teachers always use ipsative assessment in their classes (fig 1.2). 10 teachers were chosen on the basis of these two features. 3 teachers that use math apps and don't use ipsative assessment, 3 teachers that use them both and 2 teachers that use ipsative assessment but don't use online math apps. To reach them the google form was collecting the emails of the participants which helped to contact them through e-mail.

2 - 2 - 1 Pilot of the questionnaire

To conduct the pilot study, the objectives were clearly set. The sample was selected to be representative and similar to my actual respondents. Once, the questionnaire is completed, the questionnaire was piloted on 23 teachers. The collected results ensured that the questionnaire items were easily understood and answered.

2 - 2 - 2 Pilot of the 4 assessments

Four assessments were addressed and piloted with 12 students in a school in Baabda district. The results were compared using independent sample t-test in IBM SPSS 21. The independent-sample t-test was run to determine if the e-feedback was more effective at increasing the number of correct answers than learning without providing e-feedback. The results showed that the participants when receiving positive e-feedback (M=4.00, SD=1.279) reported higher number of correct answers than when not receiving e-feedback (M= 2.92, SD= 1.505). This difference was not significant (t (-1.900) p=.071) p>.05 at 5% significance level. Thus, Further studies are required to accept or reject these results.

Table 1.1: Pilot study

Group Statistics

phase1		N	Mean	Std. Deviation	Std. Error Mean
scores1	1	12	2.92	1.505	.434
	2	12	4.00	1.279	.369

2 - 2 - 3 Pilot of the questions for the focus group

The questions of the interview were piloted with a teacher and 2 students to check understandability and to approximate the time needed to conduct the meeting with the focus groups. The questions were prepared in both languages Arabic and English. The consumed time to answer them was 22 min. so the expected time for the meeting should be 30-40 min.

2 - 3 Data collection and instruments

The online apps that were adopted: Google form to investigate teachers' methods and use of assessment and feedback, the IXL to foster e-learning and formative feedback, Quizizz (Wayground) for e-assessment to compare previous work with the current performance with formative-ipsative feedback and Seesaw for feedback and reflections. As for communication, WhatsApp, email and messenger were used to communicate with teachers and students in addition to in-person contact.

As a first stage, questionnaires were prepared to reach math coordinators and teachers. To prepare this questionnaire, 23 articles about educational technology, feedback and assessment were deeply reviewed. A deep search for the contact numbers of the math coordinators and teachers was done either through their school principals, their colleagues, or their students. Second, the accounts for three online applications were prepared to integrate them accordingly in my study. Students were helped to set up their mobile apps on their devices using small documents that explain the instructions to download and sign in to the apps and links. Then, the credentials, usernames and passwords, were set and sent via private messages on their mobile phones or delivered to them in person at their schools. The third stage was designing the tools needed to measure students' progress. Four main assessments were designed to be assigned to students via the math online app, Quizizz. The misconceptions were based on simple skills that most students always fail to master (Stemele, B. P., & Jina Asvat, Z., 2024). Teachers usually try their best to build their students' knowledge about algebraic terms and expressions as soon as they start learning operations. But most students fail to master these skills. The skills that were chosen in this study were: factor quadratics, factor out a monomial, polynomial vocabulary, add and subtract polynomials, multiply a polynomial by a monomial, multiply two binomials, distributive property, identify equivalent linear expressions, and simplify variable expressions involving like terms.

The last tool, was the questions for interviewing the coordinators and teachers that will participate in the focus group which were prepared depending on the collected responses of the questionnaire that was previously filled by the them. The questions for students' focus groups were emphasized about their own perceptions to infer to what extent their self-efficacy has changed.

2 - 4 Validity and reliability of instruments

For the reliability and validity of the questionnaire, piloting and Cronbach's alpha measure were applied. The internal consistency, the Cronbach's alpha measure, was calculated using IBL SPSS 21, which was found to be 0.742 for the 13 ordinal variables. A Cronbach's alpha value of 0.742 indicates an acceptable level of internal consistency among the scale items.

Table 1.2: Reliability of the teacher's questionnaire

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.742	.750	13

For the assessment tools, piloting the assessments with different group of students under the supervision of 2 other math teachers ensured their reliability and validity. Moreover, Piloting the focus group's questions with other teachers and students assured their validity and consistency.

2 - 5 Ethical concerns

The questionnaire responses were confidential and anonymous and the participants responded voluntarily to them. The research purposes and procedures were communicated with school principals, coordinators, teachers and students in advance. Besides, all contact numbers of teachers and students remained confidential, all students should be able to access assessments, and they should be made as inclusive as possible. Feedback ought to be timely, helpful, and respectful of each person's requirements.

2 - 6 Implementation, collecting data and evidence of students' progress.

First, a post-study survey was delivered to math coordinators and teachers in private chats via social media apps and emails ,111 math coordinators and teachers filled the questionnaire out of 145. Those who didn't participate referred that to their unstable living situation during the Lebanese crisis of the Israeli attacks. Second, the first assessment was designed to diagnose students' mastery of certain skills. As (Yovanoff, 2009) inferred assessment results may provide information about students' mastery of relevant prior knowledge and skills as well as preconceptions or misconceptions and teachers may adjust their instruction relying on these results by identifying which areas students have or have not mastered. The 3rd stage is considered as construction of knowledge as (Veletsianos, 2016) mentioned all forms of constructivist theories "share the understanding that individuals' construction of knowledge is dependent upon individual and collective understandings, backgrounds, and proclivities" (p. 38). Using the IXL application aimed to help students understand the concepts and skills experience and deep practice. During one month (30 days), 7,287 questions were solved. The application's student quick review showed that students spent 91hrs 19min practicing the assigned skills. The skills that were assigned were chosen depending on the results of the first quiz. Hereby, the concept of formative assessment is applied.

Therefore, the ipsative approach was introduced to evaluate each student's progress compared to his/her previous results. Using positive self-referential feedback aimed to provide learners with feedback electronically on their progress as well as on their learning outcomes. (G. Huges, E. Wood, K. KItagawa, 2014) described the importance of engaging students with feedback to become self-regulating and act as assessors through encouraged self-review. Hence, using Seesaw helped students receive feedback on their outcomes and their progress and allowed them to add their comments as a self-review over the whole process. Students were also allowed, after receiving feedback, to rejoin the same questions and resolve them during the week. After comparing the results of both attempts for each student, the efficacy of the feedback they received was noticed. Digital platforms facilitated the comparison of students' previous work with their current performance, allowing for a clear assessment of progress. By sharing the results directly through the Seesaw app, students were able to access the feedback promptly and engage in self-reflection.

