

**CAN COMPUTER-ASSISTED INSTRUCTIONS THROUGH TAILORED MOTION
GRAPHICS ASSIST IN BIOLOGY TEACHING AND ENHANCE ACADEMIC RESULTS
AND SCIENCE VISUAL LITERACY IN GRADE 8 BIOLOGY LEARNERS IN
MAURITIUS?**

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Abstract

This mixed-methods study sought to determine the effect of tailored motion sequences on teaching, performance and science visual literacy in Grade 8 Biology learners. Fifteen animations were created using the ADDIE design model which were evaluated by the research team and field tested by students. A new Learning Style Instrument (LSI) was devised to capture data on students' learning style\ and a pilot study was conducted to validate the use of the instrument. Other instrumentations were survey tools, interviews and focus groups captured qualitative responses from teachers and learners. Pre, post and summative tests demonstrated whether visual literacy skills have been enhanced through seven visual literacy indicators. Statistical analysis of the values of significance concluded an inclination towards visual, read\write and kinesthetic learning mode. The Spearman's rho correlation gave a weak negative correlation for aural preference and the strength of the visual mode of learning in single and multiple modes of learning scored a 'strong and very strong' visual preference. As for the summative test, it revealed that nine animations were very effective so far performance was concerned. Moreover, an increase in mean marks and ranks was noted for the indicators school-wise and gender-wise it was observed that girls had a higher mean percentage than boys except for the "essence" and "understand" indicators. Coding methods revealed twenty five categories that were reduced to five themes where students demonstrated an increase preference for tailored animations and also the choice to use them in future by the teachers and students.

Keywords: Learning Style Instrument

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Biology is the most visual of all the sciences. A lot of teaching aids can be used intensively in the teaching of Biology to make the subject alive by creating animated mental images (T. Demissie et al., 2013) in the students' mind. It is to be noted that both still and animated visuals may be obtained from the web or may be already available from instructional CDs available in the market. However, these visuals are often targeted for a general audience across the world without taking into consideration the syllabus content or context in which the students are evolving. In the present case, having to deal with mixed ability students, made it essential to create tailored visuals according to the level of understanding of the students. Using visual-based teaching, allowed growth of high order visual literacy in students. Today's college learners are exposed to lots of visuals and do their routine activities through smart phones, Youtube, games, facebook, advertisement among others. But their participation in a highly visual culture does not prepare the learners to engage critically and effectively with the visuals in an academic environment (Hattwig et al., 2013). It is thus exciting to tap and exploit the visual capabilities of young people hence making them visually literate.

Science subjects including Biology are becoming less attractive to students. Less than 30% of O-level students and less than 15% of A-level students opt for science including Biology in the secondary schools in Mauritius (Bholah. R., 2017). Statistics on percentage constitution of grades presented by the Mauritius Institute of Education (Bholah. R., 2016) has shown that between 30 to 50% of the students at Grade 9 National exams earned less than 40 marks and with less than 10% obtained between 90 to 100 marks. At School Certificate level, less than 15% earned distinctions and around 60% obtained grades above or equal to 6. Regarding the pass rate

at A-level, a decrease in the percentage of students by around 25% from 2002 up to 2015 was depicted. The subject is being perceived as difficult where lots of abstract concepts are portrayed to students during teaching. Thus sporadic use of visuals like charts, diagrams, models, clips, flow diagrams, concept maps, downloaded animations among other visuals does not suffice for effective and meaningful learning to take place. These should be used more intensively and frequently during teaching, experiments and demonstrations, class work and home work, revision, evaluation, presentations, remedial sessions and in many other domains.

Statistics have shown that around 70% of students drop science that includes Biology, Chemistry and Physics as a subject after Grade 9. The Grade 9 National examinations have revealed that the National Pass Rate in Biology for the year 2013 was 48.8% (below 50%) and the National mean mark scored was 20.5 on 50 marks, again below 50%. A decline in the pass rate of Biology has been noted from 70% in 2011 to 48.8 % in 2013 (MoE, 2014). However, the pass rates for subjects like English, French and Computer studies were above 60%. Moreover, a report from the quality assurance department (MoE, 2014) commented that ‘most students were able to tackle low order questions with one word or short answer questions. Students had difficulty in answering questions requiring descriptive answers (MRC, 2004; Ministry of Finance and Economic Development, 2017). A survey has pointed out that science teaching in schools is uninteresting and unexciting because a didactic approach is followed in most schools because of various factors mentioned above. It is recommended that more active learning approaches to science teaching should be employed and greater opportunities must be provided to use computer soft-wares and multimedia to promote independent learning among students (MRC, 2004). Biology is a subject dealing with lots of abstract and complex concepts which act as a learning barrier among other barriers. So, visual-based pedagogy can be one of the solutions to this

problem because visualisation is a means to see phenomenon and events that are microscopic, too slow or too fast for the naked eyes (Buckley, 2000). During the past ten years governments and education departments across the world have invested significant sums of money in a range of whole-class visual display technologies (Cuthell, 2005a). There have been many reasons for their adoption: the technologies have been seen as a way for providing access to the latest educational resources or as a way of transforming and modernising the outcomes of educational systems (Cuthell, 2005a).

Literature review

Hegarty. M (2014) defines a motion graphic “as a combination of static images that changes its structure or properties over time and which triggers the perception of a continuous change by viewers.” It has been advocated by Linn (2003) that the application of technology where animations are used in science classes helps to explain real-world situations and also contribute to producing more autonomous learners. To enhance the effectiveness of an animation, the information is presented slowly and incrementally in smaller chunks to students thus providing them with ample time to digest and assimilate the features that are obvious to the designer but not to the students. Chunking is where each frame is split into a sequence of three or four smaller units of texts and visuals and it is believed that there is less distraction letting the learners’ focus onto the intended information. Animations are an ideal tool to present concepts in its natural logical order and also to show the steps to be followed for a procedural task. Another importance of animations is to assist in describing concepts that are difficult to elucidate through verbal instructions only. Thus animations are principally used to exhibit an idea and to illustrate an abstract concept that may be difficult to understand with text or sound. Animation elicits the viewer's automatic ability of the visual system to directly encode them into both visual and

verbal form, while static image requires an additional effort to form mental images by connecting and integrating discretely presented information. Evidence was found for the compensatory effects of animations over static pictures (Münzer. S., 2015). Thus encoding to the dual form allows the information to remain longer in the memory and also facilitate accessibility of the latter than when encoded in the single form. This is because two different subsystems in the memory are interacting to complement each other in the understanding of the concept. Mayer and Anderson (1991) suggest that an animation should be coupled with verbal explanation concurrently to facilitate the connection between the areas in the nervous system.

There are more research works on the effectiveness of static visuals than animated motion graphics but no mention is made about the materials that were used and the way they were designed. Many research works have demonstrated the ineffectiveness of the instructional effects of the animations because of the burden on the learners to process an excessive amount of information and the inadequacy of learner's engagement in processing activities as charted out by Lowe (2002). Proponents of animations have demonstrated better performance than with static graphics and claimed that animations are superior to still graphics in the sense that the fine details can be seen (Tversky. B and Julie Bauer Morrison. B.J. ,2002).

Different theories share common attributes more specifically the visual and verbal aspects in their various forms like for example in the dual coding theory that helped in understanding and enhancing visual literacy in students and at the same time assisting teachers in their teaching process. Depending on the type and form of information being processed by the Information Processing Theory, the cognitive load theory comes into play where the order and form of information contribute to its proper functioning. As for the multimedia theory, it lays out the best principle to be followed when designing visuals and using the two routes for optimum