To promote and foster the sense of ipsative assessment, the 2nd assessment covered the similar content to record students' improvement. Corrective feedback should be avoided not to emphasize on weaknesses. However, positive feedback starting with the students' accomplishments can be followed with the critique as inferred by (G. Huges, E. Wood, K. KItagawa, 2014) that critical feedback is sandwiched between two sets of praise in an attempt to make the filling easier to swallow. Hereby, the 3rd and the 4th assessments were introduced to repeat the same process followed with the 1st and the 2nd assessment. Assessments were also introduced after a week allowing students to join the e-learning stage through IXL and receiving e-feedback via Seesaw (fig 1.3). Furthermore, the WhatsApp groups assured the continuous backup whenever students' engagement diminished or showed delay. The integration of different applications covered all areas of communication especially the difficulties faced related to internet connection and availability of network.

Therefore, the intervention integrated online mathematics applications to provide e-learning, e-assessment, and individualized e-feedback. Students completed repeated assessments in two phases. Performance trends were examined by comparing assessment scores across time points and by reviewing score distributions (including boxplot summaries) to identify shifts in performance levels.

Figure 1.3 Sequence of tools implementation with students

Focus group: Conducting focus group meeting with students and teachers

Focus groups offer a powerful method for gathering rich qualitative data. (Leung FH, SavithiriR., 2009). Focus groups can provide rich qualitative data that offers deep insights into participants' perceptions and experiences. This tool requires skilled moderation to manage diverse opinions and ensure equal participation of all participants especially when conducted with expert participants who can have different views and can be easily supported with relevant evidences based on their own experience. These focus groups produced rich qualitative data by enabling a deeper examination of participants' experiences and viewpoints. Thus, the goal of this study was to provide an in depth and detailed knowledge of the research issues by integrating these quantitative and qualitative methodologies accordingly.

Theoretical background

Older studies have always discussed different types of assessments which compare the test-takers' results against peers or certain criteria. Other types of assessment are the diagnostic, formative, summative, …that also show their influence on the learning process. Focusing on strengths to enhance learning abilities is necessary for motivating students (Hughes et al., 2014). This study is framed in integrated theoretical framework composed of three theories (fig. 1.4)

Formative Assessment Theory and Constructivist Approach, Self-efficacy Perspective and Achievement Behavioral Learning Theory and Connectivism Learning Theory.

Formative assessment that emerged from constructivist learning theory (Atasoy & Kaya, 2022) is associated with the writings of major authors like Lev Vygotsky, John Dewey, and Jean Piaget (Mattar, 2018). Constructivism, as Tam (2000) reported, assessing students using a special type of formative assessment which is: ipsative assessment, it is considered as the first challenge of re-conceptualizing learning as a constructive method. And designed to allow students to compete with and improve upon their prior performance on the same assessment which is a natural continuation of retrieval practice (Penn & Wells, 2018). Moreover, (Clark, 2012) inferred that by determining the degree to which formative feedback actualizes and reinforces students' self-regulated learning techniques, the idea of formative ipsative assessment is proven to be a unifying theory of teaching that directs practice and enhances the learning process.

Formative-Ipsative assessment offers resolutions as a motivational device and in helping learners to develop self-regulatory skills over time (Hughes et al., 2014). Ipsative feedback also plays an important role in building self-confidence. Critic or negative feedbacks have a negative influence on learners' self-efficacy. Some instructors use devices such as the "feedback sandwich" in which critical feedback is sandwiched between two sets of praise or positive feedback in an attempt to make 'filling' easier to swallow (Hughes et al., 2014). Self-Efficacy is a person's particular set of beliefs that determine how well one can execute a plan of action in prospective situations (Bandura, 1977). By recognizing their strengths and building on their past successes, students can develop a positive mindset and a stronger sense of self-belief. Thus, formative-ipsative assessment is a suitable behaviorist approach due to the formation of new skills and knowledge in a certain coarse. (Schunk, 1984) advocates students' achievement expectancies affect behavior and perceived self-efficacy is an important variable in understanding achievement behavior.

In addition to these competing theories, connectivism, a learning theory that emphasizes the importance of networks and connections, aligns well with the personalized nature of formative ipsative assessment. By leveraging digital tools and platforms, teachers can implement formative ipsative assessments within a connectivist framework. In a time when knowledge is no longer acquired in a linear fashion, technology performs many of the cognitive functions that learners once performed (such as storing and retrieving information), and performance is frequently required in the absence of full comprehension, learning theories should be modified (Mattar, 2018).

Connectivism, as (Siemens, Connectivism: A Learning Theory for the Digital Age, 2004) states, is a new learning theory (more adequate than behaviorism, cognitivism, and constructivism for a digital age). Connectivism carries the learning process in a highly connected world to a newer perspective than pre-digital world. Students are connected with their electronic devices (smart phones, tablets, …) to information sources. From this view, as (Ottenbreit-Leftwich & Kimmons, 2020) reported, learning need not be isolated to the mind, but becoming a learned capable citizen in a digital society requires learners to become connected efficiently and persistently. Researchers, like Gwyneth Hughes, have extensively explored the concept of ipsative assessment, emphasizing its role in promoting student self-evaluation and progress monitoring. By incorporating technology into the classroom, educators can facilitate the implementation of formative ipsative assessment, providing students with timely and targeted feedback.

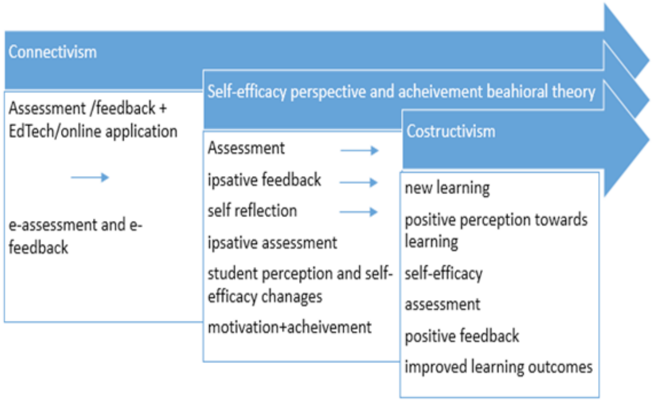

Figure 3.4: Conceptual Framework

3 – 1 Operational Definitions

Ipsative assessment

The word ipsative comes from the Latin ipse that means "of the self". Ipsative assessment is a type of assessment in which the student is compared to his best previous attempt within the same curricular concepts (american board, n.d.). Ipsative assessment can also be defined as: ipsative assessment compares existing performance with previous performance. (Hughes, 2011).

Educational technology

Educational technology (also known as "EdTech") refers to an area of digital technology devoted to the development and the application of tools (including software, hardware, and appropriate technological processes) intended to promote education (Lazaro, 2021)..

Ipsative feedback

Ipsative feedback involves references to previously-provided feedback and the personal progress that students have made compared to that (Ventista, 2018). The aim of ipsative feedback scheme was to provide learners with feedback on their progress as well as the outcomes of their work (Hughes et al., 2014).

Self–efficacy

Self–Efficacy is the belief that you are capable of achieving a specific goal or performing a particular task (Writer, 2015). Self–efficacy is task–specific. For example, if your boss asked you to manage a simple project, then you might feel confident in your ability to complete this task (Writer, 2015).

Computer–based intervention

Computer–based intervention is a broad term used to describe the use of technology to have students practice tasks, provide tutoring, and assist in the management of instructional programs for students that need assistance (Kulik, C & Kulik, J, 1991; Rich et al., 2017).

Literature Review

4 – 1 Educational technology and feedback

According to earlier research Feedback needs to be clear, concise, timely, non–threatening, and editable in order to be effective (Schwartz, tsang, Blair, 2016). Computerized feedback can be utilized to produce more detailed and accurate diagnostic data from e–assessments in addition to presenting students' overall performance (Bulut, 2020). As explained by Irwin et al. (2011), rather than the structure of the feedback itself, we are more concerned in its creation, delivery, and utilization process. As (Barnes, 2023) notes, "educators must weigh the benefits of innovation against the risks of inequity and misuse to ensure technology truly enhances learning outcomes.". Recognizing that technology should enhance rather than replace successful teaching methods, it is crucial to find a balance between traditional and modern approaches.

4 – 2 Feedback in Mathematics Education

Feedback in education plays a crucial role in enhancing student learning, but its effectiveness varies depending on factors like timing, method of delivery, and the type of feedback provided. A systematic review by Söderström and Palm (2024) on feedback in mathematics education. Using Hattie and Timperley's (2007) framework. The study found that task-level feedback was most frequently addressed, while feedback targeting self-regulation, despite its potential for fostering independent learning, was less commonly explored. These findings point to the need for further research particularly self-regulation feedback and strategies to encourage students to use feedback meaningfully in mathematics education.

Barana, Marchisio, and Sacchet (2021) investigated the effects of Interactive Feedback (IF) within the context of Automatic Formative Assessment (AFA) in digital mathematics learning, emphasizing its role in promoting student engagement and self-regulation.

4 - 3 Formative Ipsative Assessment

Nishizuka (2022) explored the use of formative ipsative assessment in a high school inquiry-based learning environment, focusing on how comparing students' current work with their previous efforts can promote personal development. Palmberg et al. (2024) examine the application of a multi-faceted formative assessment approach and the results showed that these methods enhanced behavioral engagement and promoted autonomous motivation by fostering self-regulation and a sense of competence. Boström and Palm (2023) carried out an experimental study to examine the impact of formative assessment practices on the academic performance, the results indicate that while formative assessment has the potential to improve learning outcomes, its effectiveness largely depends on the precision and quality of its implementation. Rakoczy et al. (2019) explored the effects of formative assessment and the results showed that the intervention enhanced students' perceptions of feedback as valuable and improved their self-efficacy, with slight gains in interest. However, no significant differences in achievement were found between the intervention and control groups. Smit et al. (2022) explored the impact of formative feedback on primary students' mathematical reasoning, with a focus on the role of self-efficacy as a mediator. The results showed that while formative feedback indirectly enhanced reasoning through improved self-efficacy at the class level, no direct effects were observed at the individual level.

4 - 4 Self-efficacy

Schunk (1984) stated self-efficacy refers to own perceptions about one's abilities to organize and implement behaviors in given situations. Individuals who have a high level of confidence in their abilities view challenging tasks as challenges to be conquered rather than as dangers to be avoided. An effective perspective like this encourages natural curiosity and intense engagement with activities. They have a strong commitment to the challenging goals they set for themselves. Despite failure, they intensify and maintain their efforts. (Bandura, 1977) also explained then they experience setbacks or failures, they quickly regain their sense of effectiveness. They assign failure to a lack of effort or attainable knowledge and abilities.

Study and Results

5 - 1 Survey for Coordinators and Teachers

5 - 1 - 1 Demographic Information

The study consisted of a survey shared privately with 145 math coordinators and teachers all over Lebanon. 111 responses were collected all over Lebanon. The coordinators and teachers represented both private and public Lebanese schools where 40.5% were private school teachers, 50.5% were public school teachers and 9% were teaching in both. The participants' experience in the education field was almost fairly distributed among the provided intervals, 13.5% of the participants has been in the education field between 1 to 5 years, 14.4% between 5 and 10 years, 26.1% between 10-15 years, 18.9% between 15 and 20 years and 27%

which is the highest percent have been in the domain for more than 20 years. These results helped me know that the opinions of all categories are representative.

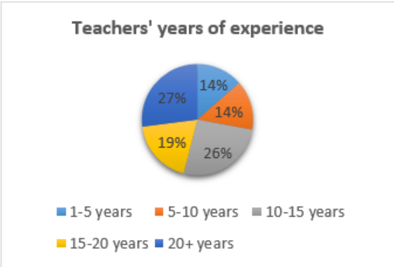

Figure 2.1 Teachers' years of experience

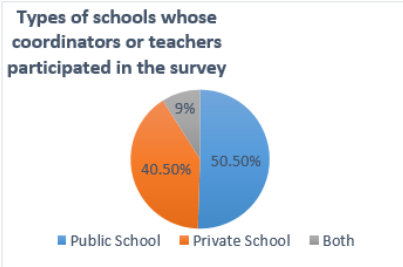

Figure 2.3: Types of schools whose coordinators or teachers participated in the

Also, 53.2% of them are middle school teachers. The percentage support this study since the students involved are 8th graders. The survey also reflected some positive perspectives of Lebanese coordinators and teachers where 55% of them use math online applications for both e–learning and e–assessments and 72.1% of them seek and attend trainings and workshops for professional development that are not supported by their schools. This reveals the intention of lifelong learning that could have positive reflections on their students.