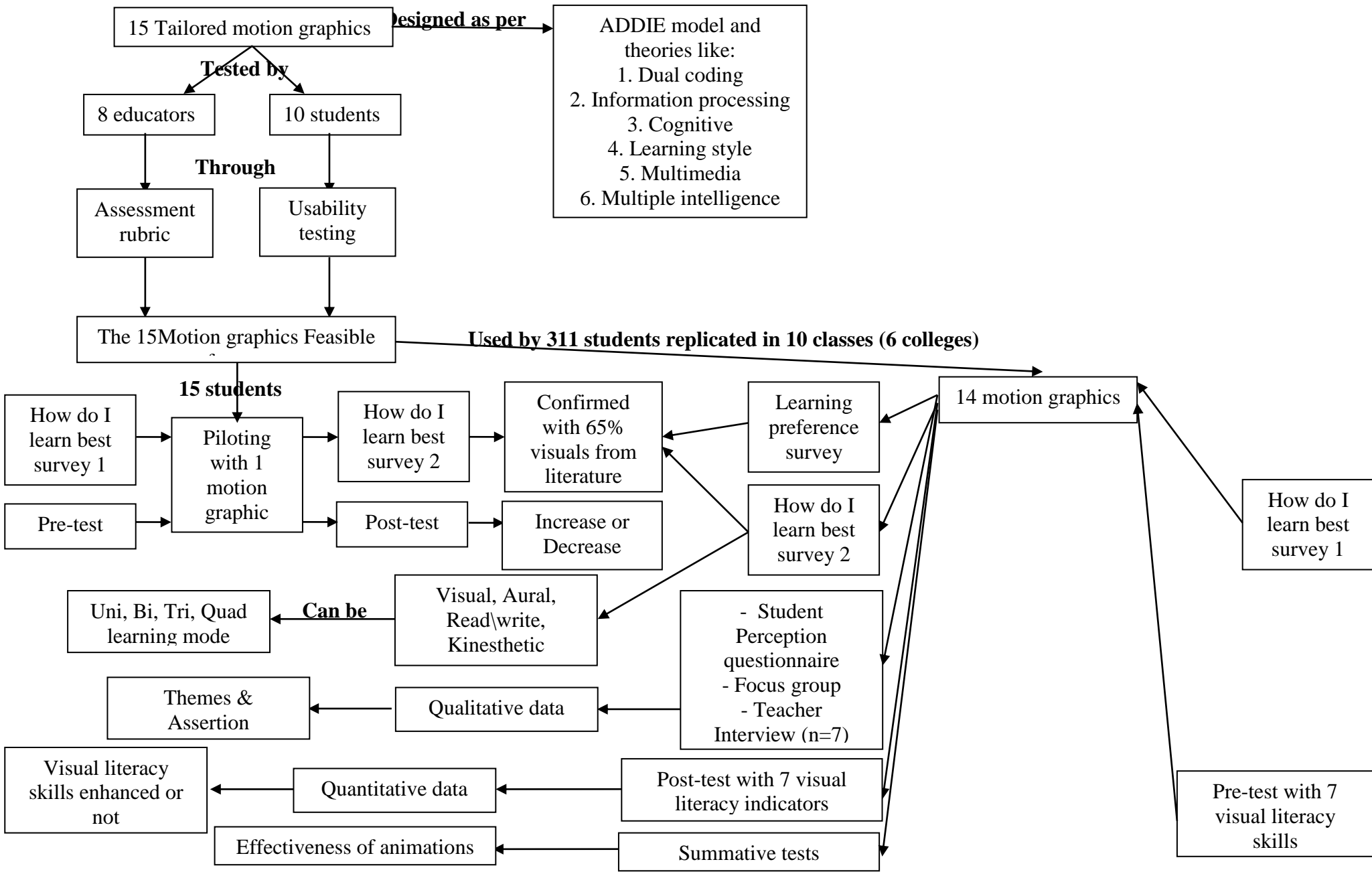
efficiency. As regards to the learning style theory, it was mainly used to identify the learning style of the students before and after the interventions. The last theory on intelligence solves problems using the different intelligences but mostly the spatial and linguistic intelligences.

A growing body of research has revealed countless variations on the definition for Visual Literacy. Baca and Braden (1990) have postulated that each author has defined the term from their own perspective and professional background. An exact definition remains elusive because of the complexity and multidimensional nature of the skills involved. Science graphics' reading is complex because learners have to attend to both text and the visual and without proper skills they are unaware of the order that the graphics should be examined. They also get difficulty to filter and distill out the superfluous information from the pertinent one as well as connecting and integrating related knowledge. Smolkin and Donovan's (2004) observed that graphics were used in the classrooms by just pointing to them without venturing through and across them. Concentration was mostly on reading and writing (Yeh & Lohr, 2010). This promotes only low order visual literacy skills. High order visual literacy skills can be achieved through science visual literacy where teachers can spare some time to teach about science graphics on its purpose and how students should examine graphics effectively (McTigue. E et al., 2011) so that learners can construct meaning from the visuals. Most people are known to be visual learners (Pettersson 1993) but that does not mean they possess visual literacy skills. The five main steps before understanding a concept is 1. Seeing, 2. Examining and Learning, 3. Interpretation, 4. Communication and 5. Comprehension. Visually literate person will use all the 5 steps unconsciously. So training is important where students are taught how, where and what to "see". Sinatra. R (1986) said that visual literacy is a primary skill that precedes other literacies like verbal skills during the course of the human development. The work corroborates with some

facts that we can observe in our daily life like being with babies. At the age of around eight months, they are able to memorise and distinguish their parents from other people. Children at the tender age of 1 year are able to read graphics. For example they know that a representation of an orange equates to a real orange. At three, they can produce their own drawings for example showing emotions like happiness. They can even use visual symbols like rectangles and circles to draw a car.

Methodology

Research Design outline



Conception of motion graphics

Fifteen tailored animated motion graphics which were in line with the National Curriculum Framework were created using the Macromedia Flash Mx 2004 software following the ADDIE and ACE models. The motion graphics consisted of the different types of visuals (Levin et al., 1987) like representative, organizational, interpretive and transformative animated sequences that make information more concrete and augment retention and recall. The five steps mentioned by Hoban & Nielsen (2010) were taken onboard for the creation of the digital motion graphics. Four levels of understanding were incorporated in the animations namely, the symbol, macroscopic, microscopic and process level as per Saar (2007). The attempt was to make comprehension better than commonly used visuals. Other conventions were followed like the selection, organization and integration principles (Schnotz & Bannert, 2003) so far visual grammars like text, lines, contours, labels, colour, white spaces, contrast, font size among others (Tufte, 1983) were concerned. The animated visuals were self-reviewed and self-edited (Lohr. L., 2008) for their effectiveness in teaching and learning (Figure 1).