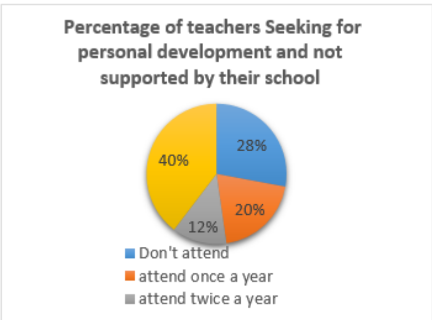

Figure 2.2 Percentage of teachers Seeking for personal development and not supported by their school

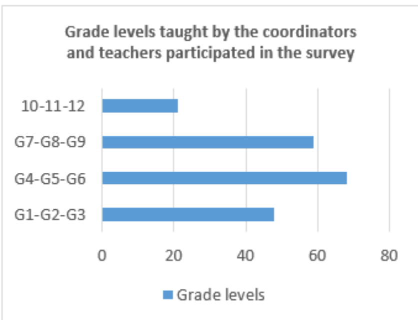

Figure 2.2: Grade levels taught by the coordinators and teachers

The study's coordinators and teachers demonstrated the use of their teaching expertise and methodologies. This is reflected by results of the SPSS software used to study the percentiles of the teachers' responses. The provided descriptive statistics offer valuable insights into teachers' perceptions of assessment practices and technology integration. However, it is important to note that there is variability in teacher practices, as indicated by the standard deviations.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Type of school	111	1	3	1.59	.653	.673	.229	-.556	.455
School assessments	110	1	6	3.77	1.961	-.299	.230	-1.510	.457
School-encouragement for training	111	1	4	2.97	1.013	-.426	.229	-1.122	.455
Oral feedback	111	3	6	5.18	1.185	-1.025	.229	-.645	.455
Written feedback	111	3	6	4.61	.955	-.042	.229	-.937	.455
Feedback given in each assessment	111	3	6	5.26	.979	-.963	.229	-.415	.455
Rubric-based Feedback	111	3	6	4.68	1.243	-.245	.229	-1.578	.455
self-reflection after feedback	111	3	6	4.54	1.126	-.025	.229	-1.377	.455
Feedback is given	111	1	5	2.32	1.502	.689	.229	-.999	.455
Identify assessment's objectives	111	3	6	5.72	.741	-2.780	.229	6.863	.455
Diagnostic assessment	111	3	6	5.14	.999	-.909	.229	-.316	.455
Formative assessment	111	3	6	5.18	.916	-.873	.229	-.169	.455
Summative assessment	111	3	6	5.11	.947	-.677	.229	-.652	.455
Ipsative assessment	111	3	6	4.13	1.169	.516	.229	-1.247	.455
assess to evaluate teaching methodology	111	3	6	4.69	1.174	-.238	.229	-1.441	.455
assess to rank students	111	3	6	4.36	1.110	.259	.229	-1.268	.455
assess to identify misconceptions	111	3	6	5.05	1.099	-.761	.229	-.823	.455
Valid N (listwise)	110								

Table 2.1: Teachers' perceptions of assessment practices and technology integration

5 - 1 - 2 Teachers' Assessments and Math Online Apps

The analysis of the data indicates that while the use of math online apps has been integrated into the learning process, there is no statistically significant relationship between app usage and the specific types of assessments employed (diagnostic, formative, summative, and ipsative.

Table 2.2: Teachers' different types of assessments and using math online apps

How often do teachers use assessments		Teachers use Math online applications: Yes	Teachers use Math online applications: no	Pearson Chi-Square Asymp. Sig. (2-sided)
To identify assessments' objectives	Weekly	8.0%	6.6%	.317
	Always	88.0%	82.0%	
To identify misconceptions	Weekly	36.0%	13.1%	.025
	Always	44.0%	50.8%	
To evaluate teaching methodology	Weekly	34.0%	11.5%	.030
	Always	32.0%	37.7%	
As diagnostic assessment	Weekly	32.0%	26.2%	.578
	Always	50.0%	45.9%	
As formative assessment	Weekly	42.0%	24.6%	.247
	Always	40.0%	50.8%	
As summative assessment	Weekly	38.0%	21.3%	.182
	Always	34.0%	52.5%	
As ipsative assessment	Weekly	14.0%	16.4%	.235
	Always	12.0%	26.2%	
To rank students	Weekly	18.0%	18.0%	.248
	Always	14.0%	29.5%	

Table 2.3: Chi-square of assessments

Chi-square Test		Diagnostic			Formative			Summative			ipsative		
Pearson-Chi-square		value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)
		1.972	3	0.578	4.138	3	0.247	4.861	3	0.182	4.258	3	0.235
Likelihood Ratio		2.04	3	0.564	4.165	3	0.244	4.893	3	0.18	4.389	3	0.222
Linear-by-Linear Association		1.225	1	0.268	0	1	0.999	1.185	1	0.276	4.036	1	0.045
		value	Approx. Sig.		Value	Approx. Sig.		Value	Approx. Sig.		Value	Approx. Sig.	
Nominal by nominal	Phi	0.133	0.578		0.193	0.247		0.209	0.182		0.196	0.235	
	Cramer's V	0.133	0.578		0.193	0.247		0.209	0.182		0.196	0.235	
N of Valid Cases		111			111			111			111		

formative). While the Cramer's V values suggest a small to moderate association between app usage and assessment types, the non-significant p-values indicate that these associations may be due to chance.

Also, the p-value (Asymp. Sig. (2-sided)) for Pearson Chi-square statistic is higher than .05 ($p > .05$), all tested types of assessment are not dependent on using online math apps. So, we reject the null hypothesis that using diagnostic, formative, summative or ipsative assessment is the same across using math online apps and conclude that types of the tested assessments are not related to using online math apps. The findings of this study suggest that while online math apps have been integrated into the teaching practices of many teachers, there is no significant association between their use and the specific types of assessments employed (diagnostic, formative, summative, and ipsative).

5 - 1 - 3 Teachers' Feedback and Math Online Apps

A chi-square test for independence was computed to determine whether teachers' feedback is independent of using math online apps. The results are not significant, $\chi2(3) = 5.278$, $p = .153$, Cramer's V/phi = .153. The p-value (Asymp. Sig. (2-sided)) for

Pearson Chi-square statistic is higher than .05 ($p > .05$), so giving feedback in each assessment is not dependent on using online math apps. So, we reject the null hypothesis that giving feedback in each assessment is not the same across using online math apps and conclude that giving feedback in each assessment is not related to using math online apps. Also, the Cramer's V/Phi is close to 0.20 which is considered to be of small impact.

All results in the cross tabulation of feedback and online math apps shows that the p-value (Asymp. Sig. (2-sided)) for Pearson Chi-square statistic is higher than .05 ($p > .05$). Thus, the types of feedback provided by teachers are not dependent on using online Math apps. So, we fail to reject the null hypothesis. See table 2.5.

The results reflect the importance of feedback for most teachers. Teachers that always provide feedback in each assessment and tend to use online math apps represent 56% and who provide it weekly are 24%. This makes a total of 80% which reflects the importance of regular feedback in teachers' performance to enhance the teaching –learning process. This is also reflected with the percentage of teachers that don't use math

Table 2.3: Chi-square of feedback

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.278[a]	3	.153
Likelihood Ratio	5.370	3	.147
Linear-by-Linear Association	.033	1	.855
N of Valid Cases	111		

2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.15.

Table 2.4: Chi-square and Cramer's V for feedback

Symmetric Measures			
		Value	Approx. Sig.
Nominal by Nominal	Phi	.218	.153
	Cramer's V	.218	.153
N of Valid Cases		111	

online apps and always provide feedback in each assessment represent 59.09% and 11.59% of them provide feedback in each assessment weekly. The total percentage adds up to 70.68%.

The percentage of teachers using oral feedback always is relatively the same, about 62%, compared to using math online apps or not. While in written feedback, the highest percentage, 40%, was for the teachers using online apps and provide weekly feedback. Rubric-based feedback seemed more popular among teachers that don't use math online apps where their total percentage was about 59% while the percentage of teachers that use rubric-based feedback and use math online apps was 54%. As for using self-reflection feedback along with math online apps the percentage was 52% and without using math apps was 49.2%. The slight difference between the percentages of teachers using math apps or not confirms the fact of failing to reject the null hypothesis. The table shows the Chi-square test statistic of teachers' feedback along with using math online apps and its significance.

Chi-square Test													
		Oral Feedback			Written Feedback			Rubric-based feedback			Self-reflection after feedback		
Pearson-Chi-square		value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)
		5.814	3	.121	2.435	3	.487	2.706	3	.439	1.700	3	.637
Likelihood Ratio		6.516	3	.089	2.433	3	.488	2.712	3	.438	1.702	3	.637
Linear-by-Linear Association		.025	1	.873	.075	1	.784	1.185	1	.516	.027	1	.869
		value	Approx. Sig.		Value	Approx. Sig.		Value	Approx. Sig.		Value	Approx. Sig.	
Nominal by nominal	Phi	.229	.121		.148	.487		.156	.439		.124	.637	
	Cramer's V	.229	.121		.148	.487		.156	.439		.124	.637	
N of Valid Cases		111			111			111			111		

Table 2.5: Chi square for feedback

How often do teachers use		Teachers use Math online applications		Pearson Chi-Square Asymp. Sig. (2-sided)
		Yes	No	
Oral feedback	Weekly	16.0%	8.2%	.121
	Always	62.0%	62.3%	
Written feedback	Weekly	40.0%	26.2%	.487
	Always	18.0%	23.0%	
Rubric-based feedback	Weekly	22.0%	14.8%	.439
	Always	32.0%	44.3%	
Self-reflection after feedback	Weekly	28.0%	19.7%	.637
	Always	24.0%	29.5%	
Feedback in each assessment	Weekly	24.0%	11.59%	.153
	Always	56.0%	59.09%	

5 - 1 - 3 - 1 1st and 2nd assessments (Phase 1)

The results indicate a non-significant difference between the 1st assessment (M=2.98, SD=.934) and the 2nd assessment (M=3.94, SD=1.006), [t(124) =-5.501 , p = .000 < .05]. The 95% confidence interval of the difference between means ranged from [-1.293 to -.609] and did not indicate a difference between the means of the sample. Consequently, we reject the null hypothesis that there is no difference between the scores of the 1st and 2nd assessments.

There seems to be a contradiction between the t-test results and the interpretation provided.

T-test Results: The t-test statistic is significant ($p < .05$). The confidence interval does not include zero, indicating a statistically significant difference between the two means. The interpretation suggests that there is no significant difference, which contradicts the statistical results.

Misinterpretation of p-value: It's possible that there might have been a misunderstanding of the p-value. A p-value less than 0.05 indicates statistical significance, not insignificance. There might be an error in the calculation of the confidence interval. While the confidence interval can provide additional information, it should not be the sole basis for interpreting the results. The t-test itself is the primary statistical test to determine significance.

Given the significant t-test result and the confidence interval that does not include zero, we can conclude that there is a statistically significant difference between the mean scores of the first and second assessments. The second assessment's mean score is significantly higher than the first assessment's mean score.

The mean of the 1^{st} assessment is 2.98 while the mean of the 2^{nd} assessment is 3.94. this difference assures the fact that the students showed achievement after providing the e-learning via IXL and the e-feedback via Seesaw. The substantial increase in the mean score from 2.98 to 3.94 between the first and second assessments indicates a notable improvement in student performance. Additionally, the boxplot analysis reveals a clear shift in the distribution of scores, with over 75% of students achieving higher scores (around 4 out of 5) after the intervention.

Table 2.6: Assessments phase1

Group Statistics

Phase 1		N	Mean	Std. Deviation	Std. Error Mean
Number of correct answers	1	64	2.98	.934	.117
	2	62	3.94	1.006	.128

Table 2.7: Independent t-test for assessments 1 and 2

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Number of correct answers	Equal variances assumed	.722	.397	-5.501	124	.000	-.951	.173	-1.293	-.609
	Equal variances not assumed			-5.495	122.626	.000	-.951	.173	-1.294	-.608

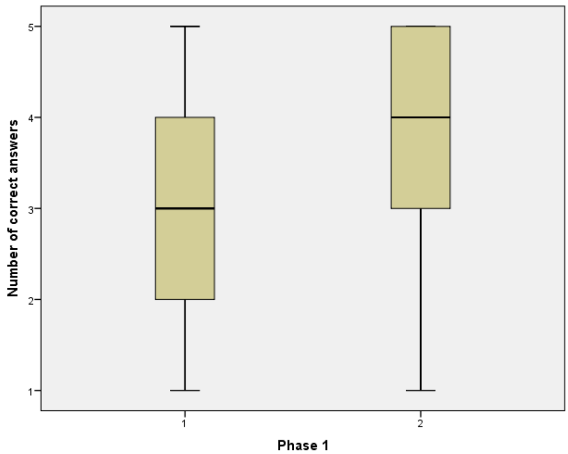

Figure 2.1 Boxplot for assessments 1 and 2

(3rd and 4th assessments (Phase 2 1.1.1.1

The results indicate a significant difference between the 3rd assessment (M=3.11, SD=1.079) and the 4th assessment (M=3.92, SD=.948), [t(125) =-4.500 , p = .000 < .05]. The 95% confidence interval of the difference between means ranged from [-1.167 to -.454] and indicate a difference between the means of the sample.

Table 2.7: Assessments 3 and 4 phase2

Group Statistics					
Phase 2		N	Mean	Std. Deviation	Std. Error Mean
Number of correct answers	3	63	3.11	1.079	.136
	4	64	3.92	.948	.118

Table 2.8: Independent t-test of assessments 3 and 4

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Number of correct answers	Equal variances assumed	.240	.625	-4.500	125	.000	-.811	.180	-1.167	-.454
	Equal variances not assumed			-4.495	122.433	.000	-.811	.180	-1.168	-.454

Case Processing Summary							
		Cases					
Phase 2		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Number of correct answers	3	63	98.4%	1	1.6%	64	100.0%
	4	64	100.0%	0	0.0%	64	100.0%

The mean of the 3rd assessment is 3.11 while the mean of the 4th assessment is 3.92. This difference assures the fact that the students showed achievement after providing continuous e-learning via IXL and e-feedback ipsatively via Seesaw. The means of the 3rd and 4th assessment in the boxplot shows that less than 50% of the students scored about 3 out of 5 correct responses while after providing self-referential feedback, students showed achievement where more than 75% of the students scored about 4 out of 5 correct responses.