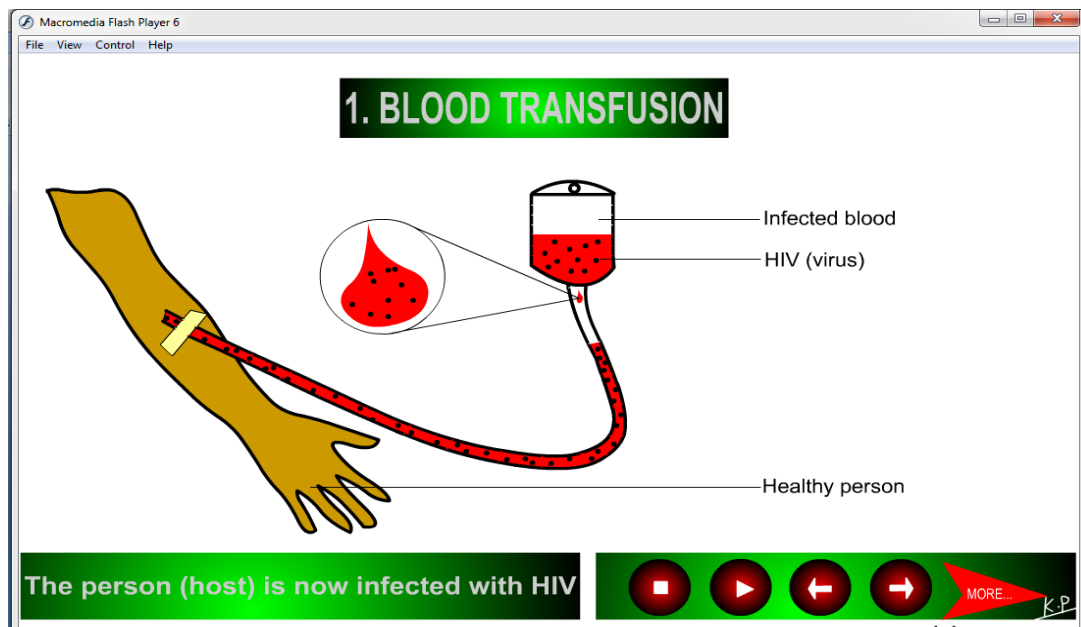


Figure 1: Screenshot demonstrating a representative visual and accompanying notes.

A 5-point Likert scale assessment rubric on the effectiveness of the instructional materials was used to collect information on different aspects of the visuals from the eight educators and same were field tested using a usability testing form (Yin, 2003) in two iterative phases by a group of 10 randomly chosen students who did not form part of the research using a usability testing questionnaire. Lohr & Eikleberry, (2001) recommended for three questions when evaluating the animated visuals.

Piloting

A new 16-item learning style survey tool “How do I learn best survey 1 & 2’ inspired from VARK Learning Style Instrument (LSI) (Fleming. N., 2001) was devised and was piloted with a group of fifteen students to validate the tool. Each question in the survey had four options pertaining to visual, aural, read\write and kinesthetic experiences of the learners from the Mauritian context. The VARK online LSI is meant to capture data for players, athletes etc from different context as compared to the new designed tool that was meant for Grade 8 Mauritian Biology learners. No tool was found to capture data on learning style from Biology learners of a specific age group. The students were provided with the ‘How do I learn best survey 1’ followed by an animation on photosynthesis and then the ‘How do I learn best survey 2’. A pre and post-test was then applied based on the animation. The results were consistent with the literature and the set proposition of 65% of a population are visuals. The investigation was thus replicated in six other schools with ten Biology classes and eight Biology educators. The 16 items were also validated by the supervisor and the team of educators as well.

Other surveys

A road map was provided to the educators on how to use the visuals like deep viewing, deep discussion, writing, drawing, creating mental models through visual thinking (Riesland. E.,

2005) and questioning to enhance science visual literacy (Ainsworth, Prain & Tyler, 2011). Other surveys following replication were used to extract subjective evidence as per Creswell (2013) from the 311 learners. The first survey in the six schools was the learning preference survey that provided with quantitative information on the interest of the students in the study and a bird's eye view on the learning preference of the 311 students. The visual occurrences were compared and matched with the set proposition from literature that 65% of a population (Dunn, Rita, and Kenneth Dunn, 1992) is visuals.

The next survey applied to all the learners were the validated 'How do I learn best survey 1 & 2' where the survey 1 was dispensed before the use of the tailored animations and survey 2 at the end of the year. The percentages of students with visual modes were compared before and after the use of the visuals and also with the stated 65% from literature. The survey also permitted to assess the strength of the visual preference (Khongpit. V. et. al., 2018) of the students as well as whether students had a single or multiple mode of learning in essence whether they are uni, bi, tri or quad-modal.