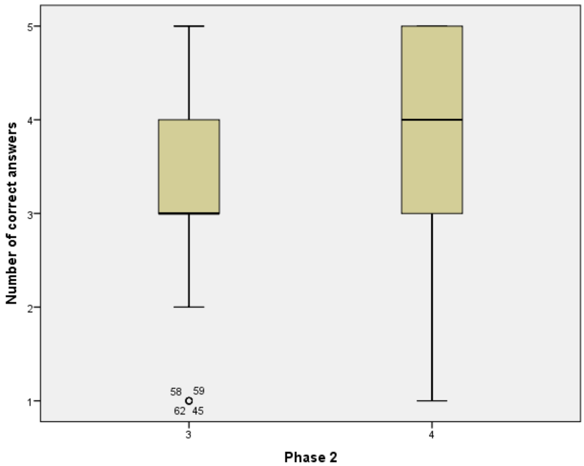

Figure 2.2: Boxplot of assessments 3 and 4

Consequently, the repeated assessments showed an increase in mean scores across both intervention phases, indicating improved performance after exposure to the integrated e-learning, e-assessment, and ipsative feedback approach. The score distributions also shifted toward higher values, with a larger proportion of students achieving higher performance bands in later assessments.

Statistical statements were interpreted using the conventional decision rule: when $p < .05$, the difference is statistically significant and the null hypothesis is rejected; when $p > .05$, the null hypothesis is not rejected (fail to reject). Accordingly, statements describing $p = .000$ (reported by SPSS as $p < .001$) indicate statistically significant differences rather than non-significant differences.

Because the same students were assessed repeatedly, paired-samples analysis is the more appropriate inferential approach when matched student-level records are available. The manuscript therefore interprets score changes as repeated-measures comparisons and avoids describing them as independent-group comparisons.

5 - 2 Students' self-efficacy

Self-efficacy has often been measured through a rather general self-assessment of an individual's capacities to master a subject. (Schulz, 2005) also explained that such self-assessments require students to respond to questions that tap their general beliefs about being able to master a subject. This approach might be seen as one that assesses the students' confidence in having the necessary resources to succeed in a particular domain. This approach is problematic as the measures are often generated 'without any clear academic activity or task in mind' (Pajares 1996).

To check students' self-efficacy, 22 students were invited to join 2 focus groups in an online recorded meeting. The groups were of 11 participants each. The students were asked to discuss 8 questions to gain deeper insights about students' perceptions to further understand their points of view towards experiencing the electronic learning, electronic ipsative assessment and electronic ipsative feedback. Coding and labeling each segment and phrase with its significance was done manually using index cards. After relating the collected codes with the research questions, the themes are organized in a table after refining them (see table 3.1).

5 - 3 Thematic Analysis of Student Responses

In this study, self-efficacy was explored qualitatively through student focus groups rather than measured using a standardized quantitative self-efficacy scale. Therefore, findings in this section are reported as students' perceived confidence, willingness to continue, and perceptions of progress, rather than as a standardized measured effect size for self-efficacy.

Table 3.1: Thematic analysis of students' focus group

Theme	Analysis of students' responses ((group A	(Analysis of students' responses (group B
Time and productivity	of Students explained that 68% online assessments before this study was effective and easy, and the percentage increased to 82% .So, 14% of this group changed their point of view from considering e-assessments as difficult and time-wasting to effective and easy.	of Students explained that online as- 61% sessments before this study was effective and easy, and the percentage increased to 83% .So, 22% of this group changed their point of view from considering e-assessments as difficult and time-wasting to .effective and easy
Impact of feedback tools and methods	Students agreed that online apps were helpful but network issues can sometimes be a barrier for not completing their tasks. 72% of students inferred that the feedback they received helped them understand their mistakes and 28% explained that the feedback was not clear enough to understand the ideas .hidden behind their mistakes	Most students faced difficulties in joining or receiving links, feedback or notifications due to network issues. They agreed that receiving personal feedback privately was effective and more preferable than feedback received in class and 90.9% informed that it helped them understand their mistakes, 9.1% claimed that feedback re- .ceived wasn't clear enough
Effectiveness of e-learning	Students logged in to IXL learning app and examined the different features provided. 63.6% of the students inferred that the time spent using online apps was exciting and effective. 36.4% explained that it was difficult to sign in and it was .boring	Students logged into the app but some of them only solved the assigned skills without examining other features of the app, only 27.2% snooped through the app and 22.7% said the time spent was boring and not effective. But 77.3% agreed that online apps are exciting and effective
Methods and effectiveness of feedback provided through the e-learning platform	inferred that apps con- 81.8% tained helpful exercises and explanations. 9.1% said that questions are difficult and explanations are short. 9.1% inferred that the questions are too .easy	Students of group B 27.4% explained the effectiveness of the explanations while 36.3% claimed that the questions were difficult and the explanations are short, while .36.3% inferred that questions are too easy
Preferences compared to in-person learning	of the students preferred 68.2% to receive math education in person with teacher regardless of enjoying online apps or not. 31.8% prefer online apps to enjoy using game-based learning and watching videos	preferred to receive math education 81.8% with teacher and 18.2% preferred online apps to enjoy using game-based learning .and watching videos

Theme	Analysis of students' responses ((group A	(Analysis of students' responses (group B
Self-efficacy in math assessments	feel more confident to 81.8% solve math assessments after participating in this study. 18.2% still feel upset to enroll in math assessments	feel more confident to solve math 63.6% assessments after participating in this study while 36.4% still feel upset to solve math .assessments
Feelings and reflection	Some students explained that it was a wonderful experience others said it is helpful but not exciting	All students agreed it is helpful to use technology but network is not helping and few of the group insisted to receive learning, .assessment and feedback in person

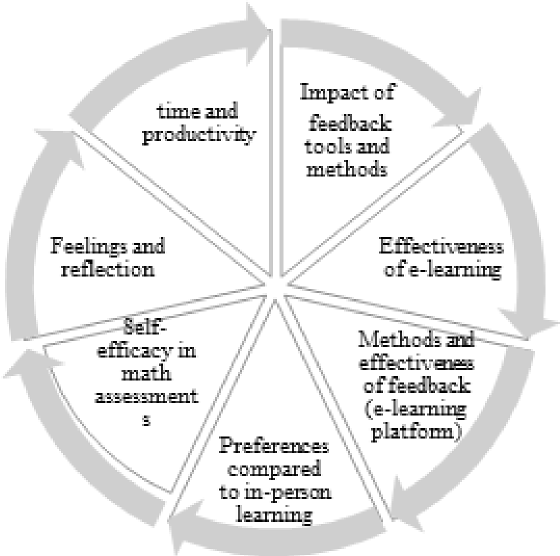

Figure 3.1 Thematic analysis of students' focus group

5 - 4 Teachers' perceptions about e-assessment, e-learning and e- feedback.