Another survey tool was the student perception survey with 1-5 Likert scales and open-ended questions collected subjective responses and responses on the effectiveness of the tailored animated visuals in learning. The students were also subjected to multiple focus group (Killingsworth et al., 2000) in the three types of schools in essence, low, average and high performing schools where open-ended, probing and final qualitative and affective questions with prompts were posed and recorded following the signed consent of the students.

Seven out of the eight educators as observers agreed for a 40 minutes semi-structured telephone interview that was recorded to extract information on the events, behavior and attitude of the learners when the tailored visuals were used. There was enough coverage of the schools as

per Corbin & Straus (1998). Coding process was then applied to the transcript using the skimming the cream technique (Shirley Agostinho, 2011) where the essentials were spotted followed by deriving categories and sub-categories. The findings were triangulated with responses from the student perception survey.

Pre and post-tests as formative and a final summative test were conducted to assess the seven visual indicators as per ACRL, (2011) which were to identify, find, understand, evaluate, use, create and extract indicators. The marks earned for each indicator were compared as well as the total marks for the formative and summative tests to see if there was any enhancement in the visual literacy skills via improvement in their academic performance. A last MCQ summative test showed which animated visuals was the best in recalling capabilities.

Results and analysis

Evaluation of the fifteen motion graphics revealed the percentage effectiveness of the motion graphics. On average 47.6% of educators found that the running of the motion graphics in terms of pace, sequence etc as being very effective and 52.4% as quite effective. Regarding the text and related aspects like size position etc, the average was 49% for very effective against 47% for quite effective. As for the graphics and related features like colour, controls etc, it was noted that the average was 54.8% as being very effective and 35.7% as being quite effective. Thus the running time was neither too long nor too short that fits in the learning curve. Some minor amendments were roped in so far the text and graphics were concerned as per the responses from the teachers. The overall quality of the animated graphics were thus acceptable which was denoted by the high average percentage of 71% and 9 out of the 15 animated visuals scored 'very good'.

The usability testing by the students disclosed crucial information on the visual grammars. Like for instance some real images were replaced by line drawings. A low percentage of 20% found that the running length and pace was poor but no modifications were brought in because they were unaware about the approach that their educators will be using with the animations. The text size was increased for better legibility in big-sized classes and long sentences were reduced.

The learning preference survey showed that around 89% of the students were either very interested or interested in knowing their learning style\'. The high mean value of 4.36 on interest backed the hypothesis that the respond rate regarding the study was high as well. Moreover, 84.56% of the students declared that they were new to such studies on learning style. Thus the large majority of the students were unaware of their learning orientation. The survey also gave firsthand information like 59.7% of the students opted for a visual preference. This confirmed the statement by Bradford, (2011) claiming that 65 % of a population is visual. This was a good start to upgrade the visual nature of the students to visually literate learners.

Kolmogorov-Smirnov test (K-S) and Shapiro-Wilk (S-W) were applied on the data collected through the 'How do I learn best surveys 1 & 2' and revealed that the data were not normally distributed with a significance of 0.000. The results below (Table 1) show an increase in mean by 2.63 for the visual mode after the use of the tailored animations attesting that the students had developed a higher preference for the visual mode of learning as compared to the other three learning styles

		Visual mode before	Visual mode after	Aural mode before	Aural mode after	Read\ Write mode before	Read\ Write mode after	Kinesthetic mode before	Kinesthetic mode after
N	Valid	304	302	304	302	304	302	304	302
	Missing	7	9	7	9	7	9	7	9
Mean		7.29	9.92	5.93	5.85	6.78	6.17	6.00	4.04
Mode		6	9	5	7	8	5	7	1

Table 1: Descriptive statistics on the means and modes for the 4 learning modes before and after the survey.

The survey also revealed a gradation of learning styles from uni-modal to multi-modal (2 or more learning modes) students. For e.g. it was found through the ‘How do I learnt best survey 1’ that out of the 26% of learners with one mode of learning, 10% had visual orientation. The 2nd survey after the use of the animated visuals divulged that 44% out of 50% of learners with one mode of learning had a visual preference i.e. an increase by 34% as shown below in Table 2. An increase was also noted for bi-modes and tri-modes i.e. students with two and three learning modes respectively. And a decrease was noted for students with four modes of learning i.e quad-modal learners. When the grand total for visual orientation in the uni, bi, tri and quad-modal learners was compiled, an overall increase by 14% was noted denoting the effect of the tailored animations on the learners on the growth in the visual mode of learning.