The focus group conducted with 10 teachers in an online meeting was attended by eight teachers because of network connection issues.

The results of this meeting was transcript and coded then reported and analyzed. The analysis of the teachers' responses is summarized in the table 3.2.

Table 3.2: Thematic analysis of teachers' focus group

Themes	Analysis of teachers' responses
Perceived Benefits	Teachers highlighted how can online apps foster students' engagement through regular practice and improve their learning outcomes. It also facilitates feedback and allows timely and specific feedback.
Challenges and barriers	Network issues, glitches and lack of technical support. Students' devices may not support the used apps which may affect students' engagement and considered unfair to not be integrated like others.
Academic performance	Teacher agreed that students can benefit from the development of their academic performance as well as their development of their digital skills.
Innovation and creativity	Using e-learning ,e-assessment and e-feedback enhance teachers' ICT skills and increases their creativity and innovation in the teaching-learning process.
Using formative assessment and feedback ipsatively	Teachers explained the importance of formative assessment that helps them highlighting students' weaknesses and strengths. Some teachers extended the views to the importance of ipsative assessment that is used to compare students' own results with previous performances.

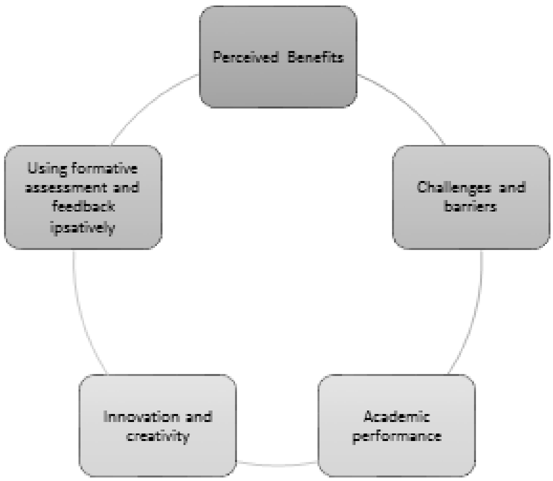

Figure 3.2 Thematic analysis of teachers' focus group

5 - 5 Answers of the research questions:

- **Major question of the study**

  What are the impacts of implementing ipsative e-assessment on the 8th Lebanese graders' progress, self-efficacy and academic achievements and particularly in Math?

- **Sub-Question 1**

  How will ipsative assessments support achievement of math concepts after a sequence of tasks and assignments?

The findings of the study show that less than 50% of the students scored about 3 out of 5 correct responses while after providing self-referential feedback, students showed achievement where more than 75% of the students scored 4 or 5 out of 5 correct responses. The integration of formative ipsative assessment, particularly through the use of online apps, has shown promising results in enhancing student achievement in mathematics. By providing timely, specific, and self-referential feedback, teachers can effectively support student learning and motivation. The positive feedback from teachers indicates that this approach is not only feasible but also beneficial for both teachers and students. However, it is important to acknowledge that the successful implementation of formative ipsative assessment requires adequate teacher training and support.

The study findings are aligned with (Nishizuka, 2022) study which highlights the effectiveness of ipsative assessment in fostering deeper learning, particularly when supported by a structured curriculum and a collaborative classroom setting.

Sub-Question 2

To what extent does using technology and new apps increase using formative and ipsative assessments?

The chi-square test results indicate that there is no statistically significant relationship between the use of math online apps and the implementation of formative ipsative assessments. This suggests that while technology can be a valuable tool in education, it may not necessarily influence the specific types of assessments teachers choose to use.

Teacher preferences and expertise has an active role in the process of assessment, feedback and integration the technological tools. Teachers may have varying levels of comfort and expertise with technology, which could influence their decision-making regarding assessment practices. Some teachers may prefer traditional assessment methods, while others may embrace technology-enhanced approaches.

Yet (Irwin, 2011) inferred that their findings after deep research, an effective and simple means of communicating formative feedback to students, and can enhance the way in which students receive and engage with feedback where students can receive and interact with reaction more effectively and easily when formative input is communicated to them via electronic means.

Sub-Question 3

To what extent does formative – ipsative assessment influence students' self-efficacy?

Formative-ipsative assessment influenced 81.8% of the students to feel more confident to solve math assessments of the 1st focus group 63.6% of the 2nd focus group after participating in this study while the rest still feel upset to enroll in math assessments. This reveals that the effectiveness of formative-ipsative e-feedback on students' self-efficacy has shown that mathematical self-efficacy and student achievement are related.

The results of the study explored by (Rakoczy, 2019) et al. also showed that the intervention enhanced students' perceptions of feedback as valuable and improved their self-efficacy, with slight gains in interest. The results suggest the need for further research to refine these practices and maximize their impact on educational outcomes. And consequently, this study showed significant differences in enhancing students' interests and self-efficacy.

Sub- Question 4

How does using technology affect giving regular feedback to student?

The non-significant p-value ($p > .05$) for all types of assessments indicates that there is no significant association between the use of math online apps and the type of assessment. This means that teachers are using different types of assessments regardless of whether they use math online apps or not.

While the statistical analysis suggests no significant association, the slight differences in the percentages of teachers using math online apps for different assessment types are worth noting. For instance, a higher percentage of teachers use math online apps with diagnostic and formative assessments compared to summative and ipsative assessments.

The nature of the assessments, teacher preferences, and school-level factors can influence the integration of online apps into assessment practices.

Computerized feedback can be utilized to produce more detailed and accurate diagnostic data from e-assessments in addition to presenting students' overall performance as (Bulut, 2020) inferred shows alignment with the findings of this study.

Sub-Question 5

To what extent do regular e-feedback enhance students' learning outcomes?

The results highlight the central role of feedback in teachers' instructional practices. A significant majority of teachers—80% overall—provide feedback either in every assessment (56%) or on a weekly basis (24%), underscoring the importance of regular feedback in enhancing the teaching–learning process. Among teachers who do not use math online applications, 59.09% consistently provide feedback in each assessment, while 11.59% do so weekly, yielding a total of 70.68%. This suggests that the practice of giving feedback is widespread regardless of the use of digital tools.

However, (Clare Kilbane and Natalie Milman , 2023) explains that dynamic, individualized instruction is possible when teachers intentionally design learning experiences and highlights how technology enables differentiated instruction across diverse student needs.

Discussion

The findings suggest that integrating e-learning, e-assessment, and ipsative e-feedback was associated with improvement in students' mathematics performance across the intervention phases. The observed increase in average scores and the shift in score distributions toward higher achievement levels are consistent with the pedagogical value of self-referenced progress monitoring, repeated practice, and feedback that highlights individual growth.

At the same time, non-significant associations in parts of the teacher survey indicate that the mere use of applications may not be sufficient to explain learning outcomes. Implementation quality, teacher mediation, task design, feedback timing, and student access conditions may be more influential than platform adoption alone. This helps explain why technology use in classrooms does not always translate into statistically detectable differences across all teacher-reported categories.

The qualitative findings strengthen interpretation of the quantitative trends by showing that students experienced the intervention as motivating and supportive, especially when feedback helped them identify errors and monitor improvement without comparison to peers. These perceptions align conceptually with ipsative assessment principles and may help explain gains in engagement and persistence.

Interpretation should remain cautious. Given the absence of a control group and the constraints of implementation in real school settings, the study supports an association between the intervention and improved outcomes but does not prove causality.

6 - 1 Future Research Directions

Based on the findings, further research is required to delve deeper into the long-term impact of such interventions and explore optimal strategies for maximizing student learning and self-efficacy in solving math assessments. Researches could also explore strategies to further optimize the assessment and feedback experience, particularly for students who may struggle with technology or who prefer more traditional instructional methods.

6 - 2 Conclusion

In conclusion, the findings of this study underscore the comprehensive role of assessment in mathematics education. Teachers' primary objectives of evaluating the effectiveness of their performance and identifying students' misconceptions, remain central regardless of the integration of online applications. While statistical analyses revealed no significant relationship between the use of math apps and the type of assessment employed, the consistent emphasis on feedback highlights its enduring importance in enhancing the teaching-learning process.

The results further demonstrate that feedback, whether supported by online tools or delivered through traditional methods, is a critical factor in fostering student growth. The significant improvement in mean scores across successive assessments delivered to students through the Quizizz platform provides compelling evidence that interventions such as the integration of IXL and ipsative feedback positively influence student performance. Students themselves reported increased confidence and a preference for personalized, private feedback, which they either received through seesaw, Quizizz or IXL applications, affirming its effectiveness in helping them recognize and correct their misconceptions.

Teachers' perspectives reinforce the motivational power of formative ipsative feedback, which emphasizes individual progress and self-efficacy. However, the effective implementation of formative ipsative assessment requires careful planning, adequate resources, and sustained professional development. Challenges such as technical issues, connectivity problems, and inequities in access to digital tools highlight the need for systemic support to ensure that all learners benefit equally from these innovations.

Ultimately, this study demonstrates that technology alone cannot transform educational practice. It is the thoughtful integration of digital resources with sound pedagogical approaches, ongoing teacher training, and a commitment to equity that creates a dynamic culture of assessment for learning. By striking this balance, educators can empower students, elevate performance, and build inclusive learning environments that advance both teaching and learning outcomes.

References

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Barnes, E. (2023, December 10). The ethical implications of educational technology in the digital age. Kenpad. https://kenpad.com/the-ethical-implications-of-educational-technology-in-the-digital-age/

Bitchener, J., Young, S., & Cameron, D. (2005). The effect of different types of corrective feedback on ESL student writing. Journal of Second Language Writing, 14(3), 191–205. https://doi.org/10.1016/j.jslw.2005.07.001

Bulut, O. C. (2020). Guidelines for generating effective feedback from e-assessments. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 35, 60–72. https://dergipark.org.tr/en/pub/hunefd

Kilbane, C., & Milman, N. (2023, June 26). Differentiated learning and technology: A powerful combination. ASCD, 80(9). https://www.ascd.org/el/articles/differentiated-learning-and-technology-a-powerful-combination

Clark, I. (2012). Formative assessment: Assessment is for self-regulated learning. Educational Psychology Review, 24, 205–249. https://doi.org/10.1007/s10648-011-9191-6

Dohrenwend, A. (2002). Serving up the feedback sandwich. Family Practice Management, 9(10), 43–46. https://www.aafp.org/pubs/fpm.html

Hughes, G., Wood, E., & Kitagawa, K. (2014). Use of self-referential (ipsative) feedback to motivate and guide distance learners. Open Learning: The Journal of Open, Distance and e-Learning, 29(1), 31–44. https://doi.org/10.1080/02680513.2014.921612

Irwin, B. H. (2011). Using technology to encourage student engagement with feedback: A literature review. Research in Learning Technology, 19(2), 117–127. https://journal.alt.ac.uk/index.php/rlt

Lazaro, H. (2021, May 24). What is edtech? General Assembly. https://generalassemb.ly/blog/what-is-edtech/

Leung, F. H., & Savithiri, R. (2009, February). Spotlight on focus groups. Canadian Family Physician. https://www.cfp.ca/

Martínez-Arboleda, A. (2021). Ipsative assessment. https://doi.org/10.4324/9781003017442

Mattar, J. (2018). Constructivism and connectivism in educational technology: Active, situated, authentic, experiential, and anchored learning. RIED: Revista Iberoamericana de Educación a Distancia, 21(2), 201–215. https://doi.org/10.5944/ried.21.2.20055

Nishizuka, K. (2022). Significance and challenges of formative assessment. SAGE Open, 12(2), 1–19. https://doi.org/10.1177/21582440221094599

Rakoczy, K., & Pinger, P. (2019). Formative assessment in mathematics:

Mediated by feedback's perceived usefulness and students' self-efficacy. Learning and Instruction, 60, 154-165. https://doi.org/10.1016/j.learninstruc.2018.01.001

Schulz, W. (2005, April). Mathematics self-efficacy and student expectations. https://www.acer.org/

Schunk, D. H. (1984). Self-efficacy perspective on achievement behavior. Educational Psychologist, 19(1), 48-58. https://doi.org/10.1080/00461528409529281

Schwartz, D. L., Tsang, J. M., & Blair, K. P. (2016). The ABCs of how we learn: 26 scientifically proven approaches, how they work, and when to use them. W. W. Norton & Company. https://wwnorton.com/books/The-ABCs-of-How-We-Learn/

Siemens, G. (2004). Connectivism: A learning theory for the digital age. International Journal of Instructional Technology and Distance Learning, 2(1). https://www.itdl.org/

Siemens, G. (2005). Connectivism: A learning theory for the digital age. https://www.edtechpolicy.org/AAASGW/Session2/siemens_article.pdf

Stemele, B. P., & Asvat, Z. J. (2024). Exploring learner errors and misconceptions in algebraic expressions with Grade 9 learners through the use of algebra tiles. https://doi.org/10.1080/18117295.2024.2334989

Tam, M. (2000). Constructivism, instructional design, and technology: Implications