Learning style1	Valid Percentage students	Learning style2	Valid Percentage	Increase (+) or Decrease (-)
UnimodeV1	10	UnimodeV2	44	+ 34
BimodeV1	7	BimodeV2	11	+ 4
TrimodeV1	11	TrimodeV2	13	+ 2
QuadmodeV1	49	QuadmodeV2	23	- 26
Grand Total V1	77	Grand Total V2	91	+ 14

Table 2: Comparative table between visual modes before and after the use of tailored animations for the different learning styles.

As for the significance through the Wilcoxon matched-pairs signed ranks test as shown under (Table 3), the values were less than 0.05% for visual, read\write and kinesthetic modes except for aural mode. Thus orientation towards visual, read\write and kinesthetic mode of learning was significantly higher and that for aural mode of learning remained the same.

	Visual mode after - Visual mode before	Aural mode after - Aural mode before	Read\Write mode after - Read\Write mode before	Kinesthetic mode after - Kinesthetic mode before
Z	-9.316	-.289	-3.021	-9.263
Asymp. Sig. (2-tailed)	.000	.772	.003	.000

Table 3: Wilcoxon Signed Ranks Test statistics table illustrating the significance of the event.

Another non-parametric test that was applied was the Spearman’s rho correlation and the result was a weak negative correlation of -0.155 between visual and aural preference (Figure 2). The variability in the aural mode that was 1.7% was because of the visual mode. There were not enough evidence about any correlation between visual and the read\write and kinesthetic modes.

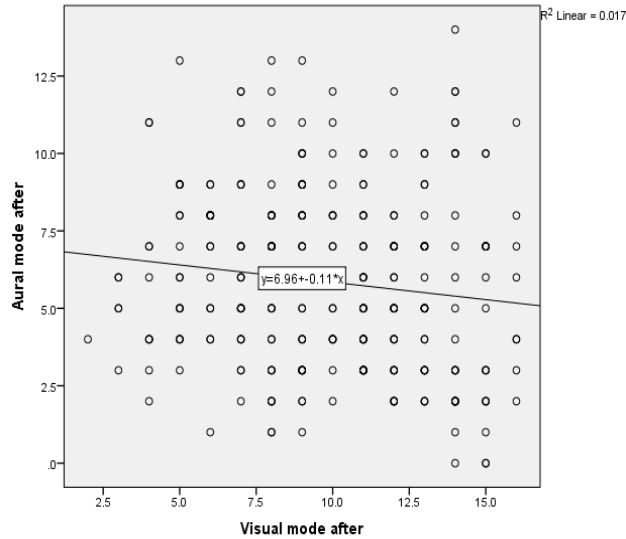


Figure 2: Scatter plot between visual mode after and aural mode after.

Regarding the strength of the visual mode of learning in all four uni, bi, tri and quad modes after the use of the visuals, 64.6% of the learners scored a ‘very strong and strong’ visual preference. As for effectiveness of the fifteen animations in recalling, a summative recall test revealed that five specific animations were very effective in the learning process as denoted by a mean score above 4. The animations in general, scored a mean value of above 3 out of a total of 5 except for one animation on vein which below 3. In addition, graphical representation through box and whisker plot revealed that all three types of school earned marks above 50% (Figure 3). It was also noted that boys with a mean performance of 56.53 marks over 54.42 marks for girls performed better than girls.

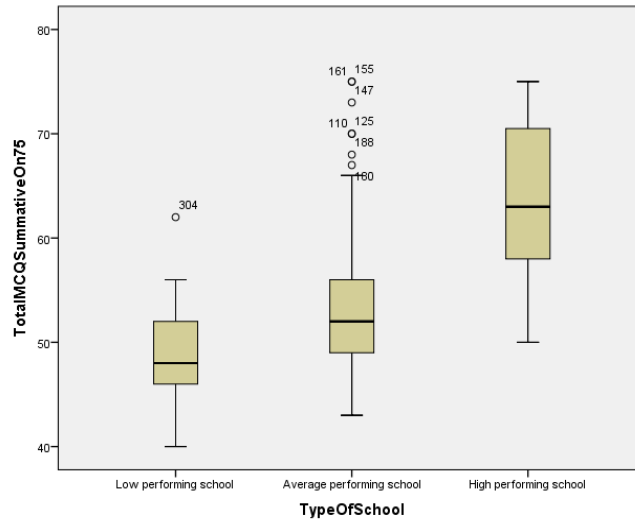


Figure 3: Box and whisker plots revealing the distribution of marks for MCQ test for the different types of schools.

Regarding the seven visual literacy indicators, the significance values for the indicators through the pre\post-tests scored 0.000 at 5% level of significance (Table 4). The scores for all the indicators when analyses separately or combined were different and higher with the introduction of the tailored visuals.

Visual literacy indicators	Z value	Asymp. Sig. (2-tailed)
IdentifyPostOn2mks - IdentifyPreOn2mks	-4.460	.000
FindPostOn9mks - FindPreOn9mks	-13.486	.000
UnderstandPostOn8mks - UnderstandPreOn8mks	-13.131	.000
EvaluatePostOn5mks - EvaluatePreOn5mks	-11.394	.000
UsePostOn11mks - UsePreOn11mks	-14.043	.000
EssencePostOn3mks - EssencePreOn3mks	-11.342	.000
CreatePostOn7mks - CreatePreOn7mks	-13.411	.000
TotalpostOn45 - TotalpreOn45	-12.834	.000

Table 4 : Wilcoxon Signed Ranks Test statistics table illustrating significance on the indicators.

Moreover, an increase in mean marks and mean ranks through the Wilcoxon matched-pairs test was noted for the separate indicators school-wise as well as when all the indicators were combined. Gender-wise it was observed that girls had a higher mean percentage than for boys

except for the “essence” indicator with 1.07% and “understand” with 5.67% (Figure 4). The contrary was noted when the total pre and post test was computed with boys scoring a slightly higher mean percentage than girls.

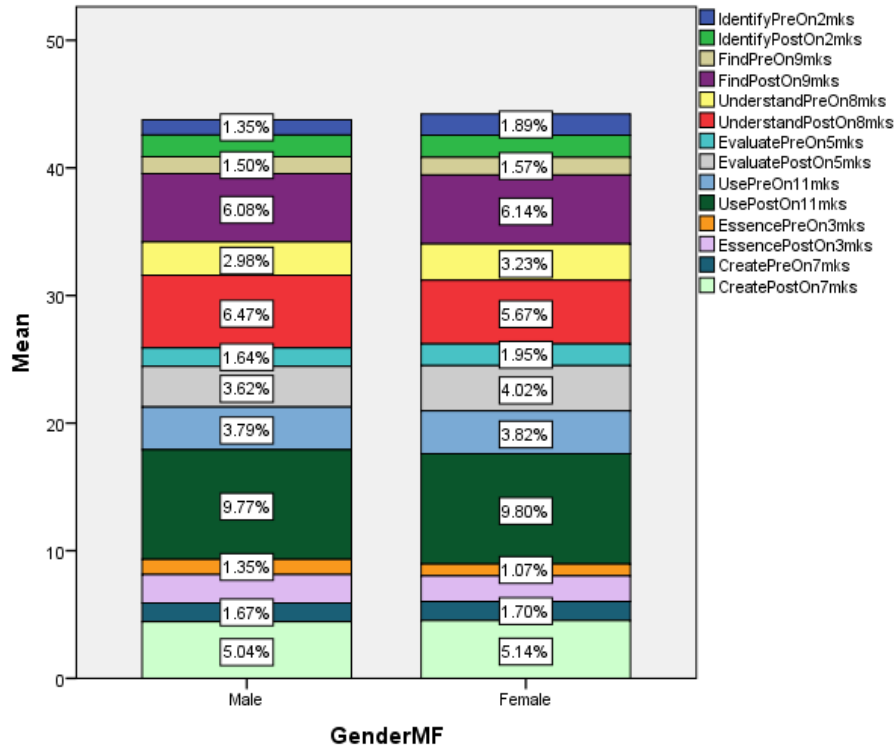


Figure 4: Gender-wise comparison for the mean marks.

Regarding the student perception questionnaire, students’ focus groups and the teacher phone interview, they generated qualitative and affective information from students and teachers. Prior to coding methods like initial coding, descriptive coding, in vivo coding, magnitude coding and process coding, twenty five different categories emanated from the qualitative data which were reduced to five themes and then into one key assertion (McCammon et al. (2012) which was as follows:

“Students can be trained to revive their visual nature and dormant capabilities to read and write messages from visuals if tailored motion graphics are effectively produced and used which in turn can contribute in improving the academic results and reduce class noise.”

Discussion and Conclusion

In general, the effectiveness of the fifteen tailored animated visuals were found to be very good which was supported by the relatively high percentage prior to their evaluations by the teachers so far the different components like running time, pace, sequence, text, colours among others were concerned. This overall good quality and effective visuals were attributed to the fact that the motion graphics were conceived using a set benchmark by using the ADDIE model where the different prescribed stages were followed. Moreover the animated visuals were field tested by the students who responded from their own perspectives and thus helped in further improving the visuals.

The investigation showed that the majority of the students were very interested with the study since it was related to their world of study. And also the majority of the students were not aware of their learning styles hence the high interest percentage in the study. Furthermore the present study confirmed for the high proportion of visual learners in a population as stated by Bradford, (2011). The assumption was that if students would demonstrate a high interest rate means that they would respond favourably to the surveys. And the assumption stood good with a high response rate for the surveys and tests.

Moreover the preference for visual mode of learning denoted by the increase in mean, following the use of the motion graphics, was attributed to the fact that the tailored visuals were used intensively in the teaching of the various concepts hence orienting the students towards the visual mode of learning more than the three other modes. On the other hand the modal value i.e. the number of occurrences showed that there was an increase in visual and aural occurrences. This was because of the narration that accompanied the visuals which was important in better understanding of the concepts. It was also found that students whether they had a single learning

preference i.e. uni-modal or multiple learning preferences i.e. bi, tri or quad-modals, the preference towards visuals was higher in uni, bi and tri-modal learning styles. Thus it was inferred that the use of the animated visuals had a greater effect on students with one, two or three modes of learning only and not the quad modes. This was because of the varying distribution for the preference across the four modes in quad-modal students. In short quad-modals seemed to have interest in all the learning styles. The tailored animation contributed in tilting the preference towards the visual mode of leaning when all the modes were combined because of the intensive use of the animated visuals. On the other hand, the test for significance showed that orientation towards visual, read\write and kinesthetic preference was higher as opposed to aural preference which was constant after the implementation of the visuals in the classes. The fact that students were involved in lots of tasks where they had to write messages from the visuals had contributed to this increase in read\write. As for the kinesthetic mode, the increase was attributed to the fact that the visual was used before an experiment allowing the students to get a firsthand knowledge on how to proceed with the experiment. This observation was corroborated by the results from the correlation test where a positive correlation was obtained between visual and kinesthetic mode of learning. No correlation was established between the visual and the other modes of learning. As for the aural preference, correlation test also showed a weak negative correlation between visual and aural mode of learning. the fact that the visuals were self-revealing with all the necessary visual grammars like labels, annotations etc meant that aural way of learning was lessen in the presence of the visuals. the visuals were more dominant in their effects than the aural mode. And it is to be noted that aural mode of learning was not something new to the students as compared to the use of the tailored visuals. But still narration is important in assisting in better comprehension when accompanying the visuals.

Concerning the strength of the visual mode, this investigation divulged a 'strong and very strong preference' for visual modes after the use of the tailored animated visuals. The strength factor is a very important aspect for the teacher and student alike to consider because a student with a weak visual preference and another one with a strong visual preference may differ in the sense that the one with the strong preference will be more apt to analyse and understand visuals than the counterpart even if he\she is visually oriented. Knowledge on the strength will permit the teacher to adapt the lessons accordingly and to instill the visual literacy skills in the students. Moreover, the knowledge of their strengths on visual mode of learning can allow students to further develop their visual literacy skills,

As for the performance, it was concluded that the animations contributed towards the good academic performance of the students irrespective of their gender and school types they were enrolled in. The improved marks earned by a great majority of the students for their formative and summative tests bore testimony for the good academic performance. Moreover the results divulged that visual literacy was enhanced in both genders and the three types of schools. Only seven indicators were taken onboard from the many indicators obtained from research works. Other indicators were not included in the study because of their complexity that students of Grade 8 may encounter which could have generated bias results. It was found that students were more apt to identify, evaluate and use visual messages as opposed to the other indicators. Significance test showed improved score for all the seven indicators that were included in the formative tests.

Moreover, since the animations were coupled with narration from the educators, it was difficult to give all the credits to the tailored animations. The tailored animations alone as instructional material would have been futile. The consistent way the teachers have used the

tailored animations should be given credence as well. Moreover, the way the animations were designed as per the ADDIE and ACE models added in the quality of the animations which greatly helped in the teaching and learning process. The educators were of the opinion that tailored animations were appropriate tools to teach Biology since the subject is rich in visuals.

Other conclusions drawn from the research so far qualitative responses were concerned were that the tailored animations were well appreciated by the student community as well as by the educators in the learning and teaching process respectively. It was also noted that class management was far better than when traditional classes were conducted. Students also acknowledge that they scored better marks when the tailored animations were used. Thus it was concluded that the tailored animations made comprehension more concrete and enjoyable. A last conclusion was that the teacher and students were in favour of using the tailored animated graphics in the near future in the teaching and learning process. Learning was more interesting, motivational and appealing with the animations irrespective of their abilities and gender. Moreover, it was noted that the teachers were agreeable to create their own animations provided that proper training is disseminated to them.

A general conclusion was that the visual preference is not exploited in the proper way to the benefit of the students. The reverse is noted in the teaching process where there is more of read\write instead of visuals. Even if the students had a liking of visuals, still we as Biology teachers are still using only traditional visuals like charts and diagrams during teaching. Educators cannot be held responsible because we are not aware of the learning preferences of our students and we are not trained adequately to produce our own visuals. It is rare to see the use of novel visuals mainly because of the bulkiness of the syllabus, time allocated for the subject and availability of out-dated visuals at school.

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